WORLD TAEKWONDO FEDERATION

Standing Procedure for WTF World Para-Taekwondo Championships

In force as of March 18, 2014

Standing Procedure for WTF World Para-Taekwondo Championships

Article 1	Purpose

1.1 As one of the WTF-promoted Taekwondo Championships stipulated in article 22.1 of WTF Statutes and article 3.1 of WTF Rules on Organization and Operation of International Taekwondo Championships, the WTF World Para-Taekwondo Championships shall meet the demands of the leading taekwondo nations of the World Taekwondo Federation (hereinafter referred to as "WTF") to have competition at the highest level based on para-taekwondo competition format.

1.2 The purposes of the WTF World Para-Taekwondo Championships (hereinafter referred to as "Championships") are: (1) to realize the operational objectives of the WTF, with special emphasis on the promotion and development of para-taekwondo; (2) to provide para-athletes with the opportunity to have an international competition of their own; (3) to develop para-taekwondo worldwide and to make taekwondo a truly all-inclusive martial art; and (4) to share knowledge and techniques as well as friendship and understanding among countries.

1.3 In addition, this document is intended to clarify the nature and competition format of the Championships which are different from those of individual and team taekwondo competitions.

Article 2	Name, Powers and Jurisdiction

2.1 The Championships shall be officially known as the "[4th, 5th, 6th etc.] WTF World Para-Taekwondo Championships [name of host city].

2.2 The Championships shall be held every year in. However, the Championships may not be held in certain years upon decision of WTF Council.

2.3 The name, its symbol, motto and emblem of the Championships that have been approved by the WTF are exclusive properties of the WTF.

2.4 The WTF shall reserve exclusive authority in the governance of the Championships program, except in matters entrusted by the WTF to the concerned Organizing Committee/Organizing National Association of the Championships.

2.5 WTF Competition Rules with modifications shall apply to the Championships.

Article 3	Classification

3.1 The WTF Para-Taekwondo and Deaf-Taekwondo Classification Rules and Regulations ("Classification Rules") will apply to the WTF World Para-Taekwondo Championships

3.2 Athletes will compete in Kyorugi classes "K" as outlined in the Classification Rules

3.3 Athletes will compete in Poomsae classes "P" as outlined in the Classification Rules

3.4 Classification is held in general one (1) to two (2) days prior to the start of competition, depending on the number of athletes registered for the Championships and number of Classification Panels.

Article 4	Competition Rules

4.1 The WTF Competition Rules shall apply for the World Para-Taekwondo Championships.

4.2 The WTF Poomsae Competition Rules shall apply for the poomsae competitions of the World Para-Taekwondo Championships.

Article 5	Kyorugi Classes and Poomsae Classes

5.1 The following classes apply for competition in Kyorugi:

- K41
- K42
- K43
- K44

5.2 The following weight divisions shall apply for competition in Kyorugi;

Male	Female
Under 61 Kilograms	Under 49 Kilograms
Under 75 Kilograms	Under 58 Kilograms
Over 75 Kilograms	Over 58 Kilograms

5.2.1 In the case of insufficient number of athletes in Kyorugi, classes may be combined following decision by Championship T/D and WTF Head of Classification

5.3 The following classes shall apply for competition in Poomsae;

- “P20” Intellectual Disabled

5.3.1 The following age categories shall apply

- Under 30 years old
- Over 30 years old

5.3.2 In the case of insufficient number of participating athletes Poomsae age divisions may be combined;

Article 6	Team Entries

6.1 Every Member National Association is permitted to enter as many athletes as they wish in each class, weight division and poomsae division of the World Para-Taekwondo Championships

6.2 The number of officials are limited as follows:

POSITION	MAX. NO. OF MEMBERS MALE	MAX. NO. OF MEMBERS FEMALE
HEAD OF TEAM:	1	
MANAGER:	1	1
COACH:	2	2
POOMSAE COACH:	1	1
TRAINER:	1	1
POOMSAE TRAINER:	1	1
TEAM DOCTOR:	1	1
ATHLETE ASSISTANT:	1/5 Athletes Kyorugi	1/5 Athletes Kyorugi
ATHLETE ASSISTANT	1/1 P20 Athlete	1/1 P20 Athlete

Article 7	Method of Kyorugi Competition

7.1 Kyorugi Competitions shall be conducted in single elimination tournament system.

7.2 A Kyorugi match shall be carried out for 3 rounds of 1-2 minutes with 1 minute break between rounds. The length of rounds will be decided by the T/D as stated in the Competition Rules.

7.3 Attack to the head is prohibited. The referee will penalize the athletes for techniques aimed for or hitting the head.

7.4 Points to the trunk are awarded with one (1) point for a valid hit to the trunk and three (3) points for a valid turning technique to the trunk.

7.5 Protector and Scoring System (PSS) shall be used for WTF World Para-Taekwondo Championships as well as Instant Video Replay (IVR).

7.6 In the event of a tied score, a 4^{th} round of one (1) minutes, also known as the golden point round, will be conducted after a minute of rest following the 3rd round. Any points, be it *Gam-jeom* or *Kyong-go*, from the previous three rounds shall not be taken into consideration in the golden point round.

When a contestant scores the first point in the golden point round, he or she shall be declared the winner. When a contestant receives a *Gam-jeom* in the golden point round, the opponent shall be declared as the winner.

In the event of a tied score after the end of the golden point round, the winner shall be decided based on a decision of superiority by all refereeing officials for the initiatives shown in the golden point round. The judges and referee shall take level of disability into consideration when deciding superiority in accordance with Art. 22.8 of the Competition Rules.

Article 8	Procedure of Kyorugi Contest

8.1 Call for contestants: The name of the contestants shall be announced at the Athlete Calling Desk three (3) times beginning thirty (30) minutes prior to the scheduled start of the contest.

8.2 Inspection of body, uniform and apparatus: After being called, the contestants shall undergo inspection of body, uniform and apparatus at the designated inspection desk by the inspectors designated by the WTF, and the contestant shall not show any signs of aversion, and also shall not wear any materials which may cause harm to the other contestant.

8.3 Entering the Competition Area: After inspection, the contestant shall proceed to the Coach's area with one coach and one team doctor or a physiotherapist (if any).

8.4 Procedure before the Beginning and after the End of the Contest

8.4.1 The center referee shall call "Chung, Hong." Both athletes shall enter the contest area wearing their head gear.
8.4.2 The contestants shall face each other and make a standing bow at the referee's command of "Cha-ryeot (attention)" and "Kyeong-rye (bow)". A standing bow shall be made from the natural standing posture of "Cha-ryeot" by bending the waist at an angle of more than 30 degrees with the head inclined to an angle of more than 45 degree. After the bow, the contestants shall put on their headgear.
8.4.3 The referee shall start the contest by commanding "Joon-bi (ready)" and "Shi-jak (start)".
8.4.4 The contest in each round shall begin with the declaration of "Shi-jak (start)" by the referee and shall end with the declaration of "Keu-man (stop)" by the referee. Even if the referee has not declared "Keu-man", the contest shall be regarded as having ended when the match clock expires.
8.4.5 After the referee declares "Keu-man", both contestants shall face each other and make a standing bow to each other following the command of the referee.
8.4.6 The referee shall declare the winner by raising his/her own hand to the winner's side.
8.4.7 Retirement of the Contestants

Article 9	Method of Poomsae Competition

9.1 WTF World Para-Taekwondo Poomsae Competitions be conducted in accordance with the WTF Poomsae Competition Rules.

9.2 Method of competition for poomsae competitions at the World Para-Taekwondo Championships shall be Cut off System as outlined in the Poomsae Competition rules.

9.3 During the Head of Team Meeting the Technical Director will draw compulsory poomsae, two for each class and division for preliminary round, semi-finals and finals.

9.4 Duration of contest

Recognized Poomsae: Individual from 30 seconds to 120 seconds

Article 10	Procedure of Poomsae Competition

10.1 Call for contestants: Thirty minutes prior to the scheduled start of the contest, the names of the contestants shall be announced three times to contestants' training area. Any contestant who fails to appear in the competition area after "Chool-jeon" command of the competition coordinator shall be regarded as having withdrawn from and forfeited the match.

10.2 Physical inspection and uniform inspection: After being called, the contestants shall undergo a physical inspection and a uniform inspection at the specified inspection desk by an inspector designated by the WTF. The contestant shall not show any signs of aversion, and shall not bear any object which may cause harm to the other contestant.

10.3 Entering the Contest Area: Following the inspection, the contestant shall enter the contestant waiting area with one coach accompanied

10.4 Pre-contest and post-contest procedures

10.4.1 The contest shall begin after the declaration of "Chool-jeon", "Cha ryeot", "Kyeong rye", "Joon-bi" and "Shi-jak" by the competition coordinator.

10.4.2 After the end of the each Poomsae, the contestants shall stand in their respective positions and make a standing bow at the coordinator's command of "Ba-ro", "Cha-ryeot", "Kyeong-rye." Contestants shall wait until the coordinator's declaration of "Pyo-chul"

10.5 The referee shall declare the winner according to the results of the judges.

10.6 Contestant's exit

Article 11	Results

11.1 Medals and certificates will be awarded to the top four athletes (Gold, Silver and two Bronzes), in the respective classes, weight divisions and age divisions in Kyorugi and Poomsae.

11.2 All participants, including team officials, will receive certificate of participation from the Organizing Committee.

11.3 Team Awards – The top five (5) teams of the Male division and the top five (5) teams of the Female division will receive trophies based on the combined total points of the point system;

11.4 Points will be calculated as follows;

11.4.1 Kyorugi

CRITERIA	NO. OF POINTS AWARDED
For every contestant who passed classification and the official weigh-in:	1
For every win (including byes):	1
For every Gold Medal:	7
For every Silver Medal:	3
For every Bronze Medal:	1

11.4.2 Poomsae

CRITERIA	NO. OF POINTS AWARDED
For every Gold Medal:	7
For every Silver Medal:	3
For every Bronze Medal:	1

Article 12	Officials

12.1 Technical Officials to be appointed by the WTF, are divided into Technical Delegate (TD), Competition Supervisory Board (CSB), Review Jury (RJ) and International Referees (IR) in accordance with article 20 of the WTF Competition Rules and Poomsae Judges and Referees as outlined in article 20 of the WTF Poomsae Competition Rules.

12.2 The roles and responsibilities of the Technical Officials are to be as stated in article 20 of the WTF Competition Rules and article 20 of the WTF Poomsae Competition Rules.

12.3 The Head of Classification shall be in charge of all classification matters for the Championships as outlined in article 2.3 of the Para-Taekwondo and Deaf-Taekwondo Classification Code

Article 13	Medical Procedures

13.1 The WTF World Para-Taekwondo Championships shall follow the WTF Medical Code

13.2 The following medical procedures, as specified by the IOC and IPC Medical Codes, shall be followed in addition to the WTF Medical Code;

13.2.1 Medical doctors (MDs) employed at competitions must hold an expertise in sports medicine and care/management of sports related injury and trauma. All final medical decisions concerning athlete health status and ability to compete are at the sole discretion of the event Chief Medical Doctor.

13.2.2 Additional medical personnel are to work as assistants to the competition Chief Medical Officer and should hold qualified medical credentials such as or equivalent to licensed physiotherapist (LPT/PT). Assistant medical personnel are also to hold expertise in sports medicine and care/management of sports related injury and trauma

13.2.3 Associate medical personnel not holding the above medical credentials (MD, PT) may be allowed to provide medical services at competitions, however preference must be held with employing professionals with credentials closely related to treating and caring for sports trauma injuries and the physically active populations, especially athletes.

13.2.4 One medical doctor (MD) and two (2) sports physiotherapists (PTs) are to be assigned for one medical team. One medical team is to be responsible for athlete care of three (3) competition courts. Therefore, a competition with six courts requires two medical teams (2 MDs, 4 PTs).

13.2.5 Event medical personnel shall be responsible for providing acute care of injuries sustained at competitions to registered athletes.

13.2.6 In the event of the necessity to transport injured athletes to a local emergency department, the competition arena shall have a direct access gate for ambulance vehicles into the main competition courts (field of play: FOP).

13.2.7 Advanced life support staff are to be supplied by local hospital to administer care for athletes suffering from severe head injury, cervical spine injury, or compromised airway.

13.2.8 All event medical personnel shall make efforts to comply with recommended international standard for care for the following injuries/illnesses (concussion/head injury, cervical spine injury, heat related illness):

13.2.9 All event medical personnel are to adhere to the most current recommendations concerning the care of the concussed athlete as recommended by the International Conference on Concussion in Sport (4th Consensus statement (McCrory et al., 2013) as of 2014). Appendix 1. Medical personnel shall also adhere to the Sport Concussion Assessment Tool 3 Appendix 2

13.2.10 All event medical personnel are to adhere to the most current recommendations concerning the care of the cervical spine injured athlete as recommended by the National Athletic Trainers' Association Position Statement: Acute Management of the Cervical Spine-injured Athlete (Swartz et al., 2010). Appendix 3

13.2.11 All event medical personnel are to adhere to the most current recommendations concerning the care of athletes suffering exertional heat illness recommended by the National Athletic Trainers' Association Position Statement: Exertional Heat Illness (Binkley et al., 2010). Appendix 4

Article 14	Research

14.1 In accordance with IPC Handbook and IPC Medical Code and in an effort to provide the fair and safe competition for all competitors, the WTF recommends ongoing scientific study of evidence based classification research. To comply with IPC Handbook guidelines concerning evidence based classification principles, during competitions the WTF aims to adhere to these recommendations, and others (IPC Position Stand on Evidnce Based Classification Research [Tweedy and Vandlandeqijck, 2011; Appendix 5) in part by conducting on-site (at competition events) research data collection of related topics concerning sport performance and fitness testing, biomechanical motion analyses, medical evaluation of impairments, injury evaluation, registry, and surveillance. As the aforementioned research areas are in direct compliance with IPC Handbook regulations and IPC Classification Guidelines, the WTF requests all responsible event staff to make all efforts to ensure these scientific activities are carried out to the highest level.

14.1.1 In an effort to identify injury patterns at Para-taekwondo competitions and to continually improve athlete classifications, all event medical personnel are to utilize the WTF injury reporting form (Appendix 6) and complete all individual medical reports prior to the close of championships. All injuries sustained at sanctioned competitions shall be reported to the event Chief Medical Officer who is responsible for ensuring all injury data are complete and forwarded to WTF injury epidemiology personnel.

14.1.2 The WTF recommends ongoing investigation into scientific research concerning classification development in poomsae competition. Research concerning poomsae classification research will be under the direct administration of the WTF Para-Taekwondo Committee and collaboration with host country organizations are encouraged to ensure ongoing development of poomsae competition.

14.1.3 In accordance with the IPC Classification Code, outcomes of the conducted research are to be presented in a public forum (e.g., scientific medical association meeting or peer reviewed medical journal) for WTF to contribute to the research community and be in line with the best practices of the IPC an in accordance with ethical principles of the Helsinki Accord.

14.2 Prior to any personal data are collected concerning medical history of athletes and/or athletic performance data (e.g., fitness testing results, biomechanical data) all athletes must be provided opportunity to read and sign an informed consent. Any efforts on behalf of the WTF to collect and/or analyze data with subsequent presentation and/or publication of these data are to ensure all research activities are in accordance with the Helsinki Accords concerning ethical considerations of research with human subjects.

Article 15	Anti-Doping

15.1 At the Taekwondo events promoted or sanctioned by the WTF, any use or administration of drugs or chemical substances described in the WTF Anti-Doping Rules is prohibited.

15.2 The WTF may carry out any doping tests deemed necessary to ascertain if a contestant has committed a breach of this rule, and any winner who refuses to undergo this testing or who proves to have committed such a breach shall be removed from the final standings, and the record shall be transferred to the contestant next in line in the competition standings.

15.3 The Organizing Committee shall be responsible for making all necessary preparations for conducting doping tests.

Article 16	Amendment

16.1 These Championship Standing Procedures shall be amended by the WTF Council.

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Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012

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PREAMBLE

This paper is a revision and update of the recommendations developed following the 1st (Vienna 2001), 2nd (Prague 2004) and 3rd (Zurich 2008) International Consensus Conferences on Concussion in Sport and is based on the deliberations at the 4th International Conference on Concussion in Sport held in Zurich, November 2012.[1–3]

The new 2012 Zurich Consensus statement is designed to build on the principles outlined in the previous documents and to develop further conceptual understanding of this problem using a formal consensus-based approach. A detailed description of the consensus process is outlined at the end of this document under the Background section. This document is developed primarily for use by physicians and healthcare professionals who are involved in the care of injured athletes, whether at the recreational, elite or professional level.

While agreement exists pertaining to principal messages conveyed within this document, the authors acknowledge that the science of concussion is evolving, and therefore management and return to play (RTP) decisions remain in the realm of clinical judgement on an individualised basis. Readers are encouraged to copy and distribute freely the Zurich Consensus document, the Concussion Recognition Tool (CRT), the Sports Concussion Assessment Tool V.3 (SCAT3) and/or the Child SCAT3 card and none are subject to any restrictions, provided they are not altered in any way or converted to a digital format. The authors request that the document and/or the accompanying tools be distributed in their full and complete format.

This consensus paper is broken into a number of sections

1. A summary of concussion and its management, with updates from the previous meetings;
2. Background information about the consensus meeting process;
3. A summary of the specific consensus questions discussed at this meeting;
4. The Consensus paper should be read in conjunction with the SCAT3 assessment tool, the Child SCAT3 and the CRT (designed for lay use).

SECTION 1: SPORT CONCUSSION AND ITS MANAGEMENT

The Zurich 2012 document examines the sport concussion and management issues raised in the previous Vienna 2001, Prague 2004 and Zurich 2008 documents and applies the consensus questions from section 3 to these areas.[1–3]

Definition of concussion

A panel discussion regarding the definition of concussion and its separation from mild traumatic brain injury (mTBI) was held. There was acknowledgement by the Concussion in Sport Group (CISG) that although the terms mTBI and concussion are often used interchangeably in the sporting context and particularly in the US literature, others use the term to refer to different injury constructs. Concussion is the historical term representing low-velocity injuries that cause brain 'shaking' resulting in clinical symptoms and that are not necessarily related to a pathological injury. Concussion is a subset of TBI and will be the term used in this document. It was also noted that the term *commotio cerebri* is often used in European and other countries. Minor revisions were made to the definition of concussion, which is defined as follows:

> Concussion is a brain injury and is defined as a complex pathophysiological process affecting the brain, induced by biomechanical forces. Several common features that incorporate clinical, pathologic and biomechanical injury constructs that may be utilised in defining the nature of a concussive head injury include:

1. Concussion may be caused either by a direct blow to the head, face, neck or elsewhere on the body with an ''impulsive' force transmitted to the head.
2. Concussion typically results in the rapid onset of short-lived impairment of neurological function that resolves spontaneously. However, in some cases, symptoms and signs may evolve over a number of minutes to hours.
3. Concussion may result in neuropathological changes, but the acute clinical symptoms

largely reflect a functional disturbance rather than a structural injury and, as such, no abnormality is seen on standard structural neuroimaging studies.

4. Concussion results in a graded set of clinical symptoms that may or may not involve loss of consciousness. Resolution of the clinical and cognitive symptoms typically follows a sequential course. However, it is important to note that in some cases symptoms may be prolonged.

Recovery of concussion

The majority (80–90%) of concussions resolve in a short (7–10 day) period, although the recovery time frame may be longer in children and adolescents.[2]

Symptoms and signs of acute concussion

The diagnosis of acute concussion usually involves the assessment of a range of domains including clinical symptoms, physical signs, cognitive impairment, neurobehavioural features and sleep disturbance. Furthermore, a detailed concussion history is an important part of the evaluation both in the injured athlete and when conducting a preparticipation examination. The detailed clinical assessment of concussion is outlined in the SCAT3 and Child SCAT3 forms, which are given in the appendix to this document.

The suspected diagnosis of concussion can include one or more of the following clinical domains:

1. Symptoms—somatic (eg, headache), cognitive (eg, feeling like in a fog) and/or emotional symptoms (eg, lability);
2. Physical signs (eg, loss of consciousness (LOC), amnesia);
3. Behavioural changes (eg, irritability);
4. Cognitive impairment (eg, slowed reaction times);
5. Sleep disturbance (eg, insomnia).

If any one or more of these components are present, a concussion should be suspected and the appropriate management strategy instituted.

On-field or sideline evaluation of acute concussion

When a player shows ANY features of a concussion:

A. The player should be evaluated by a physician or other licensed healthcare provider onsite using standard emergency management principles and particular attention should be given to excluding a cervical spine injury.

B. The appropriate disposition of the player must be determined by the treating healthcare provider in a timely manner. If no healthcare provider is available, the player should be safely removed from practice or play and urgent referral to a physician arranged.

C. Once the first aid issues are addressed, an assessment of the concussive injury should be made using the SCAT3 or other sideline assessment tools.

D. The player should not be left alone following the injury and serial monitoring for deterioration is essential over the initial few hours following injury.

E. A player with diagnosed concussion should not be allowed to RTP on the day of injury.

Sufficient time for assessment and adequate facilities should be provided for the appropriate medical assessment both on and off the field for all injured athletes. In some sports, this may require rule change to allow an appropriate off-field medical assessment to occur without affecting the flow of the game or unduly penalising the injured player's team. The final determination regarding concussion diagnosis and/or fitness to play is a medical decision based on clinical judgement.

Sideline evaluation of cognitive function is an essential component in the assessment of this injury. Brief neuropsychological test batteries that assess attention and memory function have been shown to be practical and effective. Such tests include the SCAT3, which incorporates the Maddocks' questions[4 5] and the Standardized Assessment of Concussion (SAC).[6–8] It is worth noting that standard orientation questions (eg, time, place and person) have been shown to be unreliable in the sporting situation when compared with memory assessment.[5 9] It is recognised, however, that abbreviated testing paradigms are designed for rapid concussion screening on the sidelines and are not meant to replace comprehensive neuropsychological testing which should ideally be performed by trained neuropsychologists who are sensitive to subtle deficits that may exist beyond the acute episode; nor should they be used as a stand-alone tool for the ongoing management of sports concussions.

It should also be recognised that the appearance of symptoms or cognitive deficit might be delayed several hours following a concussive episode and that concussion should be seen as an evolving injury in the acute stage.

Evaluation in the emergency room or office by medical personnel

An athlete with concussion may be evaluated in the emergency room or doctor's office as a point of first contact following injury or may have been referred from another care provider. In addition to the points outlined above, the key features of this examination should encompass:

A. A medical assessment including a comprehensive history and detailed neurological examination including a thorough assessment of mental status, cognitive functioning, gait and balance.

B. A determination of the clinical status of the patient, including whether there has been improvement or deterioration since the time of injury. This may involve seeking additional information from parents, coaches, teammates and eyewitnesses to the injury.

C. A determination of the need for emergent neuroimaging in order to exclude a more severe brain injury involving a structural abnormality.

In large part, these points above are included in the SCAT3 assessment.

Concussion investigations

A range of additional investigations may be utilised to assist in the diagnosis and/or exclusion of injury. Conventional structural neuroimaging is typically normal in concussive injury. Given that caveat, the following suggestions are made: Brain CT (or where available an MR brain scan) contributes little to concussion evaluation but should be employed whenever suspicion of an intracerebral or structural lesion (eg, skull fracture) exists. Examples of such situations may include prolonged disturbance of the conscious state, focal neurological deficit or worsening symptoms.

Other imaging modalities such as fMRI demonstrate activation patterns that correlate with symptom severity and recovery in concussion.[10–14] Although not part of routine assessment at the present time, they nevertheless provide additional insight to pathophysiological mechanisms. Alternative imaging technologies (eg, positron emission tomography, diffusion tensor imaging, magnetic resonance spectroscopy, functional connectivity), while demonstrating some compelling findings, are still at early stages of development and cannot be recommended other than in a research setting.

Published studies, using both sophisticated force plate technology, as well as those using less sophisticated clinical balance tests (eg, Balance Error Scoring System (BESS)), have identified acute postural stability deficits lasting approximately 72 h following sports-related concussion. It appears that postural stability testing provides a useful tool for objectively assessing the motor domain of neurological functioning, and should be considered as a reliable and valid addition to the assessment of athletes suffering from concussion, particularly where the symptoms or signs indicate a balance component.[15–21]

The significance of Apolipoprotein (Apo) E4, ApoE promoter gene, Tau polymerase and other genetic markers in the management of sports concussion risk or injury outcome is unclear at this time.[22 23] Evidence from human and animal studies in more severe traumatic brain injury demonstrates induction of a variety of genetic and cytokine factors such as: insulin-like growth factor 1 (IGF-1), IGF binding protein 2, Fibroblast growth factor, Cu-Zn superoxide dismutase, superoxide dismutase 1 (SOD-1), nerve growth factor, glial fibrillar acidic protein (GFAP) and S-100. How such factors are affected in sporting concussion is not known at this stage.[24–31] In addition, biochemical serum and cerebral spinal fluid biomarkers of brain injury (including S-100, neuron-specific enolase (NSE), myelin basic protein (MBP), GFAP, tau, etc) have been proposed as a means by which cellular damage may be detected if present.[32–38] There is currently insufficient evidence, however, to justify the routine use of these biomarkers clinically.

Different electrophysiological recording techniques (eg, evoked response potential (ERP), cortical magnetic stimulation and electroencephalography) have demonstrated reproducible abnormalities in the postconcussive state; however, not all studies reliably differentiated concussed athletes from controls.[39–45] The clinical significance of these changes remains to be established.

Neuropsychological assessment

The application of neuropsychological (NP) testing in concussion has been shown to be of clinical value and contributes significant information in concussion evaluation.[46–51] Although cognitive recovery largely overlaps with the time course of symptom recovery in most cases, it has been demonstrated that cognitive recovery may occasionally precede or more commonly follow clinical symptom resolution, suggesting that the assessment of cognitive function should be an important component in the overall assessment of concussion and, in particular, any RTP protocol.[52 53] It must be emphasised, however, that NP assessment should not be the sole basis of management decisions. Rather, it should be seen as an aid to the clinical decision-making process in conjunction with a range of assessments of different clinical domains and investigational results.

It is recommended that all athletes should have a clinical neurological assessment (including assessment of their cognitive function) as part of their overall management. This will normally be performed by the treating physician often in conjunction with computerised neuropsychological screening tools.

Formal NP testing is not required for all athletes; however, when this is considered necessary, it should ideally be performed by a trained neuropsychologist. Although neuropsychologists are in the best position to interpret NP tests by virtue of their background and training, the ultimate RTP decision should remain a medical one in which a multidisciplinary approach, when possible, has been taken. In the absence of NP and other (eg, formal balance assessment) testing, a more conservative RTP approach may be appropriate.

NP testing may be used to assist RTP decisions and is typically performed when an athlete is clinically asymptomatic; however, NP assessment may add important information in the early stages following injury.[54 55] There may be particular situations where testing is performed early to assist in determining aspects of management, for example, return to school in a paediatric athlete. This will normally be best determined in consultation with a trained neuropsychologist.[56 57]

Baseline NP testing was considered by the panel and was not felt to be required as a mandatory aspect of every assessment; however, it may be helpful to add useful information to the overall interpretation of these tests. It also provides an additional educative opportunity for the physician to discuss the significance of this injury with the athlete. At present, there is insufficient evidence to recommend the widespread routine use of baseline neuropsychological testing.

Concussion management

The cornerstone of concussion management is physical and cognitive rest until the acute symptoms resolve and then a graded programme of exertion prior to medical clearance and RTP. The current published evidence evaluating the effect of rest following a sports-related concussion is sparse. An initial period of rest in the acute symptomatic period following injury (24–48 h) may be of benefit. Further research to evaluate the long-term outcome of rest, and the optimal amount and type of rest, is needed. In the absence of evidence-based recommendations, a sensible approach involves the gradual return to school and social activities (prior to contact sports) in a manner that does not result in a significant exacerbation of symptoms.

Low-level exercise for those who are slow to recover may be of benefit, although the optimal timing following injury for initiation of this treatment is currently unknown.

As described above, the majority of injuries will recover spontaneously over several days. In these situations, it is expected that an athlete will proceed progressively through a stepwise RTP strategy.[58]

Graduated RTP protocol

RTP protocol following a concussion follows a stepwise process as outlined in table 1.

With this stepwise progression, the athlete should continue to proceed to the next level if asymptomatic at the current level. Generally, each step should take 24 h so that an athlete would take approximately 1 week to proceed through the full rehabilitation protocol once they are asymptomatic at rest and with provocative exercise. If any postconcussion symptoms occur while in the stepwise programme, then the patient should drop back to the previous asymptomatic level and try to progress again after a further 24 h period of rest has passed.

Same day RTP

It was unanimously agreed that no RTP on the day of concussive injury should occur. There are data demonstrating that at the collegiate and high school levels, athletes allowed to RTP on the same day may demonstrate NP deficits postinjury that may not be evident on the sidelines and are more likely to have delayed onset of symptoms.[59–65]

'Difficult' or persistently symptomatic concussion patient

Persistent symptoms (>10 days) are generally reported in 10–15% of concussions. In general, symptoms are not specific to concussion and it is important to consider other pathologies.

Table 1 Graduated return to play protocol

Rehabilitation stage	Functional exercise at each stage of rehabilitation	Objective of each stage
1. No activity	Symptom limited physical and cognitive rest	Recovery
2. Light aerobic exercise	Walking, swimming or stationary cycling keeping intensity <70% maximum permitted heart rate No resistance training	Increase HR
3. Sport-specific exercise	Skating drills in ice hockey, running drills in soccer. No head impact activities	Add movement
4. Non-contact training drills	Progression to more complex training drills, eg, passing drills in football and ice hockey May start progressive resistance training	Exercise, coordination and cognitive load
5. Full-contact practice	Following medical clearance participate in normal training activities	Restore confidence and assess functional skills by coaching staff
6. Return to play	Normal game play	

Cases of concussion in sport where clinical recovery falls outside the expected window (ie, 10 days) should be managed in a multidisciplinary manner by healthcare providers with experience in sports-related concussion.

Psychological management and mental health issues

Psychological approaches may have potential application in this injury, particularly with the modifiers listed below.[66 67] Physicians are also encouraged to evaluate the concussed athlete for affective symptoms such as depression and anxiety as these symptoms are common in all forms of traumatic brain injury.[58]

Role of pharmacological therapy

Pharmacological therapy in sports concussion may be applied in two distinct situations. The first of these situations is the management of specific and/or prolonged symptoms (eg, sleep disturbance, anxiety, etc). The second situation is where drug therapy is used to modify the underlying pathophysiology of the condition with the aim of shortening the duration of the concussion symptoms.[68] In broad terms, this approach to management should be only considered by clinicians experienced in concussion management.

An important consideration in RTP is that concussed athletes should not only be symptom-free, but also they should not be taking any pharmacological agents/medications that may mask or modify the symptoms of concussion. Where antidepressant therapy may be commenced during the management of a concussion, the decision to RTP while still on such medication must be considered carefully by the treating clinician.

Role of preparticipation concussion evaluation

Recognising the importance of a concussion history, and appreciating the fact that many athletes will not recognise all the concussions they may have suffered in the past, a detailed concussion history is of value.[69–72] Such a history may preidentify athletes who fit into a high-risk category and provides an opportunity for the healthcare provider to educate the athlete in regard to the significance of concussive injury. A structured concussion history should include specific questions as to previous symptoms of a concussion and length of recovery; not just the perceived number of past concussions. It is also worth noting that dependence on the recall of concussive injuries by teammates or coaches has been demonstrated to be unreliable.[69] The clinical history should also include information about all previous head, face or cervical spine injuries as these may also have clinical relevance. It is worth emphasising that in the setting of maxillofacial and cervical spine injuries, coexistent concussive injuries may be missed unless specifically assessed. Questions pertaining to disproportionate impact versus symptom severity matching may alert the clinician to a progressively increasing vulnerability to injury. As part of the clinical history, it is advised that details regarding protective equipment employed at the time of injury be sought, both for recent and remote injuries.

There is an additional and often unrecognised benefit of the preparticipation physical examination insofar as the evaluation allows for an educative opportunity with the player concerned as well as consideration of modification of playing behaviour if required.

Modifying factors in concussion management

A range of 'modifying' factors may influence the investigation and management of concussion and, in some cases, may predict the potential for prolonged or persistent symptoms. However, in some cases, the evidence for their efficacy is limited. These modifiers would be important to consider in a detailed concussion history and are outlined in table 2.

Female gender

The role of female gender as a possible modifier in the management of concussion was discussed at length by the panel. There was no unanimous agreement that the current published research evidence is conclusive enough for this to be included as a modifying factor, although it was accepted that gender may be a risk factor for injury and/or influence injury severity.[73–75]

Significance of LOC

In the overall management of moderate-to-severe traumatic brain injury, duration of LOC is an acknowledged predictor of

Table 2 Concussion modifiers

Factors	Modifier
Symptoms	Number Duration (>10 days) Severity
Signs	Prolonged loss of consciousness (LOC) (>1 min), Amnesia
Sequelae	Concussive convulsions
Temporal	Frequency—repeated concussions over time Timing—injuries close together in time 'Recency'—recent concussion or traumatic brain injury (TBI)
Threshold	Repeated concussions occurring with progressively less impact force or slower recovery after each successive concussion
Age	Child and adolescent (<18 years old)
Comorbidities and premorbidities	Migraine, depression or other mental health disorders, attention deficit hyperactivity disorder (ADHD), learning disabilities (LD), sleep disorders
Medication	Psychoactive drugs, anticoagulants
Behaviour	Dangerous style of play
Sport	High-risk activity, contact and collision sport, high sporting level

McCrory P, *et al*. *Br J Sports Med* 2013;**47**:250–258. doi:10.1136/bjsports-2013-092313

outcome.[76] Although published findings in concussion describe LOC associated with specific, early cognitive deficits, it has not been noted as a measure of injury severity.[77 78] Consensus discussion determined that prolonged (>1 min duration) LOC would be considered as a factor that may modify management.

Significance of amnesia and other symptoms

There is renewed interest in the role of post-traumatic amnesia and its role as a surrogate measure of injury severity.[64 79 80] Published evidence suggests that the nature, burden and duration of the clinical postconcussive symptoms may be more important than the presence or duration of amnesia alone.[77 81 82] Further, it must be noted that retrograde amnesia varies with the time of measurement postinjury and hence is poorly reflective of injury severity.[83 84]

Motor and convulsive phenomena

A variety of immediate motor phenomena (eg, tonic posturing) or convulsive movements may accompany a concussion. Although dramatic, these clinical features are generally benign and require no specific management beyond the standard treatment of the underlying concussive injury.[85 86]

Depression

Mental health issues (such as depression) have been reported as a consequence of all levels of traumatic brain injury including sports-related concussion. Neuroimaging studies using fMRI suggest that a depressed mood following concussion may reflect an underlying pathophysiological abnormality consistent with a limbic-frontal model of depression.[34 87–97] Although such mental health issues may be multifactorial in nature, it is recommended that the treating physician consider these issues in the management of concussed patients.

SPECIAL POPULATIONS

Child and adolescent athlete

The evaluation and management recommendations contained herein can be applied to children and adolescents down to the age of 13 years. Below that age, children report concussion symptoms different from adults and would require age-appropriate symptom checklists as a component of assessment. An additional consideration in assessing the child or adolescent athlete with a concussion is that the clinical evaluation by the healthcare professional may need to include both patient and parent input, and possibly teacher and school input when appropriate.[98–104] A child SCAT3 has been developed to assess concussion (see appendix) for individuals aged 5–12 years.

The decision to use NP testing is broadly the same as the adult assessment paradigm, although there are some differences. The timing of testing may differ in order to assist planning in school and home management. If cognitive testing is performed, then it must be developmentally sensitive until late teen years due to the ongoing cognitive maturation that occurs during this period, which in turn limits the utility of comparison to either the person's own baseline performance or to population norms.[20] In this age group, it is more important to consider the use of trained paediatric neuropsychologists to interpret assessment data, particularly in children with learning disorders and/or ADHD who may need more sophisticated assessment strategies.[56 57 98]

It was agreed by the panel that no return to sport or activity should occur before the child/adolescent athlete has managed to return to school successfully. In addition, the concept of 'cognitive rest' was highlighted with special reference to a child's need to limit exertion with activities of daily living that may exacerbate symptoms. School attendance and activities may also need to be modified to avoid provocation of symptoms. Children should not be returned to sport until clinically completely symptom-free, which may require a longer time frame than for adults.

Because of the different physiological response and longer recovery after concussion and specific risks (eg, diffuse cerebral swelling) related to head impact during childhood and adolescence, a more conservative RTP approach is recommended. It is appropriate to extend the amount of time of asymptomatic rest and/or the length of the graded exertion in children and adolescents. It is not appropriate for a child or adolescent athlete with concussion to RTP on the same day as the injury, regardless of the level of athletic performance. Concussion modifiers apply even more to this population than adults and may mandate more cautious RTP advice.

Elite versus non-elite athletes

All athletes, regardless of the level of participation, should be managed using the same treatment and RTP paradigm. The available resources and expertise in concussion evaluation are of more importance in determining management than a separation between elite and non-elite athlete management. Although formal NP testing may be beyond the resources of many sports or individuals, it is recommended that, in all organised high-risk sports, consideration be given to having this cognitive evaluation, regardless of the age or level of performance.

Chronic traumatic encephalopathy

Clinicians need to be mindful of the potential for long-term problems in the management of all athletes. However, it was agreed that chronic traumatic encephalopathy (CTE) represents a distinct tauopathy with an unknown incidence in athletic populations. It was further agreed that a cause and effect relationship has not as yet been demonstrated between CTE and concussions or exposure to contact sports.[105–114] At present, the interpretation of causation in the modern CTE case studies should proceed cautiously. It was also recognised that it is important to address the fears of parents/athletes from media pressure related to the possibility of CTE.

INJURY PREVENTION

Protective equipment—mouthguards and helmets

There is no good clinical evidence that currently available protective equipment will prevent concussion, although mouthguards have a definite role in preventing dental and orofacial injury. Biomechanical studies have shown a reduction in impact forces to the brain with the use of head gear and helmets, but these findings have not been translated to show a reduction in concussion incidence. For skiing and snowboarding, there are a number of studies to suggest that helmets provide protection against head and facial injury and hence should be recommended for participants in alpine sports.[115–118] In specific sports such as cycling, motor and equestrian sports, protective helmets may prevent other forms of head injury (eg, skull fracture) that are related to falling on hard surfaces and may be an important injury prevention issue for those sports.[118–130]

Rule change

Consideration of rule changes to reduce the head injury incidence or severity may be appropriate where a clear-cut mechanism is implicated in a particular sport. An example of this is in football (soccer) where research studies demonstrated that upper limb to head contact in heading contests accounted for approximately 50% of concussions.[131] As noted earlier, rule changes may also be needed in some sports to allow an effective off-field medical assessment to occur without compromising the athlete's welfare, affecting the flow of the game or unduly penalising the player's team. It is important to note that rule enforcement may be a critical aspect of modifying injury risk in these settings, and referees play an important role in this regard.

Risk compensation

An important consideration in the use of protective equipment is the concept of risk compensation.[132] This is where the use of protective equipment results in behavioural change such as the adoption of more dangerous playing techniques, which can result in a paradoxical increase in injury rates. The degree to which this phenomenon occurs is discussed in more detail in the review published in this supplement of the journal. This may be a matter of particular concern in child and adolescent athletes where the head injury rates are often higher than in adult athletes.[133–135]

Aggression versus violence in sport

The competitive/aggressive nature of sport that makes it fun to play and watch should not be discouraged. However, sporting organisations should be encouraged to address violence that may increase concussion risk.[136 137] Fair play and respect should be supported as key elements of sport.

Knowledge transfer

As the ability to treat or reduce the effects of concussive injury after the event is minimal, education of athletes, colleagues and the general public is a mainstay of progress in this field. Athletes, referees, administrators, parents, coaches and healthcare providers must be educated regarding the detection of concussion, its clinical features, assessment techniques and principles of safe RTP. Methods to improve education including web-based resources, educational videos and international outreach programmes are important in delivering the message. In addition, concussion working groups, plus the support and endorsement of enlightened sport groups such as Fédération Internationale de Football Association (FIFA), International Olympic Commission (IOC), International Rugby Board (IRB) and International Ice Hockey Federation (IIHF), who initiated this endeavour, have enormous value and must be pursued vigorously. Fair play and respect for opponents are ethical values that should be encouraged in all sports and sporting associations. Similarly, coaches, parents and managers play an important part in ensuring that these values are implemented on the field of play.[58 138–150]

SECTION 2: STATEMENT ON BACKGROUND TO THE CONSENSUS PROCESS

In November 2001, the 1st International Conference on Concussion in Sport was held in Vienna, Austria. This meeting was organised by the IIHF in partnership with FIFA and the Medical Commission of the IOC. As part of the resulting mandate for the future, the need for leadership and future updates was identified. The 2nd International Conference on Concussion in Sport was organised by the same group with the additional involvement of the IRB and was held in Prague, the Czech Republic, in November 2004. The original aims of the symposia were to provide recommendations for the improvement of safety and health of athletes who suffer concussive injuries in ice hockey, rugby, football (soccer) as well as other sports. To this end, a range of experts were invited to both meetings to address specific issues of epidemiology, basic and clinical science, injury grading systems, cognitive assessment, new research methods, protective equipment, management, prevention and long-term outcome.[1 2]

The 3rd International Conference on Concussion in Sport was held in Zurich, Switzerland on 29/30 October 2008 and was designed as a formal consensus meeting following the organisational guidelines set forth by the US National Institutes of Health. (Details of the consensus methodology can be obtained at: http://consensus.nih.gov/ABOUTCDP.htm.) The basic principles governing the conduct of a consensus development conference are summarised below:

1. A broad-based non-government, non-advocacy panel was assembled to give balanced, objective and knowledgeable attention to the topic. Panel members excluded anyone with scientific or commercial conflicts of interest and included researchers in clinical medicine, sports medicine, neuroscience, neuroimaging, athletic training and sports science.
2. These experts presented data in a public session, followed by inquiry and discussion. The panel then met in an executive session to prepare the consensus statement.
3. A number of specific questions were prepared and posed in advance to define the scope and guide the direction of the conference. The principal task of the panel was to elucidate responses to these questions. These questions are outlined below.
4. A systematic literature review was prepared and circulated in advance for use by the panel in addressing the conference questions.
5. The consensus statement is intended to serve as the scientific record of the conference.
6. The consensus statement will be widely disseminated to achieve maximum impact on both current healthcare practice and future medical research.

The panel chairperson (WM) did not identify with any advocacy position. The chairperson was responsible for directing the consensus session and guiding the panel's deliberations. Panellists were drawn from clinical practice, academics and research in the field of sports-related concussion. They do not represent organisations per se, but were selected for their expertise, experience and understanding of this field.

The 4th International Conference on Concussion in Sport was held in Zurich, Switzerland on 1–3 November 2012 and followed the same outline as for the third meeting. All speakers, consensus panel members and abstract authors were required to sign an ICMJE Form for Disclosure of Potential Conflicts of Interest. Detailed information related to each author's affiliations and conflicts of interests will be made publicly available on the CISG website and published with the BJSM supplement.

Medical legal considerations

This consensus document reflects the current state of knowledge and will need to be modified according to the development of new knowledge. It provides an overview of issues that may be of importance to healthcare providers involved in the management of sports-related concussion. It is not intended as a standard of care, 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.

It is intended that this document will be formally reviewed and updated prior to 1 December 2016.

SECTION 3: ZURICH 2012 CONSENSUS QUESTIONS

Note that each question is the subject of a separate systematic review that is published in the *BJSM* (2013:47:5). As such, all citations and details of each topic will be covered in those reviews.

When you assess an athlete acutely and they do not have a concussion, what is it? Is a cognitive injury the key component of concussion in making a diagnosis?

The consensus panel agreed that concussion is an evolving injury in the acute phase with rapidly changing clinical signs and symptoms, which may reflect the underlying physiological injury in the brain. Concussion is considered to be among the most complex injuries in sports medicine to diagnose, assess and manage. A majority of concussions in sport occur without LOC or frank neurological signs. At present, there is no perfect diagnostic test or marker that clinicians can rely on for an immediate diagnosis of concussion in the sporting environment. Because of this evolving process, it is not possible to rule out concussion when an injury event occurs associated with a transient neurological symptom. All such cases should be removed from the playing field and assessed for concussion by the treating physician or healthcare provider as discussed below. It was recognised that a cognitive deficit is not necessary for acute diagnosis as it either may not be present or detected on examination.

Are the existing tools/examination sensitive and reliable enough on the day of injury to make or exclude a diagnosis of concussion?

Concussion is a clinical diagnosis based largely on the observed injury mechanism, signs and symptoms. The vast majority of sports-related concussions (hereafter, referred to as *concussion*) occur without LOC or frank neurological signs.[151–154] In milder forms of concussion, the athlete might be slightly confused, without clearly identifiable amnesia. In addition, most concussions cannot be identified or diagnosed by neuroimaging techniques (eg, CT or MRI). Several well-validated neuropsychological tests are appropriate for use in the assessment of acute concussion in the competitive sporting environment. These tests provide important data on symptoms and functional impairments that clinicians can incorporate into their diagnostic formulation, but should not solely be used to diagnose concussion.

What is the best practice for evaluating an adult athlete with concussion on the 'field of play' in 2012?

Recognising and evaluating concussion in the adult athlete on the field is a challenging responsibility for the healthcare provider. Performing this task is often a rapid assessment in the midst of competition with a time constraint and the athlete eager to play. A standardised objective assessment of injury, which includes excluding more serious injury, is critical in determining disposition decisions for the athlete. The on-field evaluation of sports-related concussion is often a challenge given the elusiveness and variability of presentation, difficulty in making a timely diagnosis, specificity and sensitivity of sideline assessment tools, and the reliance on symptoms. Despite these challenges, the sideline evaluation is based on recognition of injury, assessment of symptoms, cognitive and cranial nerve function, and balance. Serial assessments are often necessary. Concussion is often an evolving injury, and signs and symptoms may be delayed. Therefore, erring on the side of caution (keeping an athlete out of participation when there is any suspicion for injury) is important. An SAC is useful in the assessment of the athlete with suspected concussion but should not take the place of the clinician's judgement.

How can the SCAT2 be improved?

It was agreed that a variety of measures should be employed as part of the assessment of concussion to provide a more complete clinical profile for the concussed athlete. Important clinical information can be ascertained in a streamlined manner through the use of a multimodal instrument such as the Sport Concussion Assessment Tool (SCAT). A baseline assessment is advised wherever possible. However, it is acknowledged that further validity studies need to be performed to answer this specific issue.

A future SCAT test battery (ie, SCAT3) should include an initial assessment of injury severity using the Glasgow Coma Scale (GCS), immediately followed by observing and documenting concussion signs. Once this is complete, symptom endorsement and symptom severity, as well as neurocognitive and balance functions, should be assessed in any athlete suspected of sustaining a concussion. It is recommended that these latter steps be conducted following a minimum 15 min rest period on the sideline to avoid the influence of exertion or fatigue on the athlete's performance. Although it is noted that this time frame is an arbitrary one, the expert panel agreed nevertheless that a period of rest was important prior to assessment. Future research should consider the efficacy for inclusion of vision tests such as the King Devick Test and clinical reaction time tests.[155 156] Recent studies suggest that these may be useful additions to the sideline assessment of concussion. However, the need for additional equipment may make them impractical for sideline use.

It was further agreed that the SCAT3 would be suitable for adults and youths aged 13 and over and that a new tool (Child SCAT3) be developed for younger children.

Advances in neuropsychology: are computerised tests sufficient for concussion diagnosis?

Sports-related concussions are frequently associated with one or more symptoms, impaired balance and/or cognitive deficits. These problems can be measured using symptom scales, balance testing and neurocognitive testing. All three modalities can identify significant changes in the first few days following injury, generally with normalisation over 1–3 weeks. The presentation of symptoms and the rate of recovery can be variable, which reinforces the value of assessing all three areas as part of a comprehensive sport concussion programme.

Neuropsychological assessment has been described by the CISG as a 'cornerstone' of concussion management. Neuropsychologists are uniquely qualified to interpret neuropsychological tests and can play an important role within the context of a multifaceted-multimodal and multidisciplinary approach to managing sports-related concussion. Concussion management programmes that use neuropsychological assessment to assist in clinical decision-making have been instituted in professional sports, colleges and high schools. Brief computerised cognitive evaluation tools are the mainstay of these assessments worldwide, given the logistical limitation in accessing trained neuropsychologists; however, it should be noted that these are not substitutes for formal neuropsychological assessment. At present, there is insufficient evidence to recommend the widespread routine use of baseline neuropsychological testing.

What evidence exists for new strategies/technologies in the diagnosis of concussion and assessment of recovery?

A number of novel technological platforms exist to assess concussion including (but not limited to) iPhone/smart phone apps, quantitative electroencephalography, robotics—sensory motor assessment, telemedicine, eye-tracking technology, functional imaging/advanced neuroimaging and head impact sensors. At this stage, only limited evidence exists for their role in this setting and none have been validated as diagnostic. It will be important to reconsider the role of these technologies once evidence is developed.

Advances in the management of sport concussion: what is evidence for concussion therapies

The current evidence evaluating the effect of rest and treatment following a sports-related concussion is sparse. An initial period of rest may be of benefit. However, further research to evaluate the long-term outcome of rest, and the optimal amount and type of rest, is needed. Low-level exercise for those who are slow to recover may be of benefit, although the optimal timing following injury for initiation of this treatment is currently unknown. Multimodal physiotherapy treatment for individuals with clinical evidence of cervical spine and/or vestibular dysfunction may be of benefit. There is a strong need for high-level studies evaluating the effects of a resting period, pharmacological interventions, rehabilitative techniques and exercise for individuals who have sustained a sports-related concussion.

The difficult concussion patient—What is the best approach to investigation and management of persistent (>10 days) postconcussive symptoms?

Persistent symptoms (>10 days) are generally reported in 10–15% of concussions. This may be higher in certain sports (eg, elite ice hockey) and populations (eg, children). In general, symptoms are not specific to concussion and it is important to consider and manage co-existent pathologies. Investigations may include formal neuropsychological testing and conventional neuroimaging to exclude structural pathology. Currently, there is insufficient evidence to recommend routine clinical use of advanced neuroimaging techniques or other investigative strategies. Cases of concussion in sport where clinical recovery falls outside the expected window (ie, 10 days) should be managed in a multidisciplinary manner by healthcare providers with experience in sports-related concussion. Important components of management after the initial period of physical and cognitive rest include associated therapies such as cognitive, vestibular, physical and psychological therapy, consideration of assessment of other causes of prolonged symptoms and consideration of commencement of a graded exercise programme at a level that does not exacerbate symptoms.

Revisiting concussion modifiers: how should the evaluation and management of acute concussion differ in specific groups?

The literature demonstrates that the number and severity of symptoms and previous concussions are associated with prolonged recovery and/or increased risk of complications. Brief LOC, duration of post-traumatic amnesia and/or impact seizures do not reliably predict outcome following concussion, although a cautious approach should be taken in an athlete with prolonged LOC (ie, >1 min). Children generally take longer to recover from concussions and assessment batteries have yet to be validated in the younger age group. Currently, there are insufficient data on the influence of genetics and gender on outcome following concussion. Several modifiers are associated with prolonged recovery or increased risk of complications following concussion and have important implications for management. Children with concussion should be managed conservatively, with the emphasis on return to learn before return to sport. In cases of concussion managed with limited resources (eg, non-elite players), a conservative approach should also be taken such that the athlete does not return to sport until fully recovered.

What are the most effective risk reduction strategies in sport concussion?—from protective equipment to policy?

No new valid evidence was provided to suggest that the use of current standard headgear in rugby, or of mouthguards in American football, can significantly reduce players' risk of concussion. No evidence was provided to suggest an association between neck strength increases and concussion risk reduction. There was evidence to suggest that eliminating body checking from Pee Wee ice hockey (ages 11–12 years) and fair-play rules in ice hockey were effective injury prevention strategies. Helmets need to be able to protect from impacts resulting in a head change in velocity of up to 10 m/s in professional American football, and up to 7 m/s in professional Australian football. It also appears that helmets must be capable of reducing head-resultant linear acceleration to below 50 g and angular acceleration components to below 1500 rad/s^2 to optimise their effectiveness. Given that a multifactorial approach is needed for concussion prevention, well-designed and sport-specific prospective analytical studies of sufficient power are warranted for mouthguards, headgear/helmets, facial protection and neck strength. Measuring the effect of rule changes should also be addressed by future studies, not only assessing new rule changes or legislation, but also alteration or reinforcement to existing rules.

What is the evidence for chronic concussion-related changes?—behavioural, pathological and clinical outcomes

It was agreed that CTE represents a distinct tauopathy with an unknown incidence in athletic populations. It was further agreed that CTE was not related to concussions alone or simply exposure to contact sports. At present, there are no published epidemiological, cohort or prospective studies relating to modern CTE. Owing to the nature of the case reports and pathological case series that have been published, it is not possible to determine the causality or risk factors with any certainty. As such, the speculation that repeated concussion or subconcussive impacts cause CTE remains unproven. The extent to which age-related changes, psychiatric or mental health illness, alcohol/drug use or co-existing medical or dementing illnesses contribute to this process is largely unaccounted for in the published literature. At present, the interpretation of causation in the modern CTE case studies should proceed cautiously. It was also recognised that it is important to address the fears of parents/athletes from media pressure related to the possibility of CTE.

From consensus to action—how do we optimise knowledge transfer, education and ability to influence policy?

The value of knowledge transfer (KT) as part of concussion education is increasingly becoming recognised. Target audiences benefit from specific learning strategies. Concussion tools exist, but their effectiveness and impact require further evaluation. The media is valuable in drawing attention to concussion, but efforts need to ensure that the public is aware of the right information. Social media as a concussion education tool is becoming more prominent. Implementation of KT models is one approach organisations can use to assess knowledge gaps; identify, develop and evaluate education strategies; and use the outcomes to facilitate decision-making. Implementing KT strategies requires a defined plan. Identifying the needs, learning styles and preferred learning strategies of target audiences, coupled with evaluation, should be a piece of the overall concussion education puzzle to have an impact on enhancing knowledge and awareness.

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Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012

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SCAT3™

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Sport Concussion Assessment Tool – 3rd Edition

For use by medical professionals only

Name

Date/Time of Injury:
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Examiner:

What is the SCAT3?[1]

The SCAT3 is a standardized tool for evaluating injured athletes for concussion and can be used in athletes aged from 13 years and older. It supersedes the original SCAT and the SCAT2 published in 2005 and 2009, respectively[2]. For younger persons, ages 12 and under, please use the Child SCAT3. The SCAT3 is designed for use by medical professionals. If you are not qualified, please use the Sport Concussion Recognition Tool[1]. Preseason baseline testing with the SCAT3 can be helpful for interpreting post-injury test scores.

Specific instructions for use of the SCAT3 are provided on page 3. If you are not familiar with the SCAT3, please read through these instructions carefully. This tool may be freely copied in its current form for distribution to individuals, teams, groups and organizations. Any revision or any reproduction in a digital form requires approval by the Concussion in Sport Group.

NOTE: The diagnosis of a concussion is a clinical judgment, ideally made by a medical professional. The SCAT3 should not be used solely to make, or exclude, the diagnosis of concussion in the absence of clinical judgement. An athlete may have a concussion even if their SCAT3 is "normal".

What is a concussion?

A concussion is a disturbance in brain function caused by a direct or indirect force to the head. It results in a variety of non-specific signs and/or symptoms (some examples listed below) and most often does not involve loss of consciousness. Concussion should be suspected in the presence of **any one or more** of the following:

- Symptoms (e.g., headache), or
- Physical signs (e.g., unsteadiness), or
- Impaired brain function (e.g. confusion) or
- Abnormal behaviour (e.g., change in personality).

SIDELINE ASSESSMENT

Indications for Emergency Management

NOTE: A hit to the head can sometimes be associated with a more serious brain injury. Any of the following warrants consideration of activating emergency procedures and urgent transportation to the nearest hospital:

- Glasgow Coma score less than 15
- Deteriorating mental status
- Potential spinal injury
- Progressive, worsening symptoms or new neurologic signs

Potential signs of concussion?

If any of the following signs are observed after a direct or indirect blow to the head, the athlete should stop participation, be evaluated by a medical professional and **should not be permitted to return to sport the same day** if a concussion is suspected.

Any loss of consciousness?	Y	N
"If so, how long?"		
Balance or motor incoordination (stumbles, slow/laboured movements, etc.)?	Y	N
Disorientation or confusion (inability to respond appropriately to questions)?	Y	N
Loss of memory:	Y	N
"If so, how long?"		
"Before or after the injury?"		
Blank or vacant look:	Y	N
Visible facial injury in combination with any of the above:	Y	N

1 Glasgow coma scale (GCS)

Best eye response (E)	
No eye opening	1
Eye opening in response to pain	2
Eye opening to speech	3
Eyes opening spontaneously	4
Best verbal response (V)	
No verbal response	1
Incomprehensible sounds	2
Inappropriate words	3
Confused	4
Oriented	5
Best motor response (M)	
No motor response	1
Extension to pain	2
Abnormal flexion to pain	3
Flexion/Withdrawal to pain	4
Localizes to pain	5
Obeys commands	6
Glasgow Coma score (E + V + M)	of 15

GCS should be recorded for all athletes in case of subsequent deterioration.

2 Maddocks Score[3]

"I am going to ask you a few questions, please listen carefully and give your best effort."

Modified Maddocks questions (1 point for each correct answer)

What venue are we at today?	0	1
Which half is it now?	0	1
Who scored last in this match?	0	1
What team did you play last week/game?	0	1
Did your team win the last game?	0	1
Maddocks score		of 5

Maddocks score is validated for sideline diagnosis of concussion only and is not used for serial testing.

Notes: Mechanism of Injury ("tell me what happened"?):

Any athlete with a suspected concussion should be REMOVED FROM PLAY, medically assessed, monitored for deterioration (i.e., should not be left alone) and should not drive a motor vehicle until cleared to do so by a medical professional. No athlete diagnosed with concussion should be returned to sports participation on the day of Injury.

BACKGROUND

Name: ______ Date: ______

Examiner: ______

Sport/team/school: ______ Date/time of injury: ______

Age: ______ Gender: ☐ M ☐ F

Years of education completed: ______

Dominant hand: ☐ right ☐ left ☐ neither

How many concussions do you think you have had in the past? ______

When was the most recent concussion? ______

How long was your recovery from the most recent concussion? ______

Have you ever been hospitalized or had medical imaging done for a head injury? ☐ Y ☐ N

Have you ever been diagnosed with headaches or migraines? ☐ Y ☐ N

Do you have a learning disability, dyslexia, ADD/ADHD? ☐ Y ☐ N

Have you ever been diagnosed with depression, anxiety or other psychiatric disorder? ☐ Y ☐ N

Has anyone in your family ever been diagnosed with any of these problems? ☐ Y ☐ N

Are you on any medications? If yes, please list: ☐ Y ☐ N

SCAT3 to be done in resting state. Best done 10 or more minutes post excercise.

SYMPTOM EVALUATION

3 How do you feel?

"You should score yourself on the following symptoms, based on how you feel now".

	none	mild		moderate		severe	
Headache	0	1	2	3	4	5	6
"Pressure in head"	0	1	2	3	4	5	6
Neck Pain	0	1	2	3	4	5	6
Nausea or vomiting	0	1	2	3	4	5	6
Dizziness	0	1	2	3	4	5	6
Blurred vision	0	1	2	3	4	5	6
Balance problems	0	1	2	3	4	5	6
Sensitivity to light	0	1	2	3	4	5	6
Sensitivity to noise	0	1	2	3	4	5	6
Feeling slowed down	0	1	2	3	4	5	6
Feeling like "in a fog"	0	1	2	3	4	5	6
"Don't feel right"	0	1	2	3	4	5	6
Difficulty concentrating	0	1	2	3	4	5	6
Difficulty remembering	0	1	2	3	4	5	6
Fatigue or low energy	0	1	2	3	4	5	6
Confusion	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
Trouble falling asleep	0	1	2	3	4	5	6
More emotional	0	1	2	3	4	5	6
Irritability	0	1	2	3	4	5	6
Sadness	0	1	2	3	4	5	6
Nervous or Anxious	0	1	2	3	4	5	6

Total number of symptoms (Maximum possible 22) ______

Symptom severity score (Maximum possible 132) ______

Do the symptoms get worse with physical activity? ☐ Y ☐ N

Do the symptoms get worse with mental activity? ☐ Y ☐ N

☐ self rated ☐ self rated and clinician monitored

☐ clinician interview ☐ self rated with parent input

Overall rating: If you know the athlete well prior to the injury, how different is the athlete acting compared to his/her usual self?

Please circle one response:

no different	very different	unsure	N/A

Scoring on the SCAT3 should not be used as a stand-alone method to diagnose concussion, measure recovery or make decisions about an athlete's readiness to return to competition after concussion. Since signs and symptoms may evolve over time, it is important to consider repeat evaluation in the acute assessment of concussion.

COGNITIVE & PHYSICAL EVALUATION

4 Cognitive assessment

Standardized Assessment of Concussion (SAC)[4]

Orientation (1 point for each correct answer)

What month is it?	0	1
What is the date today?	0	1
What is the day of the week?	0	1
What year is it?	0	1
What time is it right now? (within 1 hour)	0	1
Orientation score		of 5

Immediate memory

List	Trial 1		Trial 2		Trial 3		Alternative word list		
elbow	0	1	0	1	0	1	candle	baby	finger
apple	0	1	0	1	0	1	paper	monkey	penny
carpet	0	1	0	1	0	1	sugar	perfume	blanket
saddle	0	1	0	1	0	1	sandwich	sunset	lemon
bubble	0	1	0	1	0	1	wagon	iron	insect
Total									

Immediate memory score total ______ of 15

Concentration: Digits Backward

List	Trial 1		Alternative digit list		
4-9-3	0	1	6-2-9	5-2-6	4-1-5
3-8-1-4	0	1	3-2-7-9	1-7-9-5	4-9-6-8
6-2-9-7-1	0	1	1-5-2-8-6	3-8-5-2-7	6-1-8-4-3
7-1-8-4-6-2	0	1	5-3-9-1-4-8	8-3-1-9-6-4	7-2-4-8-5-6
Total of 4					

Concentration: Month in Reverse Order (1 pt. for entire sequence correct)

Dec-Nov-Oct-Sept-Aug-Jul-Jun-May-Apr-Mar-Feb-Jan	0	1

Concentration score ______ of 5

5 Neck Examination:

Range of motion Tenderness Upper and lower limb sensation & strength

Findings: ______

6 Balance examination

Do one or both of the following tests.

Footwear (shoes, barefoot, braces, tape, etc.) ______

Modified Balance Error Scoring System (BESS) testing[5]

Which foot was tested (i.e. which is the **non-dominant** foot) ☐ Left ☐ Right

Testing surface (hard floor, field, etc.) ______

Condition

Double leg stance: ______ Errors

Single leg stance (non-dominant foot): ______ Errors

Tandem stance (non-dominant foot at back): ______ Errors

And/Or

Tandem gait[6,7]

Time (best of 4 trials): ______ seconds

7 Coordination examination

Upper limb coordination

Which arm was tested: ☐ Left ☐ Right

Coordination score ______ of 1

8 SAC Delayed Recall[4]

Delayed recall score ______ of 5

INSTRUCTIONS

Words in *Italics* throughout the SCAT3 are the instructions given to the athlete by the tester.

Symptom Scale

"You should score yourself on the following symptoms, based on how you feel now".

To be completed by the athlete. In situations where the symptom scale is being completed after exercise, it should still be done in a resting state, at least 10 minutes post exercise.

For total number of symptoms, maximum possible is 22.

For Symptom severity score, add all scores in table, maximum possible is 22 x 6 = 132.

SAC[4]

Immediate Memory

"I am going to test your memory. I will read you a list of words and when I am done, repeat back as many words as you can remember, in any order."

Trials 2 & 3:

"I am going to repeat the same list again. Repeat back as many words as you can remember in any order, even if you said the word before."

Complete all 3 trials regardless of score on trial 1 & 2. Read the words at a rate of one per second. **Score 1 pt. for each correct response.** Total score equals sum across all 3 trials. Do not inform the athlete that delayed recall will be tested.

Concentration

Digits backward

"I am going to read you a string of numbers and when I am done, you repeat them back to me backwards, in reverse order of how I read them to you. For example, if I say 7-1-9, you would say 9-1-7."

If correct, go to next string length. If incorrect, read trial 2. **One point possible for each string length**. Stop after incorrect on both trials. The digits should be read at the rate of one per second.

Months in reverse order

"Now tell me the months of the year in reverse order. Start with the last month and go backward. So you'll say December, November … Go ahead"

1 pt. for entire sequence correct

Delayed Recall

The delayed recall should be performed after completion of the Balance and Coordination Examination.

"Do you remember that list of words I read a few times earlier? Tell me as many words from the list as you can remember in any order."

Score 1 pt. for each correct response

Balance Examination

Modified Balance Error Scoring System (BESS) testing[5]

This balance testing is based on a modified version of the Balance Error Scoring System (BESS)[5]. A stopwatch or watch with a second hand is required for this testing.

"I am now going to test your balance. Please take your shoes off, roll up your pant legs above ankle (if applicable), and remove any ankle taping (if applicable). This test will consist of three twenty second tests with different stances."

(a) Double leg stance:

"The first stance is standing with your feet together with your hands on your hips and with your eyes closed. You should try to maintain stability in that position for 20 seconds. I will be counting the number of times you move out of this position. I will start timing when you are set and have closed your eyes."

(b) Single leg stance:

"If you were to kick a ball, which foot would you use? [This will be the dominant foot] Now stand on your non-dominant foot. The dominant leg should be held in approximately 30 degrees of hip flexion and 45 degrees of knee flexion. Again, you should try to maintain stability for 20 seconds with your hands on your hips and your eyes closed. I will be counting the number of times you move out of this position. If you stumble out of this position, open your eyes and return to the start position and continue balancing. I will start timing when you are set and have closed your eyes."

(c) Tandem stance:

"Now stand heel-to-toe with your non-dominant foot in back. Your weight should be evenly distributed across both feet. Again, you should try to maintain stability for 20 seconds with your hands on your hips and your eyes closed. I will be counting the number of times you move out of this position. If you stumble out of this position, open your eyes and return to the start position and continue balancing. I will start timing when you are set and have closed your eyes."

Balance testing – types of errors

1. Hands lifted off iliac crest
2. Opening eyes
3. Step, stumble, or fall
4. Moving hip into > 30 degrees abduction
5. Lifting forefoot or heel
6. Remaining out of test position > 5 sec

Each of the 20-second trials is scored by counting the errors, or deviations from the proper stance, accumulated by the athlete. The examiner will begin counting errors only after the individual has assumed the proper start position. **The modified BESS is calculated by adding one error point for each error during the three 20-second tests. The maximum total number of errors for any single condition is 10.** If a athlete commits multiple errors simultaneously, only one error is recorded but the athlete should quickly return to the testing position, and counting should resume once subject is set. Subjects that are unable to maintain the testing procedure for a minimum of **five seconds** at the start are assigned the highest possible score, ten, for that testing condition.

OPTION: For further assessment, the same 3 stances can be performed on a surface of medium density foam (e.g., approximately 50 cm x 40 cm x 6 cm).

Tandem Gait[6,7]

Participants are instructed to stand with their feet together behind a starting line (the test is best done with footwear removed). Then, they walk in a forward direction as quickly and as accurately as possible along a 38mm wide (sports tape), 3 meter line with an alternate foot heel-to-toe gait ensuring that they approximate their heel and toe on each step. Once they cross the end of the 3m line, they turn 180 degrees and return to the starting point using the same gait. A total of 4 trials are done and the best time is retained. Athletes should complete the test in 14 seconds. Athletes fail the test if they step off the line, have a separation between their heel and toe, or if they touch or grab the examiner or an object. In this case, the time is not recorded and the trial repeated, if appropriate.

Coordination Examination

Upper limb coordination

Finger-to-nose (FTN) task:

"I am going to test your coordination now. Please sit comfortably on the chair with your eyes open and your arm (either right or left) outstretched (shoulder flexed to 90 degrees and elbow and fingers extended), pointing in front of you. When I give a start signal, I would like you to perform five successive finger to nose repetitions using your index finger to touch the tip of the nose, and then return to the starting position, as quickly and as accurately as possible."

Scoring: 5 correct repetitions in < 4 seconds = 1

Note for testers: Athletes fail the test if they do not touch their nose, do not fully extend their elbow or do not perform five repetitions. **Failure should be scored as 0.**

References & Footnotes

1. This tool has been developed by a group of international experts at the 4th International Consensus meeting on Concussion in Sport held in Zurich, Switzerland in November 2012. The full details of the conference outcomes and the authors of the tool are published in The BJSM Injury Prevention and Health Protection, 2013, Volume 47, Issue 5. The outcome paper will also be simultaneously co-published in other leading biomedical journals with the copyright held by the Concussion in Sport Group, to allow unrestricted distribution, providing no alterations are made.

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ATHLETE INFORMATION

Any athlete suspected of having a concussion should be removed from play, and then seek medical evaluation.

Signs to watch for

Problems could arise over the first 24–48 hours. The athlete should not be left alone and must go to a hospital at once if they:

- Have a headache that gets worse
- Are very drowsy or can't be awakened
- Can't recognize people or places
- Have repeated vomiting
- Behave unusually or seem confused; are very irritable
- Have seizures (arms and legs jerk uncontrollably)
- Have weak or numb arms or legs
- Are unsteady on their feet; have slurred speech

Remember, it is better to be safe.
Consult your doctor after a suspected concussion.

Return to play

Athletes should not be returned to play the same day of injury.
When returning athletes to play, they should be **medically cleared and then follow a stepwise supervised program,** with stages of progression.

For example:

Rehabilitation stage	Functional exercise at each stage of rehabilitation	Objective of each stage
No activity	Physical and cognitive rest	Recovery
Light aerobic exercise	Walking, swimming or stationary cycling keeping intensity, 70 % maximum predicted heart rate. No resistance training	Increase heart rate
Sport-specific exercise	Skating drills in ice hockey, running drills in soccer. No head impact activities	Add movement
Non-contact training drills	Progression to more complex training drills, eg passing drills in football and ice hockey. May start progressive resistance training	Exercise, coordination, and cognitive load
Full contact practice	Following medical clearance participate in normal training activities	Restore confidence and assess functional skills by coaching staff
Return to play	Normal game play	

There should be at least 24 hours (or longer) for each stage and if symptoms recur the athlete should rest until they resolve once again and then resume the program at the previous asymptomatic stage. Resistance training should only be added in the later stages.

If the athlete is symptomatic for more than 10 days, then consultation by a medical practitioner who is expert in the management of concussion, is recommended.

Medical clearance should be given before return to play.

Scoring Summary:

Test Domain	Score		
	Date:	Date:	Date:
Number of Symptoms of 22			
Symptom Severity Score of 132			
Orientation of 5			
Immediate Memory of 15			
Concentration of 5			
Delayed Recall of 5			
SAC Total			
BESS (total errors)			
Tandem Gait (seconds)			
Coordination of 1			

Notes:

CONCUSSION INJURY ADVICE

(To be given to the **person monitoring** the concussed athlete)

This patient has received an injury to the head. A careful medical examination has been carried out and no sign of any serious complications has been found. Recovery time is variable across individuals and the patient will need monitoring for a further period by a responsible adult. Your treating physician will provide guidance as to this timeframe.

If you notice any change in behaviour, vomiting, dizziness, worsening headache, double vision or excessive drowsiness, please contact your doctor or the nearest hospital emergency department immediately.

Other important points:

- Rest (physically and mentally), including training or playing sports until symptoms resolve and you are medically cleared
- No alcohol
- No prescription or non-prescription drugs without medical supervision. Specifically:
  - No sleeping tablets
  - Do not use aspirin, anti-inflammatory medication or sedating pain killers
- Do not drive until medically cleared
- Do not train or play sport until medically cleared

Clinic phone number

Patient's name

Date/time of injury

Date/time of medical review

Treating physician

Contact details or stamp

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www.nata.org/jat

National Athletic Trainers' Association Position Statement: Acute Management of the Cervical Spine–Injured Athlete

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Objective: To provide certified athletic trainers, team physicians, emergency responders, and other health care professionals with recommendations on how to best manage a catastrophic cervical spine injury in the athlete.

Background: The relative incidence of catastrophic cervical spine injury in sports is low compared with other injuries. However, cervical spine injuries necessitate delicate and precise management, often involving the combined efforts of a variety of health care providers. The outcome of a catastrophic cervical spine injury depends on the efficiency of this management process and the timeliness of transfer to a controlled environment for diagnosis and treatment.

Recommendations: Recommendations are based on current evidence pertaining to prevention strategies to reduce the incidence of cervical spine injuries in sport; emergency planning and preparation to increase management efficiency; maintaining or creating neutral alignment in the cervical spine; accessing and maintaining the airway; stabilizing and transferring the athlete with a suspected cervical spine injury; managing the athlete participating in an equipment-laden sport, such as football, hockey, or lacrosse; and considerations in the emergency department.

Key Words: catastrophic injuries, emergency medicine, neurologic outcomes

The incidence of spinal cord injury in the United States is estimated to include 11 000 new cases each year.[1] Serious spinal injuries have devastating sequelae, including neurologic impairment and premature mortality. Sport participation constitutes the fourth most common cause (approximately 7.4%)[1] of these injuries overall but is the second most common cause for those younger than 30 years of age.[2] Since 2000, the majority of all cervical spine injuries have occurred in individuals between the ages of 16 and 30 years.[1]

American football in the United States is associated with the greatest number of catastrophic spinal injuries for all US sports.[3] Although catastrophic cervical spine injuries have decreased compared with the incidence in the early 1970s, an average of 7.8 catastrophic cervical spine injuries with incomplete recovery[4] and 6 quadriplegic events[5] occurred annually in football alone (data from 1997–2006). Of particular concern is a recent trend of double-digit catastrophic spine injuries in 3 of the 4 years between 2003 and 2006; from 1991 to 2002, only data from 1999 showed catastrophic spine injuries measuring in the double digits.[6]

Epidemiologic data have established the risk of catastrophic cervical spine injury in other sports as well. For example, an average of 15 catastrophic spine injuries occur annually in ice hockey in Canada and the United States.[7] Sports such as skiing,[8–13] rugby,[14–17] gymnastics,[18,19] swimming and diving,[20,21] track and field (eg, pole vaulting),[22] cheerleading,[23] and baseball[24] all involve activities that place participants at risk for spine injuries. In fact, the incidence of nonfatal, direct catastrophic injuries in the sports of lacrosse, gymnastics, and men's ice hockey is higher than that in American football (Table 1).[3]

Regardless of the sport, proper management and accurate diagnosis of acute spinal injuries are paramount because of the recognized risk of neurologic deterioration during and after the initial management of the injury.[25,26] Consequently, sports medicine providers must be familiar with the appropriate acute management guidelines for the cervical spine–injured athlete.

PURPOSE

The purpose of this position statement is to provide athletic trainers, team physicians, emergency responders, and other health care professionals with recommendations and clinical considerations for managing a major,[27] potentially catastrophic[28,29] cervical spine injury. *A catastrophic cervical spine injury* is defined as "a structural distortion of the cervical spinal column associated with actual or potential damage to the spinal cord."[28]

Table 1. Combined High School and College Catastrophic Injury Data in Select Sports Derived From the National Center for Catastrophic Sport Injury Research, Fall 1982 Through Spring 2007[3,a]

Sport	Setting	Direct Catastrophic Injuries	Direct Injury Incidence Rates (Nonfatal[b]) per 100 000 Population	
			Males	Females
American football (males)	High school	603	0.75	NA
	College	133	1.89	
Gymnastics	High school	13	2.08	0.97
	College	6	20.07	5.35
Ice hockey	High school	19	1.02	0.00
	College	12	4.18	0.00
Track and field	High school	59	0.12	0.01
	College	10	0.34	0.15
Lacrosse	High school	9	0.52	0.00
	College	11	2.11	2.01
Wrestling (males)	High school	58	0.60	NA
	College	1	0.00	NA
Cheerleading	High school	46	…	…
	College	23	…	…

Abbreviations: NA, not applicable; …, data not available.
[a] Data reprinted with permission of the National Center for Catastrophic Sport Injury Research.
[b] Nonfatal indicates permanent severe disability.

Specifically, this statement will provide recommendations based on current, rated evidence (Table 2) pertaining to the following:

1. Prevention strategies to reduce the incidence of cervical spine injuries in sport,
2. Emergency planning and preparation to increase management efficiency,
3. Maintaining or creating neutral alignment in the cervical spine,
4. Accessing and maintaining the airway,
5. Stabilizing and transferring an athlete with a suspected cervical spine injury,
6. Equipment-related issues in sports such as football, hockey, and lacrosse,
7. Imaging and diagnostic considerations in the emergency department, and
8. The role of hypothermia treatment and high-dose corticosteroids in the acute management of the cervical spine–injured athlete.

RECOMMENDATIONS

Based on current research and expert consensus related to cervical spine injury, the National Athletic Trainers' Association provides the following recommendations for prevention and emergency management of the athlete with a suspected catastrophic cervical spine injury.

Prevention

1. Individuals responsible for the emergency care of athletes should be familiar with sport-specific causes of catastrophic cervical spine injury and understand the acute physiologic response of the spinal cord to injury. *Evidence Category: C*
2. Those responsible for the emergency care of athletes should be familiar with safety rules enacted for the prevention of cervical spine injuries and should take actions to ensure that such rules are followed. *Evidence Category: C*
3. Persons responsible for the emergency care of athletes should be familiar with pertinent protective equipment manufacturers' recommendations and specifications relative to fit and maintenance. Maintaining the integrity of protective equipment helps to minimize the risk of injury. *Evidence Category: C*
4. Individuals responsible for the emergency care of athletes should educate coaches and athletes about the mechanisms of catastrophic spine injuries, the dangers

Table 2. Strength of Recommendation Taxonomy[a]

Strength of Recommendation	Definition
Patient-oriented evidence	
A	Recommendation based upon consistent and good-quality patient-oriented evidence (morbidity, mortality, symptom improvement, cost reduction, and quality of life)
B	Recommendation based on inconsistent or limited-quality patient-oriented evidence
C	Recommendation based on consensus, usual practice, opinion, disease-oriented evidence (measures of intermediate, physiologic, or surrogate end points that may or may not reflect improvements in patient outcomes), or case series for studies of diagnosis, treatment, prevention, or screening

[a] Adapted or reprinted with permission from "Strength of Recommendation Taxonomy (SORT)," March 1, 2008, American Family Physician.

of head-down contact, and pertinent safety rules enacted for the prevention of cervical spine injuries.[30] *Evidence Category:* C

Planning and Rehearsal

5. Those responsible for the care of athletes should be familiar with the National Athletic Trainers' Association position statement on emergency planning in athletics.[31] *Evidence Category: C*
6. Planning in advance of events carrying a risk of cervical spine injury should include preparation of a venue-specific emergency action plan. Components of the emergency action plan include appointing a team leader and acquiring appropriate equipment to facilitate stabilization, immobilization, and removal of treatment barriers (ie, sporting equipment). The emergency action plan should also incorporate communication with local emergency medical services and identification of the most appropriate emergency care facility to receive the injured athlete. These groups should be involved in creating the emergency action plan.[31] *Evidence Category: C*
7. All individuals responsible for the care of athletes should be involved in regular (at least annual) rehearsals of the emergency action plan, as well as training and practice in the special skills inherent to managing a cervical spine injury. Skills requiring training and regular practice may include manual head and neck stabilization techniques, the multiple methods of transferring injured athletes (eg, log-rolling, lift-and-slide techniques), equipment management (eg, gaining access to the airway or chest), and immobilization methods (eg, long spine board, cervical collar application).[31] *Evidence Category: C*

Assessment

8. During initial assessment, the presence of any of the following findings, alone or in combination, heightens the suspicion for a potentially catastrophic cervical spine injury and requires the initiation of the spine injury management protocol: unconsciousness or altered level of consciousness, bilateral neurologic findings or complaints, significant midline spine pain with or without palpation, and obvious spinal column deformity.[32–37] *Evidence Category: A*

Stabilization

9. When a potential spine injury is suspected, rescuers should ensure that the cervical spine is in a neutral position and should immediately apply manual cervical spine stabilization. This will minimize motion during the management of the injury.[38–42] *Evidence Category: B*
10. Rescuers should not apply traction to the cervical spine, as this may cause distraction at the site of injury. Traction in a cervical spine with ligamentous injury can result in excessive distraction and subluxation that can further compromise the spinal cord.[39–41,43–46] *Evidence Category: B*
11. If the spine is not in a neutral position, rescuers should realign the cervical spine to minimize secondary injury to the spinal cord and to allow for optimal airway management. However, the presence or development of any of the following, alone or in combination, represents a contraindication for moving the cervical spine to neutral position[40,41]: the movement causes increased pain, neurologic symptoms, muscle spasm, or airway compromise; it is physically difficult to reposition the spine; resistance is encountered during the attempt at realignment; or the patient expresses apprehension.[32,47–54] *Evidence Category: B*

Airway

12. Rescuers should immediately attempt to expose the airway, removing any existing barriers (eg, protective face masks). *Evidence Category: C*
13. If rescue breathing becomes necessary, the individual with the most training and experience should establish an airway and commence rescue breathing using the safest technique.[55–57] *Evidence Category: B*
14. During airway management, rescuers should cause as little motion as possible.[39,58] *Evidence Category: C*
15. The jaw-thrust maneuver is recommended over the head-tilt technique, which produces unnecessary motion at the head and in the cervical spine. Advanced airway management techniques (eg, laryngoscope, endotracheal tube) are recommended in the presence of appropriately trained and certified rescuers; these methods have been shown to cause less motion and, therefore, are less likely to worsen neurologic status.[55,59–65] *Evidence Category: B*

Transfer and Immobilization

16. Manual stabilization of the head should be converted to immobilization using a combination of external devices (eg, cervical collars, foam blocks), and stabilization of the cervical spine should be continued until a destabilizing injury has been ruled out using appropriate diagnostic testing (imaging). Whenever possible, manual stabilization should be resumed[65,66] after the application of external devices.[40,67–70] *Evidence Category: B*
17. Individuals responsible for the emergency care of athletes with cervical spine injuries should be prepared to immobilize these athletes with a long spine board or other full-body immobilization device.[57,67,69,71] *Evidence Category: B*

18. Although the traditional spine board represents the most common device used for full-body immobilization, devices such as the full-body vacuum splint are more comfortable for athletes, reduce superficial irritation and sores over bony prominences, and may be used in appropriate situations.[57,69,71] *Evidence Category: B*
19. For the supine athlete, a lift-and-slide technique (eg, 6–plus-person lift, straddle lift and slide) of transferring the athlete to an immobilization device has been reported to produce less motion at the head and in the cervical spine than the log-roll technique and should be used in appropriate situations.[72–75] *Evidence Category: B*
20. For the prone athlete, all potential rescuers must be familiar with the log-roll method of transferring to an immobilization device. *Evidence Category: C*

Equipment-Laden Athletes

21. Because removal of athletic equipment such as helmet and shoulder pads may cause unwanted movement of the cervical spine, removal of helmet and shoulder pads should be deferred until the athlete has been transported to an emergency medical facility, except under specifically appropriate circumstances. The first exception is if the helmet is not properly fitted to prevent movement of the head independent of the helmet. This is imperative, because when the helmet is left in place, it is responsible for securing the head, and, as such, immobilization of the helmet necessarily results in immobilization of the head. The second exception is if the equipment prevents neutral alignment of the cervical spine or airway access. This exception is further addressed in the following recommendations.[76,77] *Evidence Category: B*
22. Independent removal of the helmet or shoulder pads in American football and ice hockey is not recommended, because removing one and not the other compromises spinal alignment. Removal of the helmet and shoulder pads in these sports should be considered an all-or-nothing endeavor.[54,76–78] *Evidence Category: B*
23. No general recommendation regarding removal of equipment can be made for other sports that require a helmet (with or without shoulder pads) because of considerable variation in the capacity of that equipment to maintain a neutral cervical spine or immobilize the head. The primary acute treatment goals in these sports are to ensure that the cervical spine is properly aligned and that the head and neck are immobilized. Upon observation, if the equipment being worn does not permit the cervical spine to rest in neutral or does not adequately immobilize the head, then removal of one or more pieces of equipment in a safe manner is advisable to achieve neutral alignment or adequate stabilization (or both).[79,80] *Evidence Category: C*
24. If the athletic helmet is dislodged during the injury or removed (by either the medical team or the athlete) or if the shoulder pads cannot be easily removed, care must be taken to place padding beneath the head to maintain neutral cervical spine alignment. *Evidence Category: C*
25. A rigid cervical immobilization collar should be placed on the athlete before transfer to a spine board. In equipment-laden sports, this may be difficult or impossible, although a cervical vacuum immobilization device has been shown to limit cervical spine range of motion in the fully equipped football player.[81] *Evidence Category: C*
26. Individuals responsible for the emergency care of athletes in equipment-laden sports should be familiar with their team's equipment (external defibrillators) and the tools and techniques required for removal of barriers to treatment (eg, airway management). *Evidence Category: C*
27. Face masks that interfere with the ability to access the airway should be completely removed from the helmet. *Evidence Category: C*
28. Face-mask removal should be initiated once the decision to immobilize and transport has been made. *Evidence Category: C*
29. Rescuers should be aware of, and well trained in, established face-mask removal techniques. The face mask should be removed with the tool and technique that perform the task quickly and with minimal movement and difficulty. A powered (cordless) screwdriver is generally faster, produces less head movement, and is easier to use than cutting tools; it should be the first tool used in attempting to remove a face mask attached with loop straps that are secured with screws. Because it may be impossible to remove the screws, a backup cutting tool, specifically matched to the sport equipment used, should be available. This is referred to as a *combined-tool approach*.[82–87] *Evidence Category: B*
30. To increase the likelihood that all 4 screws can be successfully removed from a football helmet face mask using a cordless screwdriver, athletic trainers, coaches, and equipment managers should ensure that corrosion-resistant hardware is used in the helmet, that helmets are regularly maintained throughout a season, and that helmets undergo regular reconditioning and recertification.[82,85] *Evidence Category: B*
31. If the face mask cannot be removed in a reasonable amount of time, then the helmet should be removed from the athlete in the safest manner possible. Helmet style will dictate the technique necessary to safely remove the helmet. A neutral cervical spine position should be preserved during and after this process by removing additional pieces of equipment (eg, shoulder pads) or by placing an object underneath the head (eg, towel, padding) to maintain neutral alignment. *Evidence Category: C*

Emergency Department Management

32. If possible, the team physician or certified athletic trainer should accompany the athlete to the hospital. This provides continuity of care, allows for accurate delivery of clinical information to the emergency department staff, and may allow the sports medicine professional to assist emergency department personnel during equipment removal. *Evidence Category: C*
33. Remaining protective equipment should be removed by appropriately trained professionals in the emergency department environment. Emergency department personnel should make an effort to become familiar with proper athletic equipment removal, seeking education from sports medicine professionals regarding appropriate methods to minimize motion.[76,77,88] *Evidence Category: C*
34. Emergency departments should consider implementing guidelines for the use of computed tomography (CT) rather than plain radiographs as the primary diagnostic test for a suspected cervical spine injury in a helmeted athlete. Obtaining plain radiographs adequate for clearance with sport equipment in place is a procedure unsupported by research. A CT may be more sensitive than plain radiographs and is associated with lower rates of missed primary and secondary injuries.[89–94] *Evidence Category: B*
35. Emergency department personnel should be aware that magnetic resonance imaging (MRI) is clinically limited for helmeted athletes and may not be suitable as an initial diagnostic tool.[95] *Evidence Category: B*

The Role of Hypothermia Treatment and High-Dose Corticosteroids in the Acute Management of an Athlete With Cervical Spine Injury

36. Although the role of hypothermia in the treatment of myocardial infarction and brain injury has been investigated and has shown potential to reduce morbidity, evidence is currently insufficient to justify its use in the acute management of the spine-injured athlete.[96,97] *Evidence Category: C*
37. High-dose methylprednisolone for acute spinal cord injury has been used in the initial management of acute spinal cord injury; however, this practice has recently been questioned. One evidence-based analysis of the published literature on methylprednisolone revealed serious flaws in data analysis and conclusions, with no clear support for the use of methylprednisolone in patients with acute spinal cord injury.[98] Until additional reliable data are available, the use of high-dose methylprednisolone in this instance remains controversial. When possible, each patient or patient's family should be informed of the risks and benefits of the medication before use. *Evidence Category: B*

CLINICAL CONSIDERATIONS

Based on expert consensus and current research, the National Athletic Trainers' Association provides the following special clinical considerations for emergency management of the athlete with a suspected cervical spine injury.

Transfer and Immobilization (Appendix A: Figures 1–5)

1. A variety of techniques exist to transfer and immobilize the injured athlete. Rescuers should use the technique that they have reviewed and rehearsed and that produces the least amount of spinal movement.
2. To facilitate transfer, the patient's body should be aligned as carefully as possible. Arms should be carefully moved to the sides and legs straightened and positioned together.
3. If the athlete is prone, rescuers should inspect the spine before moving him or her.
4. If it is necessary to reposition the patient once on the spine board, he or she should not be moved in a perpendicular direction, to avoid shearing and the possibility of spinal column movement. Instead, the patient should be moved in either a cephalad or caudad direction, as deemed necessary by the rescuer controlling the head and neck.
5. Selection of appropriate transfer and spine boarding techniques
   a. The log-roll technique requires 4 to 5 rescuers: 1 to control the head and cervical spine, 2 to 3 to roll the patient on command, and 1 to position the spine board.
   b. Lift-and-slide technique
      i. The 6–plus-person lift involves lifting the athlete to allow for spine board placement. This technique is effective in minimizing structural interference that could result in unwanted spinal column movements.
      ii. The straddle lift-and-slide technique requires only 4 rescuers to lift the body.
   c. For the supine athlete, the log-roll or lift-and-slide techniques may be used; for a prone athlete, the log-roll technique is the only option. Therefore, all rescuers must be familiar with the log roll.
6. Equipment recommendations for spine boarding
   a. A scoop stretcher with telescoping arms that is hinged on both ends may be used to "scoop" the athlete without having to perform the log roll or lift and slide; however, the device may only be used in this manner if the athlete is in the supine position.
   b. Vacuum immobilization creates a custom form-fit, full-body splint and has been found to be more comfortable for patients than a standard spine board.[57,71] This option may be used on either a supine or a prone athlete, but it may be better suited for the lift-and-slide technique because of its semirigid structure. The large size, however, may

make it difficult to slide between the rescuers on either side.

c. A short-board system may be useful in immobilizing seated athletes; those with a flexed trunk or awkward positioning; and those affected by equipment barriers, such as the gymnastics or pole-vault pit.

7. Head immobilization

   a. The head should always be the last part of the body secured to the spine board.
   b. A variety of head-immobilization options exist, including commercial head-immobilization devices, contoured helmet blocks, foam blocks, and towel rolls. Sand bags are not recommended as head-immobilization devices, as their weight is a liability during transfer.
   c. Once the selected head-immobilization device is placed to stabilize the head, tape or hook-and-loop straps should be used to secure the head to the spine board using 2 separate points of contact, the chin and the forehead,[78] to prevent as much head and neck motion as possible.

8. A spine board kit should contain all necessary packaging supplies: head-immobilization device, cervical collar, face-mask–removal tools, straps to secure the athlete to the board, wrist straps to secure the athlete's hands together, tape, and various sizes of padding or toweling.
9. Rescuers should select the strapping technique with which they are most comfortable and skilled.
10. When securing the athlete to the spine board, the arms should be kept free to facilitate a variety of diagnostic and treatment techniques.
11. Once the torso is secured to the spine board, the hands may be secured together on top of the body using hook-and-loop wrist straps or tape.
12. The athlete should be restrained and secured sufficiently to the spine board that the board may be turned without creating spinal movement, in case, for example, the athlete vomits.
13. Some athletes with cervical spine injuries may have concurrent closed head injuries. Therefore, rescuers may encounter combative athletes who resist immobilization. The rescuers should attempt to calm the patient and minimize movement as much as possible based upon the individual circumstances.
14. The ambulance should be positioned as close to the scene as possible to minimize transfer on a stretcher over surfaces that may cause body movement.

Equipment-Laden Athletes (Appendix B: Figures 6–9)

15. Face-mask removal

   a. Removing the loop straps from face masks can be a difficult skill and requires extensive practice.
   b. For a football helmet face mask with 4 attachment locations, the 2 side straps should be removed first, followed by the top straps. This prevents the face mask from rotating down onto the athlete's face or throat during the removal attempt.
   c. Placing pressure on the underside of the loop strap with the thumb of the other hand while unscrewing can assist in separating the screw from the T-nut.
   d. If, when attempting to remove the screws from the helmet, 1 or more screws cannot be removed, it is important to continue with the next screw until all screws that can be unscrewed are successfully removed.
   e. If a backup cutting tool is required, ensure that the tool chosen will successfully cut the loop straps currently being used in the helmets worn by the football team or teams being covered. Not all face-mask removal tools will remove all helmet–loop strap combinations.[86]
   f. A screwdriver may not suffice as a backup tool for loop straps secured with a quick-release mechanism rather than a traditional screw and T-nut attachment system. Therefore, an appropriate backup tool should be available to cut away the loop strap should the quick-release system fail.

16. Because individual circumstances may dictate removal of an athletic helmet or shoulder pads, athletic trainers and emergency responders should be trained in helmet and shoulder-pad removal. This skill should be rehearsed on a regular basis with the specific equipment used by that team, organization, or facility. Emergency department personnel should also be trained in athletic helmet and shoulder-pad removal.

THE EVIDENCE: BACKGROUND AND LITERATURE REVIEW

The evidence to support the above-listed recommendations follows. However, we should note that every emergency situation and every patient are unique and that individual circumstances must dictate appropriate actions. Furthermore, the recommendations listed above related to spine-injury management skills and techniques tend to be based on research results that yielded the least amount of motion at the head and neck or the most optimal position for the spinal cord. Yet, how much motion or how far from neutral alignment would result in further injury during spine-injury management is unknown. Because the "safe" amount of motion and degree of alignment are not known, and because the extent of injury in the prehospital stage is not known, we must strive to create as little motion as possible and to ensure an optimal position for the spinal cord within the spinal canal (ie, neutral alignment of the spinal column).

Prevention

Pathomechanics of Catastrophic Cervical Spine Injury. The highest number of catastrophic cervical spine injuries in the United States occurs in the sport of American football,[29,99] and the most common injury mechanism

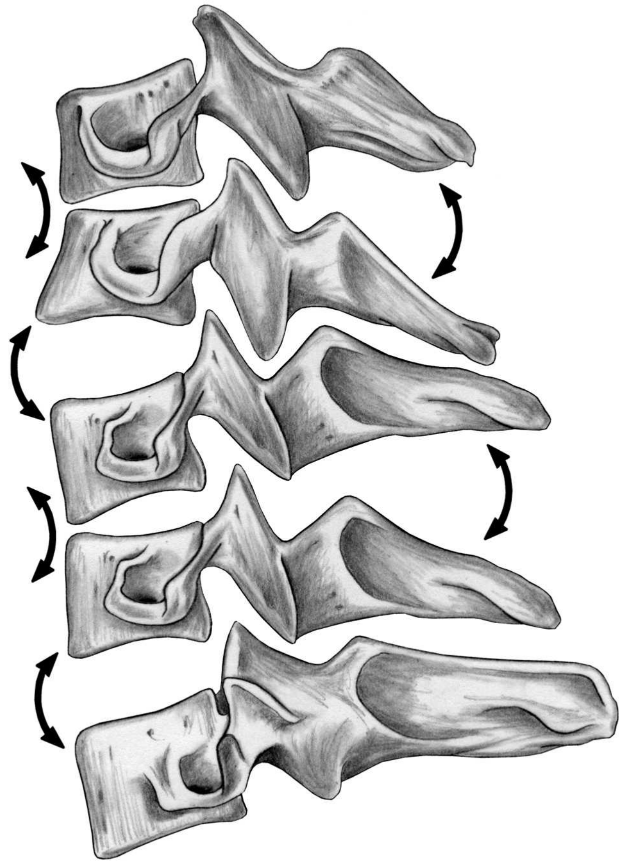

Figure 10. Buckling effect in the cervical column under axial load. Reprinted with permission from Swartz EE, Floyd RT, Cendoma M. Cervical spine functional anatomy and the biomechanics of injury due to compressive loading. *J Athl Train*. 2005;40(3):155–161.

occurs during tackling when the top of the head is used as the point of contact.[5,29,30] This mechanism is referred to as an *axial load*, which can occur in any sport. During axial loading, compressive forces create a buckling effect in the cervical spine.[100] This buckling produces large angulations within the cervical spine as a means of releasing the additional strain energy produced by the vertical loading, and this buckling is the causative factor of injury[100–102] (Figure 10). This unique buckling effect of the cervical vertebrae, partially explained through the work of Penning[103] and Amevo et al,[104] is linked to the location of a vertebra's instantaneous center of rotation (ICR). The center of rotation for a particular vertebra is located near the superior aspect of the inferiorly adjacent vertebral body. As the lines of force are transmitted down the cervical column, the vertebra experiences flexion or extension, depending on the location of the force vector relative to the ICR. Hence, if the cervical column is moving into flexion, but the relative orientation of one vertebra to the other causes the force vector to pass behind the ICR, then that vertebra extends[103,104] (Figure 11).

The resultant injury (or injuries) depends on many factors but may be influenced by the velocity of the applied load,[102,105] the point of contact on the head relative to the axis of the cervical spine,[100,101] the resultant mode of buckling,[100,101] and the type of surface with which the head came into contact (ie, solid versus padded).[106] A critical factor contributing to the degree of neurologic injury is the extent to which the injury involves the spinal cord. During axial compression or extreme ranges of motion in the cervical spine, the spinal canal experiences transient geometric changes in diameter and height, which may eliminate the space surrounding the spinal cord, potentially resulting in neural tissue damage.[47,107] Even if the spinal cord survives insult during the initial injury, its integrity may still be threatened if the osseous and soft tissue structures were injured sufficiently to create instability in the cervical spine.[27]

Acute Physiologic Response. Although most sport injuries do not result in complete transection of the cord,[108] complete sensory and motor loss can still occur. The outcome largely depends on the degree and duration of trauma. The histologic response within the spinal cord involves both primary injury and a secondary injury response that can lead to destruction of the neural tissue.

Spinal nerve destruction is attributed to both an acute vasospasm within the capillary network and edema-causing traumatic hemorrhagic necrosis within the protective layers of the cord.[109] This primary response contributes to decreased spinal cord perfusion. Capillary blood flow is disrupted after rupture of the intramedullary spinal blood vessels, resulting in gray matter hemorrhage. A build-up of cytotoxic amounts of extracellular calcium and release of norepinephrine from protective storage provoke cytotoxic responses within neurons.[110] Sodium-potassium pump disruption and subsequent cellular membrane breakdown and lipid peroxidation contribute to neuron hydrolysis at the injury site.[111] The sodium-potassium pump is a vital component in the cell's ability to repolarize, and cellular membrane destruction allows for the influx of extracellular calcium, which becomes cytotoxic to the cell.[111] The gray matter undergoes progressive dissolution before the white matter.[109] These early changes in the injured spinal cord take place within the first 2 hours after trauma.[111]

Equipment Maintenance. The National Operating Committee on Standards in Athletic Equipment (NOCSAE) was established in 1969 to research injury-reduction strategies in sports.[112] Since that time, NOCSAE has been recognized as the authority in equipment standards and the development of rules for many sport governing bodies. For example, the National Collegiate Athletic Association requires the use of NOCSAE-certified athletic equipment.[113] The NOCSAE standards ensure that a helmet is able to withstand a certain degree of impact, and recertification confirms that used helmets do not fall below NOCSAE standards.[114] Alterations (for example, the drilling of holes through the helmet shell or the use of inappropriate or unapproved hardware) may affect the helmet's effectiveness.[114] Adherence to standards concerning the helmet shell and hardware affords sports medicine personnel a reasonable degree of assurance that the variety of equipment they may need to remove in an emergency will be somewhat limited.

Current recommendations leave the frequency of helmet recertification to the discretion of the user. Swartz et al[85] demonstrated increasing difficulty with face-mask removal as the time from last recertification increased. Therefore, it appears that more regular reconditioning, including replacement of all metal hardware, would reduce the

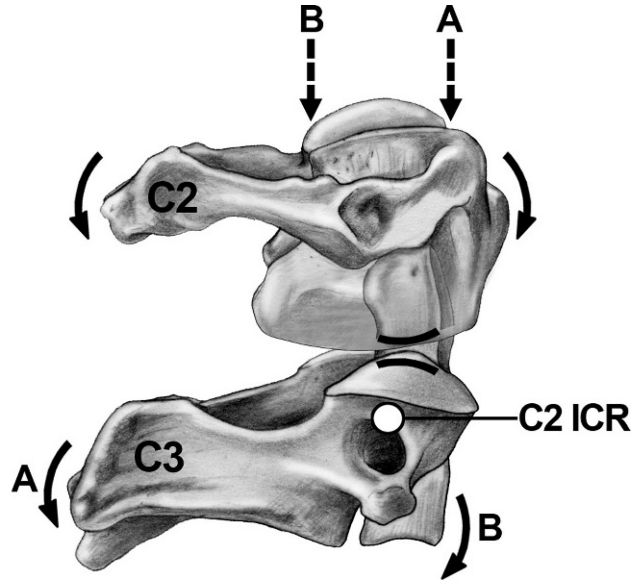

Figure 11. The instantaneous center of rotation (ICR) for a vertebra is located near the superior aspect of the inferior vertebral body. The inferior vertebra's motion depends on the location of the force vector relative to the ICR. A, Hence, if the lines of force are transmitted anterior to the ICR, the inferior vertebra extends. B, If the lines of force are transmitted posterior to the ICR, the inferior vertebra flexes. Reprinted with permission from Swartz EE, Floyd RT, Cendoma M. Cervical spine functional anatomy and the biomechanics of injury due to compressive loading. *J Athl Train.* 2005;40(3):155–161.

likelihood of face-mask removal failure during an emergency. The use of corrosion-resistant metal screws also increases the probability of face-mask removal success.[85] Regular maintenance and inspection of helmets during a season can reduce the likelihood that a rescuer will encounter impediments to successful face-mask removal.[85] One example is the presence of foreign substances embedded in the loop-strap screw heads, such as dirt or plastic from other helmets, which prevents the insertion of the screwdriver into the screw head. Finally, certified athletic trainers should be familiar with equipment standards for the sport or sports with which they work, so they can better recognize and correct potential safety issues.

Education and Rules. Continuing education of certified athletic trainers, coaches, officials, and athletes to ensure understanding of injury mechanisms may reduce the risk of catastrophic injuries. Accepting responsibility for teaching (eg, athletic trainers and coaches), legislating (eg, governing bodies), implementing (eg, athletic trainers, coaches, and athletes), and enforcing (eg, officials) safe alternatives to dangerous activities is crucial. For example, axial loading of the cervical spine is responsible for most quadriplegic cervical injuries in football[115,116] and hockey.[116,117] Understanding this concept served as a springboard for rule changes and education that subsequently reduced the incidence of such injuries. The best examples of the effectiveness of this approach are the reduction in cervical spine quadriplegic injuries associated with the banning of spear tackling in football[115,118] and hitting from behind (boarding) in ice hockey.[117] Educational multimedia, such as the *Heads Up: Reducing the Risk of Head Injuries in Football* DVD from the National Athletic Trainers' Association (http://www.nata.org/consumer/headsup.html), are available to achieve this purpose.

Planning and Rehearsal

The effect of creating or rehearsing an emergency plan, or specific skills within an emergency plan, on managing a catastrophic cervical spine injury is not well documented. Previous recommendations to incorporate planning and rehearsal of an emergency action plan appear to be based on expert consensus.[31,119,120] Many individuals responsible for the care of athletes with catastrophic cervical spine injuries have already received skills training in on-field techniques as a result of requirements or educational competencies included in obtaining a degree, certification, or license to practice (eg, certified athletic trainer, emergency medical technician, physician). Additionally, many authors investigating or comparing spine-injury management skills require participants to be thoroughly trained and familiar with the procedures before data are collected and analyzed.[72,75,86,121]

One group[73] analyzed the effect of additional training on the performance of transfer skills to an immobilization device and found no differences in proficiency between trained and untrained participants. In contrast, researchers in related fields have reported the beneficial effects of formal education[122] and training[123] on specific medical skills.

Although the recommendation to create and rehearse an emergency action plan and the skills contained within it is logical from the medical and legal perspectives, the beneficial effects of the rehearsal of the emergency plan or its skills are not established in the literature. No minimum quantity or frequency of rehearsal sessions or type of training can be endorsed.

Assessment

During the initial assessment of an injured athlete suspected of having a potentially catastrophic cervical spine injury, the presence of any or all of the following 4 clinical indicators warrants the activation of the spine-injury management protocol: unconsciousness or altered level of consciousness, bilateral neurologic findings or complaints, significant cervical spine pain with or without palpation, and obvious spinal column deformity. In the presence of any of these findings, the use of spinal injury precautions in the athletic setting have been recommended.[33,39,58,119] However, these recommendations are largely based on evidence from research in prehospital and emergency medicine settings rather than athletic settings.

Results from recent research in prehospital and emergency medicine studies have been used to develop and validate criteria for determining selective immobilization and spine clearance protocols in the prehospital setting.[34–36,124,125] The most common criteria leading to immobilization in the prehospital setting include unconsciousness, altered mental status, evidence of intoxication, neurologic deficit, long-bone extremity fracture, or cervical, thoracic, or lumbar spine pain.[34,35] Domeier et al[35] reported that most spine-injured patients (87%) included in a large prospective study presented with more than 1 of the measured clinical findings. The Glasgow Coma Scale has also been identified as a predictor of possible cervical spine injury.[36,126] Holly et al[36] noted that patients with an initial Glasgow Coma Scale score of 8 or less were more likely to have sustained a cervical injury than those with a score higher than 8. Further, Demetriades et al[126] identified an inverse relationship by which a lower Glasgow Coma Scale score correlates with a higher risk of cervical spine injury.

Holly et al[36] and Ross et al[127] have suggested a link among unconsciousness, mental status, and the possibility of cervical spine injury in trauma patients. Approximately 5% to 7% of patients presenting with unconsciousness and altered mental status had a spinal injury.[36,127] In a prospective study of emergency medical services patient charts by Domeier et al,[34] 37% of spine-injured patients presented with altered mental status. Iida et al[37] reported that one-third of all spine-injured patients studied also sustained moderate or severe head injuries. It is important to note, however, that these studies involved mechanisms of injury that included high-velocity impacts (eg, falls, motor vehicle accidents) and were not limited to athletic participation.

Bilateral neurologic findings or complaints, altered mental status, significant midline pain, or obvious spinal column deformity, alone or in any combination, are indicators of potential cervical spine injury and warrant the use of spinal precautions. These criteria are extracted from validated prehospital and emergency medicine spinal clearance protocols, but on a case-by-case basis, other individual or collective signs or symptoms may indicate the presence of a cervical spine injury.

Stabilization

Manual cervical immobilization should be implemented as soon as possible once a cervical spine injury is suspected. The head should be manually stabilized by grasping the mastoid processes bilaterally with the fingertips while cupping the occiput in the hands.[46] The rescuer should position his or her hands so the thumbs are pointed toward the face of the injured athlete. This technique ensures that hand placement does not have to be changed with repositioning of the athlete, unless rolling the athlete from a prone to a supine position is required, in which case the rescuer's arms should be crossed before rolling. If the rescuer is alone, it may be appropriate to use the knees to maintain spine stabilization, thus freeing the rescuer's hands to assist with ventilation or to conduct further tests.

Traction. Rescuers should not apply traction forces to the head of the spine-injured athlete during stabilization and immobilization. Multiple authors[39–41,44] have recommended against the application of traction during manual in-line stabilization, as movement of the unstable cervical spine may cause further injury. Cadaver-based studies and research investigating spine motion during orotracheal intubation in patients with ligamentous instability demonstrated that traction forces applied during manual in-line immobilization created distraction[43,45,46] and posterior subluxation[43] at the site of injury.

Neutral Alignment of the Head and Neck. Medical professionals accept that the cervical spine should be immobilized in the neutral position or in normal axial alignment, as in the anatomic position.[32,39–42] This position facilitates airway management procedures and application of immobilization devices and reduces spinal cord morbidity that would otherwise result from compromised local circulation. To achieve a neutral position, the spine may need to be manually realigned during the emergency management process.[32,39] Contraindications for moving the cervical spine to neutral include the following: the movement causes or increases pain, neurologic symptoms, or muscle spasm; the movement would compromise the airway[40]; it is physically difficult to perform the movement; resistance is encountered during the attempt to realign the cervical spine[41]; or the patient expresses apprehension.

Although no prospective randomized studies have been conducted to support the above recommendations, evidence can be extrapolated from anatomic and airway management research. Several groups[48,52–54,128] have investigated the size of the spinal canal in various positions of the cervical spine. Animal-based studies[129] demonstrate that the extent of spinal cord neurologic injury increases as pressure is sustained and with increasing levels of compression force. Other investigators focused on patients presenting with radicular symptoms[50] or cervical spondylosis[51] and sought to identify dynamic changes in the spinal canal. Some authors[49,130] retrospectively investigated the records of patients who sustained cervical spine injuries, assessing how these injuries affected the size of the spinal canal and how that was related to their clinical outcome. Each set of results provides evidence that the optimal position for the spinal cord is the neutral position.

De Lorenzo et al[48] performed MRI on 19 healthy volunteers to determine the optimal position for cervical spine immobilization. Participants were positioned in neutral and then in 2 cm and 4 cm of cervical flexion and extension. The angle between the cervical and thoracic spines and the ratio between the spinal canal diameter and spinal cord area were identified. Slight flexion (ie, occiput elevated) produced a 3% increase in the ratio of spinal cord area to spinal canal at C5 compared with no elevation, and, therefore, these authors[48] recommended immobilization in a position of slight flexion. In contrast, Tierney et al[54] assessed the effect of head position on the cervical space available for the cord in volunteers wearing football equipment. Changes in the sagittal diameter, spinal canal, and spinal cord at the C3–C7 levels were identified on MRI. Increased space was available for the spinal cord at 0 cm of cervical flexion compared with 2 cm and 4 cm of elevation. The space available for the cord was also greatest at the C5–C6 level. The authors[54] recommended leaving all equipment on and immobilizing the athlete in neutral without any occiput elevation.

Muhle et al[52] used whole-body MRI to determine the functional changes that occur to the cervical spine and subarachnoid space during dynamic cervical flexion and extension. Nine angles between 50° of flexion and 30° of extension were analyzed. Segmental motion, subarachnoid diameter, and cervical cord diameter were assessed. Decreased ventral subarachnoid space and widened dorsal subarachnoid space were noted during cervical flexion. Correspondingly, during extension, the ventral space increased, while the dorsal space decreased. In addition, the spinal cord diameter decreased 14% during flexion and increased 15% during extension. Depending on the location of the cervical spine injury (ie, dorsal or ventral), the authors[52] contended that movement of the cervical spine away from neutral may lead to cord compromise.

Ching et al[128] investigated the effect of postinjury position of the cervical spine on spinal canal occlusion after inducing burst fractures in 8 cadaver cervical spines. Neutral position was defined as *the most central position of the spine that preserved normal lordosis*. The authors then tested the spine in 8 directions (flexion, extension, right and left lateral flexion, and 4 intermediate positions). In addition, right and left cervical rotation, traction, and compression were assessed. Compared with the neutral position, compression, extension, and extension combined with lateral flexion increased canal occlusion.[128]

To identify the relationship between cervical spine sagittal canal diameter and neurologic injury, Eismont et al[130] retrospectively reviewed the medical records of 98 patients who had sustained closed cervical spine fractures or dislocations. A correlation between mid-sagittal spinal canal size and the onset and degree of neurologic deficit was present. In general, the larger the spinal canal diameter, the less likely the patient was to suffer a neurologic deficit.[130] More recently, Kang et al[49] retrospectively analyzed the records and radiographs of 288 patients who had sustained a cervical fracture or dislocation over a 30-year period and also identified an association between the space available for the cord at the level of injury and the severity of neurologic deficit.

In conclusion, for proper functioning of the spinal cord, space within the spinal canal must be maintained, both at rest and during movement. Neurologic injury results from sustained mechanical pressure on the cord, which leads to both anatomic deformation and ischemia.[129,131] Persistent malposition of an abnormal cervical spine may result in cord compression. If the abnormality is slight, it is likely that the malposition will need to be of greater magnitude and duration to cause harm; as the anatomic derangement increases, the duration of positional stress required to cause harm is shortened.[129] How much space is available for the cord in any potential cervical spine injury is unknown; therefore, the head and cervical spine must be positioned to create as much potential space for the spinal cord as possible.

Airway

For appropriate management of the spine-injured athlete, the airway should be easily accessible. If the athlete is wearing a face guard that impedes access to the airway, removal of the barrier or insertion of an airway management device is necessary; evidence-based strategies are described in the next section. The airway should be kept open and clear of any obstructions. Potential instability in the cervical spine due to an injury necessitates careful airway management procedures should rescue breathing or introduction of an artificial airway be necessary. In the absence of advanced equipment or training, the airway must be opened using basic techniques that provide cervical spine protection. The jaw-thrust maneuver is recommended over the head-tilt technique, which produces unnecessary motion in the cervical spine. However, the jaw-thrust maneuver may create more motion at the site of injury in the cervical spine than advanced airway maneuvers (ie, esophageal tracheal combitube, laryngoscope endotracheal tube, or laryngeal mask airway).[55,63,64] If an airway is compromised, airway management is the treatment priority, and the individual with the most training and experience should apply the safest, most advanced technique available to secure a viable airway and commence rescue breathing.

Patients with potential cervical spine injuries may be treated with the application of a cervical collar or other extrication device. Sports medicine professionals must recognize that it is possible that the application of a semirigid cervical collar may interfere with the ability to open the mouth adequately for certain airway-management techniques,[56] possibly requiring the loosening or removal of a previously applied external immobilization device, along with any tape or straps that secure the chin.

Transfer and Immobilization

Manual stabilization of the head and neck is initiated early in the care of the potentially spine-injured athlete. Once the primary survey is complete, the next step in most situations is to transfer manual head and neck stabilization to mechanical head and neck immobilization using an external device or devices. Head and cervical spine immobilization devices splint or brace the head and neck as a unit against the upper torso, typically at the intersection of the base of the neck and shoulders. A log roll has historically been used to transfer the patient to a long spine board for full-body immobilization. Other devices and techniques for transfer and full-body immobilization are available and are discussed in the following sections.

Head Stabilization. The capacity of various collars to restrict range of motion in healthy participants and in cadaver models has been assessed,[70,132–135] with no clear superiority of any single device. One researcher[136] reported that not only did cervical collars provide no support to the injured cervical spines of cadavers, but in some cases they actually increased motion at the site of injury. Rather, a combination of padding (eg, foam blocks, towels), rigid collar application, and taping to a backboard or full-body splint is recommended[40]; this combination approach has demonstrated the greatest degree of motion limitation at the head during active range of motion in healthy volunteers.[67,69,70] These findings, combined with reports[65,66] that manual cervical spine immobilization is superior to the use of external devices in reducing cervical motion during airway intubation, indicate that manual stabilization should be continued throughout the management process, whether or not external stabilization devices are applied.

Transfer and Full-Body Immobilization. Minimizing movement at the head and neck is a critical factor in the successful management of the spine-injured athlete. Any equipment or technique that limits movement will allow for the most effective and safest stabilization of a patient, reducing the potential for secondary injury.[67] Currently, emergency medical technicians, paramedics, certified athletic trainers, and emergency department personnel typically perform a log roll onto a traditional spine board to stabilize and prepare a patient for transport.[40,68]

Del Rossi et al[72–75] compared the log-roll and lift-and-slide techniques by assessing the spine movement created during these tasks in healthy[73] individuals and in cadavers with surgically destabilized cervical spines.[72,74,75] Compared with the lift-and-slide technique, the log-roll technique produced greater lateral-flexion motion and greater axial rotation of the head in healthy volunteers.[73] In another study,[72] the authors tested cadavers with surgically destabilized cervical spines at the C5–C6 level (a common site of injury in sport-related cervical spine injuries[137]) and found that both techniques created the same amount of movement at the injured cervical spine level. However, only flexion-extension angles were analyzed in that investigation.[72] The same authors[75] studied cervical spine movement in multiple planes during the log-roll and lift-and-slide transfer techniques in cadavers with induced destabilizing injuries. The cadavers were also fitted with various cervical collars, but regardless of the collar applied, the log roll created more rotation and lateral flexion than the lift and slide.[75] In another study[75] of cadavers with destabilized cervical spines, the log-roll technique resulted in more motion than a ''straddle'' lift-and-slide technique and the 6–plus-person lift-and-slide technique in multiple planes of motion.

New devices have been developed to challenge the use of the traditional spine board for head and body immobilization. One device is described as a vacuum mattress, which conforms and stiffens around a patient's body when air is pumped out of the vacuum bag. Several groups have compared the effectiveness of this vacuum mattress to a traditional spine board and found greater comfort[71] and superior immobilization with the vacuum mattress.[57,69,71]

Despite evidence indicating that lift-and-slide techniques may be more effective in minimizing motion than the log roll or that the use of a vacuum-immobilization device is superior to the traditional spine board, no reports indicate that either the log roll or the traditional spine board has resulted in further compromise of a spine injury. Therefore, the log-roll technique (which is the only method that can be used in prone patients) and the traditional spine board are still considered acceptable for transfer and immobilization of the potentially spine-injured athlete.

The Equipment-Laden Athlete

Equipment and Neutral Cervical Spine Alignment. A number of researchers[54,76–79,138–141] have investigated whether athletic equipment affects cervical spine alignment. Most have focused on football and how the helmet and shoulder pads may alter the normal lordotic curvature of the cervical spine.[54,76,77,138,140,141] The equipment worn by ice hockey[77,78,139] and lacrosse[79] athletes has also been investigated.

Numerous authors[76,138,140] have used cadavers to identify the effect of a football helmet and shoulder pads, alone or in combination, on cervical spine alignment. Gastel et al[138] obtained lateral radiographs on 8 cadaver specimens with both intact and unstable C5–C6 segments. Palumbo et al[140] also used radiography to identify cervical spine alignment in 15 cadavers, 8 of which were destabilized at the C5–C6 level. Both groups reported similar cervical alignment when comparing full equipment (helmet and shoulder pads) with no equipment and an increase in cervical lordosis (approximately 14°) when only the shoulder pads were in place.

Donaldson et al[76] identified movement in the unstable cervical spines of cadavers during helmet or shoulder-pad removal (or both). Cadaver specimens had cervical spine instability induced at 1 of 2 levels. Spinal motion was monitored constantly with fluoroscopy while 4 trained individuals removed the equipment. Maximum displacements were identified and compared with the images taken before equipment was removed. Removal of the helmet and shoulder pads correlated with decreased space available for the cord. Helmet removal increased cervical spine flexion, whereas shoulder-pad removal increased extension. Approximately 18° of total movement occurred during equipment removal. Disc height changed 2.3 mm, and the space available for the cord decreased 3.87 mm at the C5–C6 level. The authors[76] concluded that equipment removal is a very complex and difficult task that can result in potentially dangerous cervical spine motion, especially when the cervical spine is unstable.

Prinsen et al[77] used fluoroscopy to identify the position of adjacent vertebrae before, during, and after helmet removal and cervical collar application in 11 football players. Vertebral position changed during helmet removal, application of a cervical collar, and while the player lay helmet-less on the spine board.[77] Swenson et al[141] radiographically analyzed cervical spine alignment in 10 male volunteers immobilized on a spine board and found no difference between the no-equipment and full-equipment (shoulder pads plus helmet) conditions. However, with the helmet removed, cervical lordosis increased approximately 10°.[141] Using MRI in 12 participants lying on a spine board, Tierney et al[54] found that the greatest space available for the cord occurred at 0° of elevation with full equipment. The results of these investigations support the recommendation to leave all football equipment on the athlete whenever a cervical spine injury is suspected.

Similar research has been conducted using fluoroscopy,[77] CT,[139] or traditional radiographs[78] in volunteers wearing ice hockey equipment. No differences were noted between the no-equipment and full-equipment conditions. With the helmet removed but shoulder pads on, cervical lordosis was greater than in the control or full-equipment conditions. As in the case of the football player, all equipment should be left on the ice hockey player with a suspected cervical spine injury, provided that the head can be adequately immobilized and that access to the airway is established.

The effect of lacrosse equipment on cervical spine alignment has been investigated by Sherbondy et al,[79] who compared cervical angles at the levels of the occiput and C2, C2–C7, and the occiput and C-7 in 16 healthy lacrosse players. The cervical angles of the lacrosse players were analyzed in 3 conditions: no equipment, full equipment, and helmet removed. Interestingly, when the lacrosse athletes wore a helmet and shoulder pads (full-equipment condition), lateral CT images revealed an increase in cervical extension (approximately 6°) between the occiput and C7 compared with the no-equipment condition. These changes are different than those previously discussed for football and ice hockey players, in whom the full-equipment conditions left the cervical spine in neutral alignment. With shoulder pads only (helmet removed), cervical flexion increased 4.7° in the occiput to C2 level when compared with full equipment and 4.4° in the C2–C7 level when compared with no equipment.[79] The increased cervical flexion contrasted with the extension angle noted in football and ice hockey players.

More research is needed regarding the appropriate management of lacrosse equipment, as Sherbondy et al[79] only looked at a single combination of helmet and shoulder pads, whereas many types of equipment are available in the marketplace. Based on the rationale already discussed regarding the position of the cervical spine for immobilization and transport, if the presence of the supine lacrosse athlete's equipment results in an extended cervical angle, the helmet and shoulder pads may need to be carefully removed to ensure neutral alignment. However, because we do not know how much motion occurs during the removal of the lacrosse helmet and shoulder pads, the rescuer may also elect to transfer the athlete with appropriately fitting equipment in place, provided airway access has been established via face-mask removal.

External Cervical Immobilization Devices. In the equipment-laden athlete, applying a cervical immobilization device may be difficult because of the lack of space between the helmet and shoulder pads and may actually be contraindicated as a result of the motion incurred.[77] Because the helmet and shoulder pads in some sports (eg, football, ice hockey) provide neutral alignment of the cervical spine, leaving the equipment on without applying a cervical collar before transfer to a spine board is an acceptable practice. One group[81] concluded that a vacuum cervical collar adequately restricted motion in healthy volunteers wearing football equipment. In any sport, if the helmet or shoulder pads must be removed to create neutral alignment, a cervical collar should then be applied immediately.

Helmet, Face-Mask, and Equipment Removal. Although the benefits of wearing protective equipment in terms of reducing the number and severity of impact injuries are obvious, the equipment itself may act as a barrier to effective treatment of an athlete should an injury occur. Knowing how to deal with protective equipment during the immediate care of an athlete with a potential catastrophic cervical spine injury can greatly influence the outcome. Regardless of the sport or the equipment being used, 2 principles should guide management of the equipment-laden athlete with a potential cervical spine injury:

1) Exposure and access to vital life functions (airway, chest for cardiopulmonary resuscitation or use of an automated external defibrillator) must be established or easily achieved in a reasonable and acceptable manner.
2) Neutral alignment of the cervical spine should be maintained while allowing as little motion as possible at the head and neck.

Football

In the sport of American football, each player is required to wear a helmet (with a face mask) and shoulder pads. These helmets must be designed and constructed in such a way as to meet specific certification standards imposed by NOCSAE.[142] These specifications were devised to protect the wearer from head and facial injuries due to impacts. However, the protective face mask impedes airway access after a potentially catastrophic head or neck injury. Removal of a football helmet created alterations in the position of adjacent cervical vertebrae,[77,143] although in a separate study,[88] no changes were seen in disc height, cervical vertebrae translation, or space available for the cord. Regardless of the conflicting findings, because the helmet and shoulder pads in football players create neutral alignment of the cervical spine, whenever possible, these items should remain in place and the face mask should be removed in order to access the airway.

The technique used for face-mask removal should be the one that creates the least head and neck motion, is performed most quickly, is the least difficult, and carries the least chance of failure. Early recommendations for face-mask removal were to cut all the loop straps rather than unscrew the hardware holding them in place.[119] However, a cordless screwdriver is faster[86,144,145] and easier to use,[86] and it creates less torque[145] and motion[86] at the head than do many of the cutting tools commonly used to remove the face mask. Therefore, the cordless screwdriver was recommended for removal of the face mask in place of a cutting tool.[86,145] However, relying solely on a screwdriver can result in problems that are not encountered with a cutting tool. Screws may not be able to be removed, and problems with the helmet hardware (eg, screws, T-nuts), such as corrosion and rust, can cause the screw face to shred, allowing the T-nut to spin with the screw while turning or even to become so rusted as to fuse the hardware together, preventing any turning at all.[82,85,146]

These issues, combined with other issues, such as battery life, led to the early opinion[119] that a cordless screwdriver for face-mask removal is not reliable and should not be used as a primary tool, but the reliability of the cordless screwdriver has now been assessed. At several sport equipment reconditioning facilities across the country, face masks were removed from a large sample of high school football helmets (n = 2584) using a cordless screwdriver. The helmets tested had been used for at least 1 season of play and were at the facilities to be reconditioned. A total of 94% of all screws (9673 of 10 284) were successfully removed. All 4 screws were removed from the face mask with the cordless screwdriver in 84% of the entire sample (2165 successful face-mask removals, out of a possible 2584). Among the 419 failed trials, two-thirds of the helmets only had 1 screw removal failure; the remaining one-third had more than 1 screw fail. A success rate of 84% in face-mask removal from such a large sample of helmets provides evidence that the technique is fairly reliable; data for some individual team helmets within the sample showed 100% success, demonstrating that overall reliability could actually be improved. However, because the face mask could not be removed in 16% of the overall sample, concerns are reasonable.

A prospective study[82] incorporating a combined-tool technique to address the possibility of screw removal failure was performed on a Division II football team. The investigators removed face masks from the helmets of players during the course of a full football season. One researcher used a cordless screwdriver to attempt face-mask removal but was also prepared with a backup cutting tool to cut away loop straps associated with any screw removal failures. At the end of the season, the face mask had been successfully removed from 75 of 76 helmets (a success rate of 98%). Five of 6 loop straps associated with screwdriver failure were removed with the backup cutting tool. One trial was classified as a failure because it exceeded the 3-minute time limit for all trials. In a separate study,[82] investigators traveled to sport equipment reconditioning facilities to test this technique on used helmets after the football season was complete. Of 300 face-mask removal attempts with the screwdriver, 57 failed, but those face masks were successfully removed with the backup cutting tool. Thus, 100% of the face masks were removed with the combined-tool approach. The evidence from both studies indicates that this technique is reliable.

From the research to date, we can conclude that the cordless screwdriver is the most efficient tool for face-mask removal in helmets with 4 loop straps and screw and T-nut attachments. Because screw failure is a possibility, the combined-tool technique provides the rescuer the added security of a backup cutting tool. The backup cutting tool could be one specifically designed for this task, such as the Trainers Angel (Riverside, CA), FM Extractor (Sports Medicine Concepts Inc, Livonia, NY), or a tool used for other purposes, such as an anvil pruner. However, this backup cutting tool must be appropriately matched to the helmet and loop strap type being used.[86]

As helmet, face-mask, loop-strap fastener, and tool designs change, so may these specific recommendations. For example, recent changes in the design of the Riddell Revolution football helmet (Riddell Sports Inc, Elyria, OH) include a quick-release attachment system for the face mask. The quick-release system is currently used to attach only the 2 side loop straps, while the top loop straps are secured with the traditional screw and T-nut configuration (Figure 12). Two of the authors (E.E.S. and L.C.D.; unpublished data, 2008) have conducted preliminary research on the quick-release system and found that the average time to remove the face mask was 34.63 ± 14.24 seconds and that the resultant head motion was less than that with a traditional helmet. Regardless of the tool or attachment system, the goal is always to protect the athlete during the management process by minimizing time, motion, and difficulty.

Face-mask removal precludes the need to remove the helmet and shoulder pads in the prehospital setting. However, there may be situations in which exposure of the head, chest, or body is necessary. As stated earlier, anytime either the helmet or shoulder pads should be removed, rescuers should remove both the helmet and shoulder pads. This practice is followed for several reasons, but most importantly, removal of both the helmet and shoulder pads leaves the cervical spine in neutral alignment.[140] Another consideration is that it is much easier to remove the shoulder pads if the helmet has already been removed. Removal of the helmet and shoulder pads using 4 health care providers has been shown[88] to be effective in limiting motion in the cervical spine of a healthy volunteer, although, as mentioned earlier, other reports[77,143] have provided conflicting results.

Finally, immediate rescue breathing or cardiopulmonary resuscitation may be necessary for the cervical spine–injured football player. In this situation, a pocket mask may be inserted through the face mask and attached to a bag valve mask, allowing the rescuers to ventilate the patient while the face mask is being removed. Ray et al[147] conducted a study to compare pocket-mask insertion techniques. Inserting the pocket mask through the face-mask eye hole produced less cervical spine movement than inserting it between the chin and the face mask. Both techniques produced less movement than removing the side loop straps by manual screwdriver and rotating the mask. Yet the face-mask eye-hole technique is not feasible for all types of football face masks (eg, those with a center bar or a shield attachment).

Figure 12. The Riddell Revolution football helmet (Riddell Sports Inc, Elyria, OH) includes a quick-release attachment system for the face mask. The quick-release system is currently used to attach only the 2 side loop straps, while the top loop straps are secured with the traditional screw and T-nut configuration.

Ice Hockey

In ice hockey, research indicates that players lying supine with the helmet and shoulder pads left in place have neutral cervical spine alignment[78,139] and that removing the helmet may alter that alignment.[77] As is the case with football and lacrosse helmets, an ice hockey helmet is also reported[148] to immobilize the head of an athlete immobilized on a spine board, provided the helmet was applied correctly and securely. These findings indicate that when an ice hockey player may have a cervical spine injury, the helmet should be left in place.

However, anecdotal reports indicate that not all hockey helmets are worn appropriately. Mihalik et al[80] investigated head motion created during a prone log roll in hockey players wearing properly fitted helmets, improperly fitted helmets, and no helmets. The smallest amount of head motion occurred when the volunteers wore no helmet at all. With the improperly fitted helmets, the volunteers' heads moved independently, indicating that the rescuers would be unable to secure appropriate head immobilization during the task. The authors[80] recommended removal of the ice hockey helmet before performing a prone log roll to limit the motion that might otherwise occur. This does present a dilemma, though, in that removal of the ice hockey helmet may cause undue motion in the cervical spine.[77]

If an athlete who is wearing a helmet and shoulder pads has a potential cervical spine injury and the helmet does not provide adequate immobilization or cervical spine alignment or if face-mask removal is not possible, the rescuer may need to remove the helmet. If time and personnel allow, the shoulder pads should also be removed. If time or resources do not allow simultaneous removal of the helmet and shoulder pads, then foam padding or a similar article (eg, folded towel) should be placed under the head of the athlete to maintain neutral alignment in the cervical spine.

Lacrosse and Other Equipment-Laden Sports

In supine lacrosse players, equipment may not create the same neutral positioning of the cervical spine as that created in football and ice hockey players.[79] As is the case with football helmets, a lacrosse helmet can provide head immobilization when an athlete is immobilized on a spine board, provided the helmet is applied correctly and fitted securely.[148] These findings indicate that leaving the equipment in place precludes neutral alignment of the cervical spine. Additionally, in many lacrosse helmets, the face masks are not easily removed. Until we can be certain that lacrosse equipment aligns the cervical spine in a neutral position and that the face mask is easily removed, the lacrosse helmet may need to be removed on the field. At this time, however, no researchers have reported on motion created in the cervical spine during lacrosse helmet removal.

Additional data for lacrosse and many other equipment-laden sports and recreational activities, such as horseback riding, downhill skiing, baseball, softball, and mountain biking, are not available. When dealing with a suspected catastrophic cervical spine injury in athletes in these sports, adhering to the 2 underlying principles of managing the equipment-laden athlete dictates the necessary steps during the management process.

Emergency Department Management

The athletic trainer or team physician should accompany the injured athlete to the hospital for several reasons. This practice provides continuity of care, allows for accurate delivery of clinical information to the emergency department staff, and allows the sports medicine professionals to assist emergency department personnel during equipment removal. Unfortunately, this may be difficult or impossible in some settings. Whether or not the sports medicine professional can accompany the athlete, communication between sports medicine and emergency department staffs during the emergency planning phase is important.

Improved communication between team and hospital personnel can only enhance the care delivered. At a minimum, hospital personnel should understand standards of on-field care for the athlete with a potential spine injury and should receive training regarding the proper approach to equipment removal. We recognize that hospital personnel may be unfamiliar with athletic equipment, including helmets, face masks, shoulder pads, and chest protectors. Sports medicine professionals can be a resource for such information, simultaneously increasing communication and improving collegiality.

Equipment Removal and Imaging. Protective equipment should be removed by appropriately trained professionals in the controlled emergency department environment. Previous recommendations[78] call for clearance plain radiographs to be taken before equipment removal. Although removal of athletic equipment can cause motion in the cervical spine during the process,[76,77] one group[88] concluded that it was possible to remove a football helmet and shoulder pads from healthy volunteers without creating significant motion. Two reports[93,94] documented that obtaining adequate radiographs in healthy, helmeted football players was difficult. In fact, it is difficult to attain adequate visualization of the full cervical spine even in patients without equipment.[149–152] Missed diagnoses with negative consequences in nonhelmeted cervical spine–injured patients have been reported; often these consequences included delayed diagnoses related to improper radiographic choices or interpretations.[152,153] Based on this evidence and the lack of evidence indicating negative consequences caused by equipment removal before radiographic imaging, we cannot make a recommendation to perform radiographic imaging with equipment in place. One group[93] suggested that "guidelines for players' cervical spine imaging should incorporate procedures for removal of equipment before initial radiographic evaluation"; this recommendation offers an alternative to inaccurate diagnoses based on less-than-optimal radiographic findings.

The advent of readily available multidetector CT has replaced the use of plain radiography at many trauma centers, and initial CT evaluation has been recommended[89–92] in cases involving acute cervical spine trauma. Not only is CT more sensitive, but it carries lower rates of missed primary and secondary injuries,[154] which may spur reconsideration of guidelines for the implementation of CT as the primary diagnostic test for helmeted athletes with suspected cervical spine injuries. Lateral CT scout films have been used with good success in several studies,[139,141] and CT films with helmet and shoulder pads in place were adequate for initial diagnosis and triage.[155] Although MRI of acute spinal cord injury in the unhelmeted patient provides excellent visualization of neurologic and soft tissue structures, the amount and type of metal within the modern football helmet results in field inhomogeneity and skew artifact (ie, errors in the image), precluding adequate evaluation of the cervical structures and limiting the value of MRI in this setting.[95]

The Roles of Hypothermia Treatment and High-Dose Corticosteroids in the Acute Management of Cervical Spine Injury

The exact mechanism of action is unclear, but hypothermia may slow metabolism, decrease the demand for oxygen, and inhibit a cascade of deleterious chemicals, such as inflammatory agents and excitatory amino acids.[156,157] Clinical hypothermia has shown promise as a treatment for patients with myocardial infarction, yet potentially deleterious effects (such as sepsis, bleeding, and cardiac arrhythmias) have been demonstrated in patients with brain injury.[157] In addition, rewarming may lead to dangerous drops in blood pressure.[157]

Clinical data on hypothermia as a treatment for brain injury and myocardial infarction are abundant, but few clinical reports have addressed hypothermia for spinal cord injury. Laboratory experiments have shown inconsistent effects, and clinical studies[96,97,156,158–162] have been limited by small sample sizes and a lack of controls. Many unanswered questions concerning hypothermia treatment for spinal cord injury remain, including the following: (1) What is the optimal temperature and duration for hypothermia?[156] (2) How soon after injury must hypothermia be instituted to be effective? (3) Is regional (epidural versus subarachnoid) or systemic cooling more efficacious? (4) What is the best way to rewarm the body after hypothermia without causing harm? Although regional cooling can lead to faster cooling and fewer systemic effects, technical logistics make this treatment impractical in the management of the on-field athlete. A clinical trial is underway to assess the effects of moderate hypothermia (33°C [92°F]) induced via a cooling catheter placed in the femoral artery immediately after injury. Cooling is maintained for a 48-hour period, followed by slow rewarming of 1°C every 8 hours.[163] The catheter has a gauge that allows for temperature monitoring. Despite this clinical trial, hypothermia should be considered an experimental treatment that requires further research before being recommended as a standard component of the on-field spinal cord injury management protocol.

In the early 1990s, the use of high-dose methylprednisolone for the treatment of acute spinal cord injury became the standard of care. Bracken et al[164] found that patients with acute spinal cord injury who were treated with high-dose methylprednisolone within the first 8 hours of injury had significant neurologic improvement at the 6-month follow-up compared with a placebo group. The recommended dose of methylprednisolone is an intravenous bolus of 30 mg/kg body weight over 1 hour, followed by infusion at 5.4 mg/kg per hour for 23 hours. One evidence-based review[98] of the published literature on methylprednisolone revealed serious flaws in data analysis and conclusions, with no clear support for the use of methylprednisolone in patients with acute spinal cord injury. In fact, several studies[98] showed a higher incidence of respiratory and infectious complications with methylprednisolone. Until additional reliable data are available, the use of high-dose methylprednisolone for acute spinal cord injury remains controversial. When possible, each patient or patient's family should be informed about the risks and benefits of the medication before use.

CONCLUSIONS

In no other sport injury are the elements of efficient immediate care, transport, diagnosis, and treatment more critical to the outcome than in the athlete with a potentially catastrophic cervical spine injury. A high level of evidence (ie, prospective randomized trials) on this topic is in most cases impossible to identify or create. However, the recommendations provided in this position statement are based on the best currently available evidence and expert consensus. Technology, equipment, and techniques will undoubtedly evolve, but the primary goals in managing the spine-injured athlete will remain the same: create as little motion as possible and complete the steps of the emergency action plan as rapidly as is appropriate in order to facilitate transport to the nearest emergency treatment facility.

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Appendix A. Clinical Considerations in the Management Protocol for the Spine-Injured Athlete: Transfer and Immobilization

FULL-BODY IMMOBILIZATION

To achieve full spinal immobilization during on-the-field management of an injury, patients are typically transferred and then secured to a long spine board. The task of moving a patient to a spine board can prove challenging, as the head and trunk must be moved as a unit. Spine boarding athletes may present additional challenges, from the size of the athlete to equipment considerations to athletic venue barriers or obstacles, such as spine boarding an athlete from a swimming pool, a pole-vault pit, or a gymnastics foam pit.

A variety of techniques exist to move and immobilize the injured athlete. Rescuers should use the technique that they have reviewed and rehearsed and are most comfortable with and, most importantly, that produces the least amount of spinal movement.

SELECTION OF APPROPRIATE TRANSFER AND SPINE-BOARDING TECHNIQUES

Supine Log-Roll Technique

When transferring an athlete found in the supine position to a spine board, the supine log-roll technique may be used. The rescuer in charge (rescuer 1) provides cervical spine stabilization. Ideally, 3 additional rescuers are positioned on 1 side of the athlete, with rescuer 2 at the shoulders and thorax, rescuer 3 at the hips, and rescuer 4 at the legs. Rescuer 5 is positioned on the opposite side of the athlete with the spine board. Rescuers 2 through 4 reach across the athlete and, on command from rescuer 1, carefully roll the athlete toward them while rescuer 5 positions the spine board at a 45° angle beneath the athlete. On command, rescuers 2 through 4 slowly lower the athlete as rescuer 5 controls the spine board. Throughout this process, rescuer 1 provides all commands while maintaining manual cervical spine immobilization. The supine log-roll technique may also be used for the athlete found in the side-lying position.

Prone Log-Roll Technique

When transferring an athlete found in the prone position to a spine board, the prone log-roll technique may be used. Two variations to this technique are the prone log-roll pull and prone log-roll push. In the prone log-roll pull, the rescuer in charge (rescuer 1) provides cervical spine stabilization, crossing his or her hands initially, so that when the roll is complete, the hands are uncrossed. Ideally, 3 additional rescuers are positioned on 1 side of the athlete, with rescuer 2 at the shoulders and thorax, rescuer 3 at the hips, and rescuer 4 at the legs. Rescuer 1 directs the other rescuers to position themselves on the appropriate side of the athlete. In some instances, the athlete may be prone with the head turned to 1 side. In this case, rescuer 1 directs rescuers 2 through 4 to position themselves on the side opposite the athlete's face. Rescuer 5 is positioned on the same side as the other rescuers, holding the spine board at the feet of the athlete. Rescuers 2 through 4 reach across the athlete and, on command from rescuer 1, carefully roll the athlete by pulling toward them. When the athlete is pulled onto his or her side, rescuers 1 through 4 pause while rescuer 5 carefully slides the spine board between rescuers 2 through 4 and the athlete. On command, rescuers 2 through 4 slowly lower the athlete as rescuer 5 controls the spine board. Throughout this process, rescuer 1 provides all commands while maintaining manual cervical spine immobilization.

It may be difficult for rescuer 5 to slide the spine board between the athlete and rescuers 2 through 4 without touching each other's arms and possibly jeopardizing their hold on the athlete. To address this issue, an alternative technique is the prone log-roll push, shown in Figure 1.

Lift-and-Slide Technique

An alternative to the log roll is the lift-and-slide transfer technique. Variations include the 6–plus-person lift and the straddle lift and slide. In contrast to the log roll, in which the athlete is rolled to a side-lying position and the spine board is positioned beneath him or her, with the lift-and-slide technique the athlete is simply lifted off the ground to allow for spine board placement. The premise behind the lift-and-slide technique is that the work of lifting the athlete is handled efficiently by involving 4 to 7 rescuers. In addition, this technique avoids rolling the injured athlete over the arm, as well as over possibly bulky protective equipment, and, therefore, this technique may be extremely effective at minimizing structural interference that could result in unwanted spinal column movements.[72,73] The lift-and-slide technique may only be used for supine athletes, whereas a prone athlete must be log rolled for transfer to a spine board.

The 6–plus-person lift is shown in Figure 2. A disadvantage of this procedure is that it requires 6 additional rescuers.

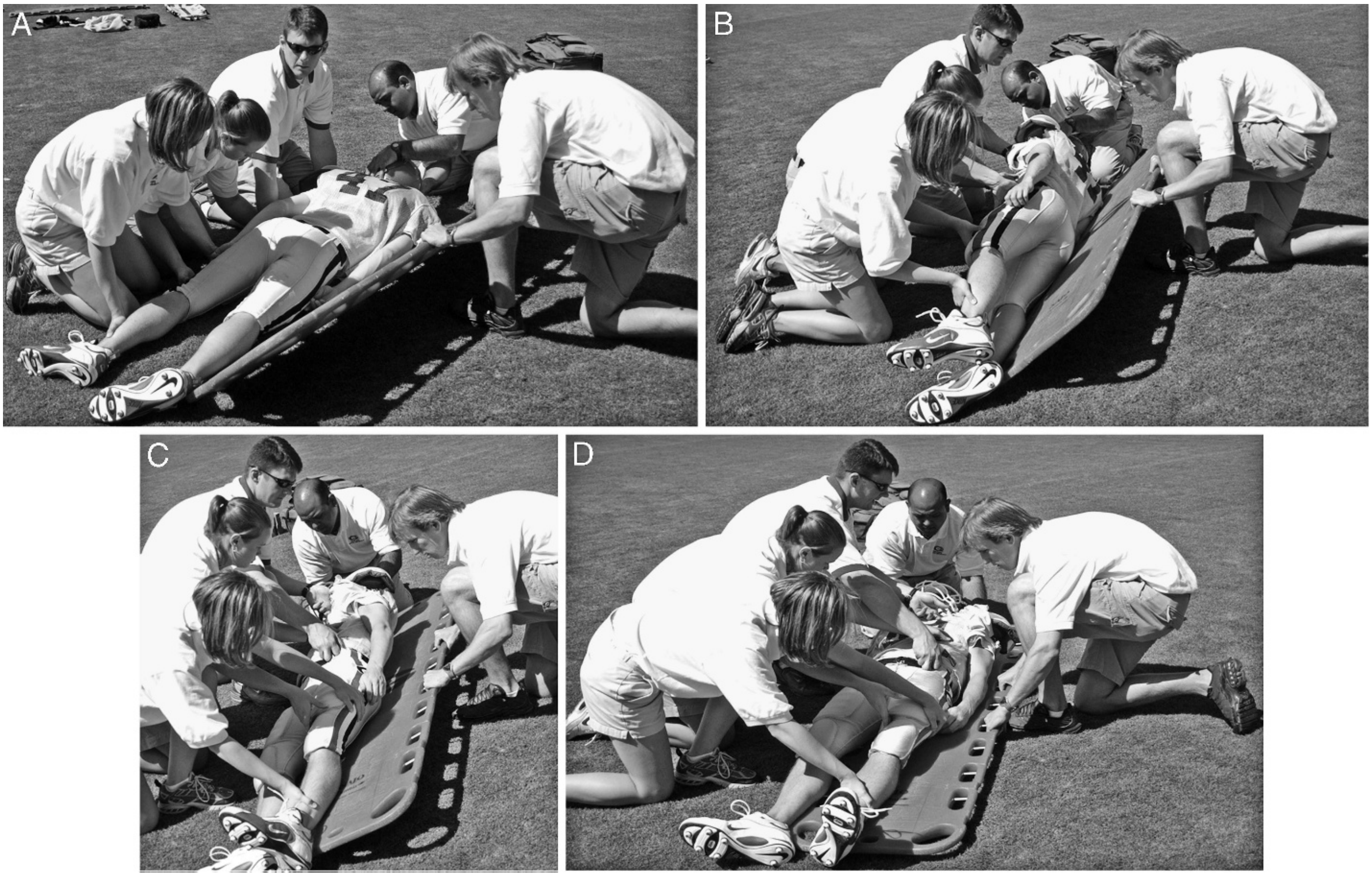

Figure 1. The prone log-roll push technique. A, Rescuer 1 provides cervical spine stabilization. Rescuers 2 through 4 are positioned on the side the athlete's head is facing. Rescuer 5 is on the opposite side, holding the spine board. B, Rescuers 2 through 4 reach across the athlete and, on command from rescuer 1, carefully roll the athlete away from them by pushing toward rescuer 5, who positions the spine board at a 45° angle beneath the athlete. C and D, Rescuers 2 through 4 slowly lower the athlete as rescuer 5 controls the spine board.

An alternative lift technique may be used with 3 rescuers who straddle the athlete rather than lifting from the side; this is referred to as the straddle lift and slide. With the straddle lift and slide, rescuer 1 provides cervical spine stabilization. Three additional rescuers straddle the athlete, with rescuer 2 at the upper torso, rescuer 3 at the hips and pelvis, and rescuer 4 at the legs. On command from rescuer 1, rescuers 2 through 4 lift the athlete approximately 6 inches (15.24 cm) off the ground while rescuer 5 slides the spine board beneath the athlete. On command, rescuers 2 through 4 slowly lower the athlete onto the spine board. Throughout this process, rescuer 1 provides all commands while maintaining cervical spine immobilization.

Other Alternatives for Transfer and Spine Boarding

Another alternative that may be used for transfer or full-body immobilization is the scoop stretcher. A stretcher that is hinged on both ends and has telescoping arms may be used to "scoop" the athlete without having to log roll or lift him or her. As with the lift-and-slide technique, the scoop stretcher may only be used on athletes in the supine position. With the scoop stretcher, the rescuer in charge (rescuer 1) provides cervical spine stabilization. Two additional rescuers, rescuers 2 and 3, position the stretcher. Rescuers 2 and 3 first adjust the length of the stretcher to the athlete using the telescoping arms. Because the stretcher is hinged at both ends, 2 different techniques may be used. Rescuers 2 and 3 may open both hinges, separating the stretcher into 2 sections. Rescuer 2 positions the stretcher from one side, carefully sliding the stretcher beneath the athlete, while rescuer 3 does the same from the other side. They then work together to align the hinges and reconnect the scoop stretcher. An alternate technique is to open only one hinge and spread the scoop stretcher open in the shape of a "V," position the stretcher at one end of the athlete, and then carefully close it, sliding the stretcher beneath the athlete and reconnecting the open hinge. The athlete may be secured to the scoop stretcher itself or, once the athlete is on the scoop stretcher, the lift-and-slide technique may be used. Rescuers raise the stretcher as a unit from both sides and slide a spine board beneath the scoop stretcher. The athlete may then be secured to the spine board. When using the scoop stretcher, rescuers should be aware that it may be difficult to close and secure the hinge at the top of the stretcher without interfering with rescuer 1's maintenance of cervical spine stabilization. It may be necessary for a rescuer to assume cervical spine control from the front of the athlete for rescuer 1 to allow for the top hinge to be secured. Additionally, it may be difficult to close the hinge(s) on heavier athletes as a result of their weight or on athletes who are wearing protective gear, such as shoulder pads.

Another alternative used for transfer or spine boarding is vacuum immobilization. The vacuum-immobilization system is based upon the same principle as extremity vacuum splints.

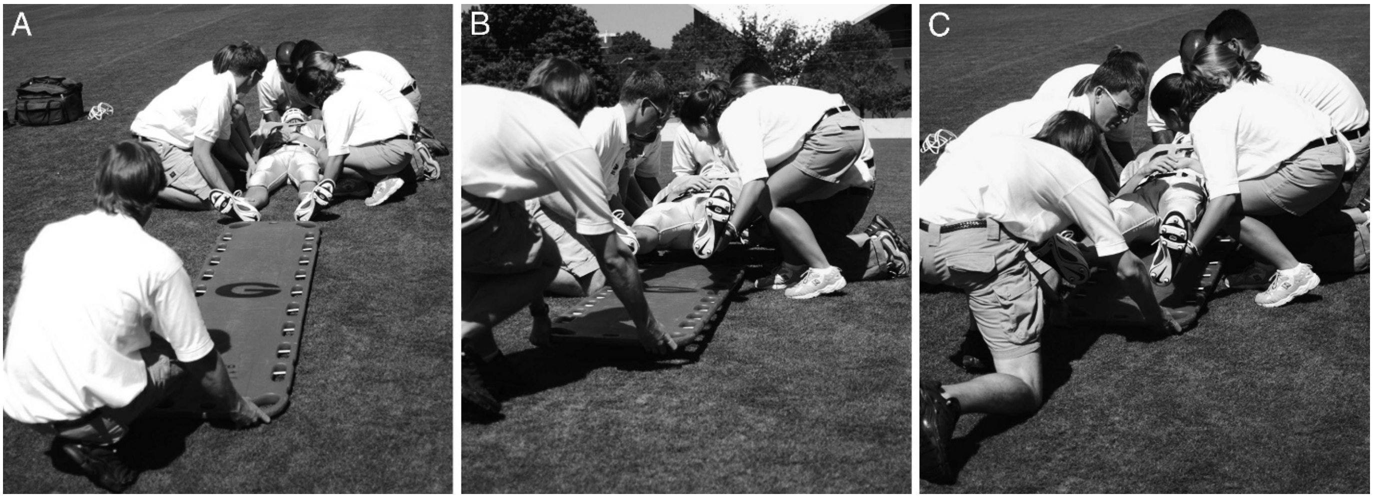

Figure 2. The 6–plus-person lift. A, Rescuer 1 provides cervical spine stabilization. Rescuers 2 through 4 are positioned on one side at the shoulders and thorax, hips, and legs, respectively; rescuers 5 through 7 are positioned similarly on the other side. Rescuer 8 is at the athlete's feet with the spine board. B, On command from rescuer 1, rescuers 2 through 7 lift the athlete approximately 6 inches off the ground, while rescuer 8 slides the spine board beneath the athlete. C, Rescuers 2 through 7 slowly lower the athlete onto the spine board.

Originally developed in Europe, the vacuum-immobilization systems for the spine are now available in the United States. The system is composed of a large nylon shell filled with tiny Styrofoam (The Dow Chemical Co, Midland, MI) beads. The system is spread out flat, and an air pump is used to withdraw air from the shell, making it semirigid. The athlete is then placed on the system, using either the log-roll or lift-and-slide technique. Air is pumped into the shell and the system conforms to the athlete. Then air is again withdrawn, creating a custom, form-fitted, full-body splint. Straps are built into the system to secure the athlete. An advantage of the vacuum-immobilization system is athlete comfort,[71] as a result of the softness of the Styrofoam bead shell and the custom fit, which protects areas of bony prominence (eg, scapula, pelvis) that may develop pain and ischemic injury from prolonged compression on a hard surface, such as a standard spine board. The system also provides support to contour areas, such as the lumbar spine, buttocks, and popliteal fossa. Disadvantages are the size of the system, which renders it cumbersome, and the semirigidity of the system. The lift-and-slide technique may be better suited for the vacuum-immobilization system's semirigidity; however, the large size of the system may make it difficult to slide between the rescuers on either side.

Another technique that may be used for transfer or spine boarding is a short-board system such as the Kendrick Extrication Device (KED; Ferno, Wilmington, OH). Traditionally used by emergency medical services personnel for vehicle extrication, the short board may be placed on a patient who is seated or has a flexed trunk. This technique may be useful in immobilizing athletes positioned awkwardly or where equipment barriers exist, such as in the gymnastics pit or pole-vault pit. A systematic review of prehospital spinal immobilization by Kwan and Bunn[165] showed a reduction in motion reported with the short-board technique compared with cervical-collar immobilization. With the short-board technique, rescuer 1 stabilizes the cervical spine from the front of the patient while rescuer 2 positions the short board behind the patient. Straps are used to secure the short board to the patient's chest, abdomen, and hip, and the last straps, with or without tape, secure the head to the board. Once immobilized with the short board, the patient may be extricated and then placed on and secured to a long spine board.

REPOSITIONING AFTER TRANSFER TO THE SPINE BOARD

In many cases, the athlete's position on the spine board after the initial spine-boarding procedure may not be ideal for securing him or her appropriately, particularly when using the log-roll technique. Therefore, it may be necessary to reposition the athlete to assure proper placement. After the initial spine-board placement, rescuer 1 assesses the athlete's overall position on the spine board. The athlete should never be moved perpendicular to the long axis of the board to avoid shearing and the possibility of spinal column movement. Instead, the athlete should be moved

Figure 3. Repositioning after transfer to the spine board. A, Rescuer 1 provides cervical spine stabilization. B, The other rescuers straddle the athlete and C, slide the athlete into position on command.

cephalad or caudad at an angle, depending on his or her position on the spine board. When repositioning, rescuer 1 provides specific commands: "On the count of 3, we are going to slide the athlete up and to the right … ready … 1 … 2 … 3." The rescuers sliding the athlete may either straddle the athlete (Figure 3) or position themselves on both sides and slide from the sides. Throughout this process, rescuer 1 provides all commands while maintaining cervical spine immobilization.

Head Immobilization

A variety of head-immobilization options are available for securing the athlete to a spine board, including commercial devices, contoured helmet blocks, foam blocks, and towel rolls. Although once used extensively, sand bags are no longer recommended as head-immobilization devices because of their weight. If the spine board must be turned on its side, the sand bags will move the head laterally, compromising the cervical spine. Rescuers should select the head- immobilization technique with which they are most comfortable and be skilled in the use of that particular technique. *The head should always be the last part secured to the spine board.* Once the selected head-immobilization device stabilizes the head, either tape or hook-and-loop straps secure the head to the spine board. Two separate points of contact at the chin and the forehead[78] should be secured to prevent as much head and neck motion as possible. The tape or strap at the forehead should be placed at the level of the eyebrows to avoid slipping off the rounded top of the head. When using tape to secure the forehead, the rescuer applies the tape circumferentially for additional stability. The rescuer tears off a strip of tape approximately 4 ft (1.22 m) in length and "shimmies" the tape beneath the spine board, holding a tape end in each hand. One side of tape is pulled across the forehead at the level of the eyebrows, followed by the other side across the first piece (Figure 4). During this process, it may be necessary for a rescuer to assume cervical spine control from the front of the athlete for rescuer 1 to allow the head to be properly secured.

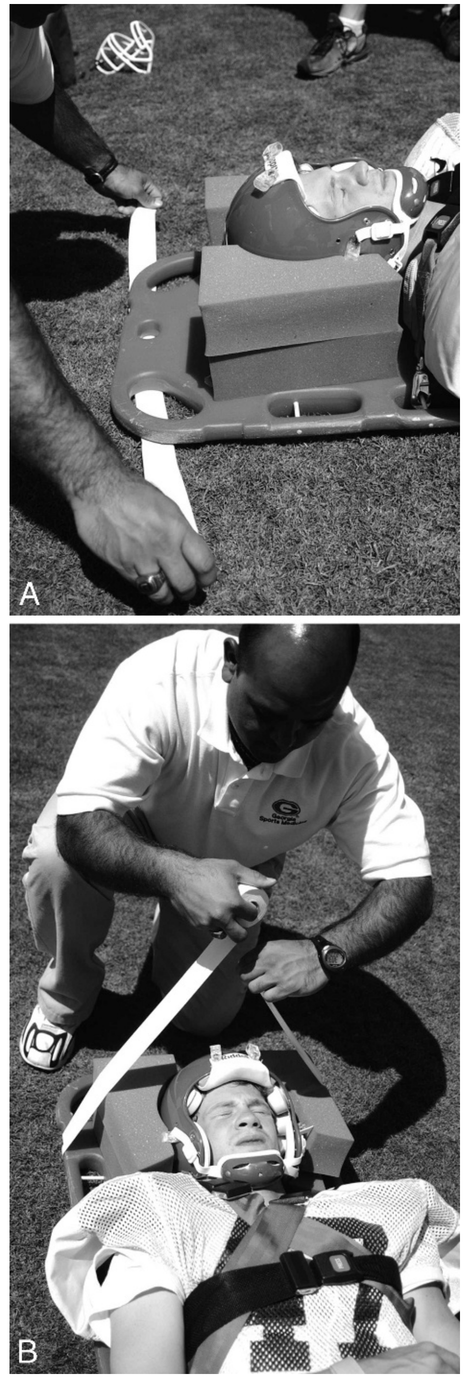

Figure 4. Head immobilization. A, Once the athlete is positioned properly, the rescuer "shimmies" a 4-ft (1.22-m) length of tape under the spine board. B, One side of the tape is pulled across the forehead at the level of the eyebrows, followed by the other side across the first piece.

Types of Spine Boards and Full-Body Immobilization Devices

A variety of spine boards and full-body immobilization devices exist. The most commonly used device is the standard spine board. In the past, these boards were typically wood; however, most spine boards today are constructed of lighter fiberglass or a similar composite, offering increased strength and durability and easier cleaning, which is particularly important in light of bloodborne pathogens. Oversize spine boards to accommodate larger athletes should be considered based upon the athletic population being covered.

Rigid spine boards may be equipped with nonabsorbent padding. A patient strapped to spine boards may be restrained for several hours throughout the hospital emergency department evaluation and diagnostic testing process. Areas of bony prominence (eg, scapula, pelvis) may develop pain and ischemic injury from prolonged compression on a hard surface. Padding may help to reduce this, making the athlete more comfortable.

Most spine boards are the traditional rectangular shape and have cutouts that serve both as handles and sites to secure straps. Some spine boards are contoured on the bottom with tapered edges to facilitate placing straps and hands into the cutouts, particularly when the spine board is on a soft surface, such as a grass field, on which the weight of the athlete can press the spine board into the ground (Figure 5).

Spine-Board Kit

Individuals responsible for the emergency care of athletes should prepare a spine-board kit to be maintained

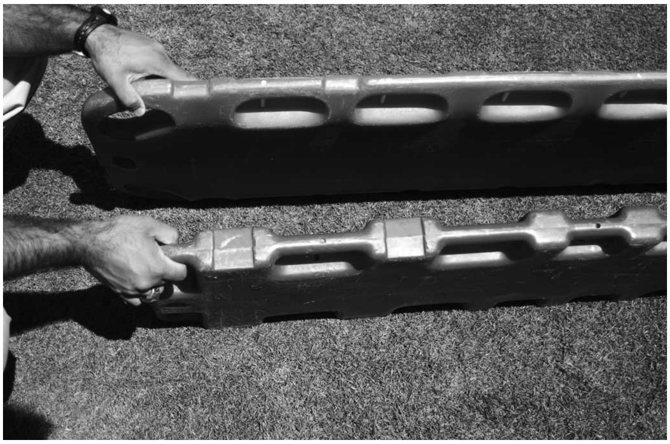

Figure 5. Long spine-board handle designs. The board in the left hand has a beveled bottom, whereas the board in the right hand has recessed handles.

with the spine board. This kit should contain necessary supplies, such as a head-immobilization device, cervical collar, face-mask removal tools for sports in which helmets are worn (ideally on the rescuer's person during competition), straps to secure the athlete to the board, wrist straps to secure the athlete's hands together, tape, and various sizes of padding or toweling. In many cases, padding may be necessary for filling in gaps or spaces to maintain proper spinal column positioning.

Strapping Options and Techniques

Once the athlete is positioned on the spine board, securing with adequate strapping is essential to minimize excess movement during transport and transfers. A variety of strapping options exist, ranging from tape to the traditional 3-strap technique (chest, pelvis, and thighs), to spider straps to speed clips. When securing the athlete to the spine board, the arms should be kept free to facilitate a variety of diagnostic and treatment techniques. Once the torso is secured to the spine board, the hands may be placed together on top of the body using hook-and-loop wrist straps or tape.

In strapping the body to the spine board, the rescuers should use a technique to restrain the athlete as securely as possible. If the athlete vomits, which may occur with a closed head injury, the spine board may need to be turned to the side to allow airway clearance. Proper strapping will minimize lateral movement.

Rescuers should also consider strapping in terms of ambulance transport. With stopping and starting of the vehicle, the athlete may move axially or caudally on the board if not properly secured: such movement places additional stress on the cervical spine. To address this, 2 straps may be crossed in an "X" pattern below one axilla and across the body above the opposite shoulder; the process is repeated on the other side. Additionally, specifically placed strapping should be added to the torso to reduce lateral motion on a backboard.[166] A 7-strap system provides excellent stabilization on the spine board:

Straps 1 and 2: "X" at the chest and run across the shoulders
Strap 3: across chest
Straps 4 and 5: "X" across pelvis
Strap 6: across mid-thighs
Strap 7: across mid-lower legs

MANAGING THE COMBATIVE ATHLETE

As a result of the mechanism of injury, some athletes with cervical spine injuries may have concurrent closed head injuries. In this situation, rescuers may encounter a combative athlete who resists immobilization techniques, whether consciously or reflexively. This creates a problem for the rescuers, who should be aware that attempts to manually restrain a patient's head against his or her will may increase the stresses placed upon the patient's cervical spine. Rescuers should attempt to calm the patient and minimize movement as much as possible based upon the individual circumstances.

Appendix B. Clinical Considerations in the Management Protocol for the Equipment- Laden Athlete With a Spine Injury

FACE-MASK REMOVAL

Combined-Tool Approach

In equipment-laden sports, the face mask is secured to the helmet via loop straps that are screwed into the shell of the helmet with a screw and T-nut configuration. This arrangement can vary in style or number both within and between different types of sports. When the face mask must be removed from the helmet, the tool and technique selected should be those that create the least head and neck motion, are the fastest and easiest to use, and that impose the lowest chance of failure. For football helmets, authors have reported that a screwdriver, or cordless screwdriver, is faster,[86,144,145] easier to use,[86] and creates less torque[145] and motion[86] at the head than many of the cutting tools commonly used to remove the face mask. However, screw removal can fail, and problems with the helmet hardware (screws, T-nuts), such as corrosion and rust, can cause the screw face to shred, allowing the T-nut to spin with the screw while turning or even to become so rusted as to fuse the hardware pieces together, preventing them from turning at all.[85] Therefore, a combined-tool approach provides the rescuer the added security of using a backup cutting tool, but only when necessary.

In describing the combined-tool approach to face-mask removal, we use the example of a football helmet face mask that is attached with 4 separate loop-strap attachments. We refer to the loop-strap locations under the earholes as the left side and right side loop strap or screw locations and the loop straps located at the forehead as the left top and right top loop strap or screw locations.

1. First attempt face-mask removal using a screwdriver.
   a. The 2 side loop straps should be removed first. The top loop straps are then removed. This order prevents the face mask from rotating down onto the athlete's face or throat. Once all the screws are withdrawn far enough that they are totally

removed from the T-nut holding the face mask in place on the underside of the helmet shell, the face mask is simply lifted away, usually with the loop straps still attached to the face mask.

b. Placing pressure on the underside of the loop strap with the thumb of the other hand while unscrewing can assist in separating the screw from the T-nut (Figure 6).

c. If, when attempting to remove the screws from the helmet, 1 or more screws cannot be unscrewed, skip to the next screw until all screws that can successfully be unscrewed are removed.

2. Use a backup cutting tool to cut away any remaining loop strap(s) (Figure 7).

a. Ensure that the cutting tool chosen will successfully cut the loop straps of the helmets currently worn by the football team or teams being covered. Not all face-mask removal tools will remove all helmet or loop-strap combinations.[86] If the home-team athletic trainer is the primary caregiver for the visiting team, he or she should identify the equipment used by the visitors and have the appropriate removal tools available.

b. In some traditional helmets with standard loop straps, the face mask can be rotated to the side, leaving more of the loop strap exposed for easier access with the cutting tool. This technique will not work on all helmet models.

c. The proper technique for cutting loop straps should be used with the chosen removal tool. For example, the Trainers Angel removal tool differs significantly in its cutting mechanism from the FM Extractor. Removal tools often come with instructions for their use. These should be followed and the techniques practiced thoroughly.

d. Loop straps should be cut in such a way as to ensure that the face mask can easily be lifted away from the helmet without loop-strap remnants obstructing removal. Sometimes, more often with the top loop-strap locations, a complete-thickness cut can be made through the entire loop strap. In other cases, it may be necessary to cut a "window" in the loop strap to allow the face-mask bar to be easily extracted; depending on the type of loop strap, at least 2 cuts are required.

e. Practicing face-mask removal is extremely important if cutting loop straps will be the chosen approach, as removing loop straps from face masks using cutting tools can be a difficult skill to perform.[86]

Fortunately, athletic trainers can do much to increase the chances that a screwdriver will be successful in removing a screw and the face mask from a helmet. Weather-related factors have less effect on successful face-mask removal using a screwdriver than other factors that are under human control.[85] With the use of corrosion-resistant hardware in the helmet, more regular equipment maintenance, and annual reconditioning, the chances of all 4 screws being successfully removed from the helmet increase.

Figure 6. Face-mask removal. Placing the thumb behind the top loop strap while unscrewing the screw allows the loop strap to be lifted away once the screw is separated from the T-nut on the underside of the helmet. Reprinted with permission from Gale SD, Decoster LC, Swartz EE. The combined tool approach for face mask removal during on-field conditions. *J Athl Train.* 2008;43(1):14–20.

As helmet, face-mask, and tool designs change, so too may these recommendations. For example, a recently developed face-mask attachment system in football helmets incorporates quick-release loop-strap attachments. To remove the loop straps, the quick-release mechanism is triggered by using the appropriately sized, pointed end of a tool to depress a button, which detaches the T-nut from the inside of the helmet (Figure 8). With any current or future developments in equipment and design, the goal for face-mask removal will always be to perform the task in an efficient manner in order to protect the athlete as much as possible during the management process and to do no further harm.

HELMET AND SHOULDER-PAD REMOVAL

Removal of either the helmet or shoulder pads may be necessary when such equipment prevents access to the airway or chest for primary life-support measures. Equipment removal may also be necessary if the helmet and shoulder pads do not maintain neutral cervical spine or

Figure 7. The backup cutting tool is used to cut away any remaining loop straps.

provide adequate immobilization of the head. Equipment design varies considerably, both among and within equipment-laden sports. This variability requires emergency responders to familiarize themselves with the nuances inherent in individual helmet and shoulder-pad models. The following are general guidelines offered to facilitate an approach to helmet and shoulder-pad removal.

1. The chin strap is removed from the helmet. Cutting away the chin strap is preferable to unsnapping it to avoid unnecessary movement.
2. Cheek pads should be removed from helmets if they interfere with the ability to remove the helmet from the head. Not all cheek pads in all types of helmets interfere with the ability to remove the helmet, so this step can be skipped with certain helmets. However, whether this step is necessary should be determined in advance. The method for removing cheek pads may differ based upon the type of helmet:
    a. Some cheek pads are snapped into place and may be detached using a thin, rigid object, such as a tongue depressor, bite stick, or scissor tip.
    b. Some cheek pads are secured with hook-and-loop straps and may also be removed by sliding a thin, rigid object between the strap sections.
    c. Some cheek pads may require cutting with scissors for complete removal.
3. If the helmet contains air bladders, the air should be drained with a deflation needle or blade to loosen the fit of the helmet and facilitate removal.
4. Before helmet removal, cervical spine stabilization should be transferred from the rescuer at the head to another rescuer, who assumes cervical spine control from the front. The rescuer at the head then grasps the helmet at the sides and gently removes it from the athlete. Slightly spreading the helmet from the sides and rotating the helmet up while sliding it off the head may facilitate removal. However, these techniques should be practiced in advance to ensure they enhance, rather than inhibit, helmet removal (Figure 9).
5. Once the helmet is removed, a cervical collar is placed on the athlete before the shoulder pads are removed. Padding may also need to be placed underneath the head to avoid dropping the head and cervical spine into extension.

Figure 8. Quick-release loop-strap attachments. A, The quick-release mechanism is triggered by depressing the button. B, The T-nut is then detached from the inside of the helmet.

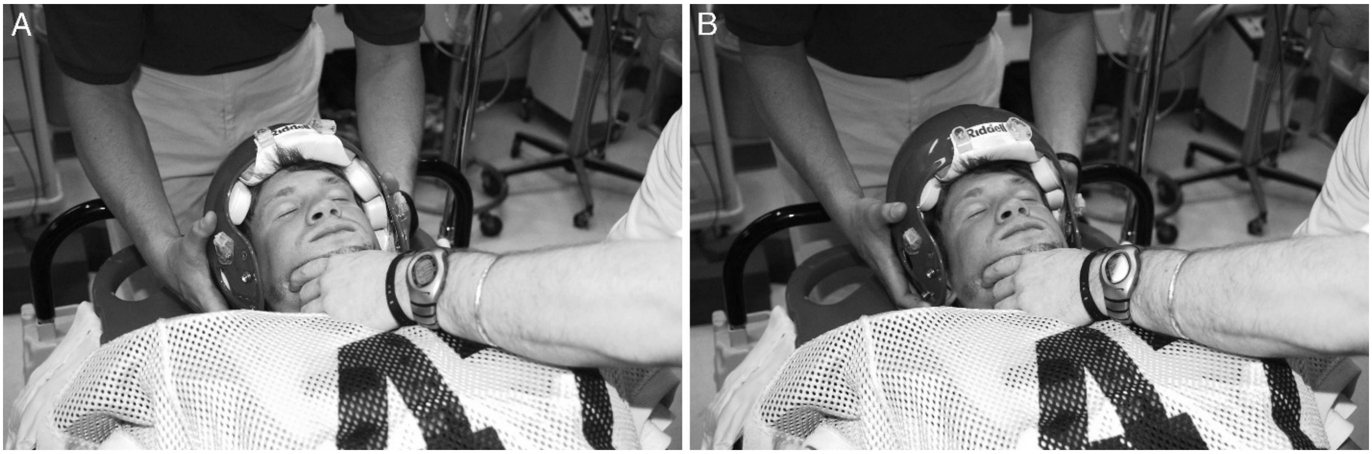

Figure 9. Helmet removal. A, Cervical spine stabilization is transferred from the rescuer at the athlete's head to another rescuer, who assumes control from the front. The rescuer at the head grasps the helmet at its sides and B and C, gently removes it from the athlete.

6. Any uniform top or jersey worn over the shoulder pads should be cut away before removing them. Using scissors, cut along the midline of the jersey, as well as out through each sleeve.
7. Cut through the strings or disconnect or cut through the plastic buckles in front of the shoulder pads.
8. Be aware of additional equipment that may be secured to the shoulder pads, such as rib pads or collars.
9. Remove the shoulder pads using one of the following techniques or a suitable alternative:

   a. A standard technique requires transfer of cervical spine control from the rescuer at the head to another rescuer, who assumes cervical spine control from the front. The rescuer at the head then carefully removes the shoulder pads by sliding them out from under the athlete.
   b. An alternative technique requires cutting the shoulder pads in the front and, if possible, in the back to split the pads into 2 sections. This technique does not require the helmet to be removed first but must be planned in advance, so that the cut in the back of the shoulder pads can be made during a log-roll maneuver. Once both sections of pads have been cut, simply pull apart from the sides while the rescuer at the head maintains cervical spine stabilization.

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National Athletic Trainers' Association Position Statement: Exertional Heat Illnesses

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Objective: To present recommendations for the prevention, recognition, and treatment of exertional heat illnesses and to describe the relevant physiology of thermoregulation.

Background: Certified athletic trainers evaluate and treat heat-related injuries during athletic activity in "safe" and high-risk environments. While the recognition of heat illness has improved, the subtle signs and symptoms associated with heat illness are often overlooked, resulting in more serious problems for affected athletes. The recommendations presented here provide athletic trainers and allied health providers with an integrated scientific and practical approach to the prevention, recognition, and treatment of heat illnesses. These recommendations can be modified based on the environmental conditions of the site, the specific sport, and individual considerations to maximize safety and performance.

Recommendations: Certified athletic trainers and other allied health providers should use these recommendations to establish on-site emergency plans for their venues and athletes. The primary goal of athlete safety is addressed through the prevention and recognition of heat-related illnesses and a well-developed plan to evaluate and treat affected athletes. Even with a heat-illness prevention plan that includes medical screening, acclimatization, conditioning, environmental monitoring, and suitable practice adjustments, heat illness can and does occur. Athletic trainers and other allied health providers must be prepared to respond in an expedient manner to alleviate symptoms and minimize morbidity and mortality.

Key Words: heat cramps, heat syncope, heat exhaustion, heat stroke, hyponatremia, dehydration, exercise, heat tolerance

Heat illness is inherent to physical activity and its incidence increases with rising ambient temperature and relative humidity. Athletes who begin training in the late summer (eg, football, soccer, and cross-country athletes) experience exertional heat-related illness more often than athletes who begin training during the winter and spring.[1–5] Although the hot conditions associated with late summer provide a simple explanation for this difference, we need to understand what makes certain athletes more susceptible and how these illnesses can be prevented.

PURPOSE

This position statement provides recommendations that will enable certified athletic trainers (ATCs) and other allied health providers to (1) identify and implement preventive strategies that can reduce heat-related illnesses in sports, (2) characterize factors associated with the early detection of heat illness, (3) provide on-site first aid and emergency management of athletes with heat illnesses, (4) determine appropriate return-to-play procedures, (5) understand thermoregulation and physiologic responses to heat, and (6) recognize groups with special concerns related to heat exposure.

ORGANIZATION

This position statement is organized as follows:

1. Definitions of exertional heat illnesses, including exercise-associated muscle (heat) cramps, heat syncope, exercise (heat) exhaustion, exertional heat stroke, and exertional hyponatremia;
2. Recommendations for the prevention, recognition, and treatment of exertional heat illnesses;
3. Background and literature review of the diagnosis of exertional heat illnesses; risk factors; predisposing medical conditions; environmental risk factors; thermoregulation, heat acclimatization, cumulative dehydration, and cooling therapies;

Table 1. Signs and Symptoms of Exertional Heat Illnesses

Condition Sign or Symptom*
Exercise-associated muscle (heat) cramps[6,9–11]
Dehydration
Thirst
Sweating
Transient muscle cramps
Fatigue
Heat syncope[10,12]
Dehydration
Fatigue
Tunnel vision
Pale or sweaty skin
Decreased pulse rate
Dizziness
Lightheadedness
Fainting
Exercise (heat) exhaustion[6,9,10,13]
Normal or elevated body-core temperature
Dehydration
Dizziness
Lightheadedness
Syncope
Headache
Nausea
Anorexia
Diarrhea
Decreased urine output
Persistent muscle cramps
Pallor
Profuse sweating
Chills
Cool, clammy skin
Intestinal cramps
Urge to defecate
Weakness
Hyperventilation
Exertional heat stroke[6,9,10,14]
High body-core temperature (>40°C [104°F])
Central nervous system changes
Dizziness
Drowsiness
Irrational behavior
Confusion
Irritability
Emotional instability
Hysteria
Apathy
Aggressiveness
Delirium
Disorientation
Staggering
Seizures
Loss of consciousness
Coma
Dehydration
Weakness
Hot and wet or dry skin
Tachycardia (100 to 120 beats per minute)
Hypotension
Hyperventilation
Vomiting
Diarrhea
Exertional hyponatremia[15–18]
Body-core temperature <40°C (104°F)
Nausea
Vomiting
Extremity (hands and feet) swelling
Low blood-sodium level
Progressive headache
Confusion
Significant mental compromise
Lethargy
Altered consciousness
Apathy
Pulmonary edema
Cerebral edema
Seizures
Coma

*Not every patient will present with all the signs and symptoms for the suspected condition.

4. Special concerns regarding exertional heat illnesses in prepubescent athletes, older athletes, and athletes with spinal-cord injuries;
5. Hospitalization and recovery from exertional heat stroke and resumption of activity after heat-related collapse; and
6. Conclusions.

DEFINITIONS OF EXERTIONAL HEAT ILLNESSES

The traditional classification of heat illness defines 3 categories: heat cramps, heat exhaustion, and heat stroke.[6–8] However, this classification scheme omits several other heat- and activity-related illnesses, including heat syncope and exertional hyponatremia. The signs and symptoms of the exertional heat illnesses are listed in Table 1.

Heat illness is more likely in hot, humid weather but can occur in the absence of hot and humid conditions.

Exercise-Associated Muscle (Heat) Cramps

Exercise-associated muscle (heat) cramps represent a condition that presents during or after intense exercise sessions as an acute, painful, involuntary muscle contraction. Proposed causes include fluid deficiencies (dehydration), electrolyte imbalances, neuromuscular fatigue, or any combination of these factors.[6,9–11,19]

Heat Syncope

Heat syncope, or orthostatic dizziness, can occur when a person is exposed to high environmental temperatures.[19] This condition is attributed to peripheral vasodilation, postural pooling of blood, diminished venous return, dehydration, reduction in cardiac output, and cerebral ischemia.[10,19] Heat syncope usually occurs during the first 5 days of acclimatization, before the blood volume expands,[12] or in persons with heart disease or those taking diuretics.[10] It often occurs after standing for long periods of time, immediately after cessation of activity, or after rapid assumption of upright posture after resting or being seated.

Exercise (Heat) Exhaustion

Exercise (heat) exhaustion is the inability to continue exercise associated with any combination of heavy sweating, dehydration, sodium loss, and energy depletion. It occurs most frequently in hot, humid conditions. At its worst, it is difficult to distinguish from exertional heat stroke without measuring rectal temperature. Other signs and symptoms include pallor, persistent muscular cramps, urge to defecate, weakness, fainting, dizziness, headache, hyperventilation, nausea, anorexia, diarrhea, decreased urine output, and a body-core temperature that generally ranges between 36°C (97°F) and 40°C (104°F).[6,9,10,13,19]

Exertional Heat Stroke

Exertional heat stroke is an elevated core temperature (usually >40°C [104°F]) associated with signs of organ system failure due to hyperthermia. The central nervous system neurologic changes are often the first marker of exertional heat stroke. Exertional heat stroke occurs when the temperature regulation system is overwhelmed due to excessive endogenous heat production or inhibited heat loss in challenging environmental conditions[20] and can progress to complete thermoregulatory system failure.[19,21] This condition is life threatening and can be fatal unless promptly recognized and treated. Signs and symptoms include tachycardia, hypotension, sweating (although skin may be wet or dry at the time of collapse), hyperventilation, altered mental status, vomiting, diarrhea, seizures, and coma.[6,10,14] The risk of morbidity and mortality is greater the longer an athlete's body temperature remains above 41°C (106°F) and is significantly reduced if body temperature is lowered rapidly.[22–24]

Unlike classic heat stroke, which typically involves prolonged heat exposure in infants, elderly persons, or unhealthy, sedentary adults in whom body heat-regulation mechanisms are inefficient,[25–27] exertional heat stroke occurs during physical activity.[28] The pathophysiology of exertional heat stroke is due to the overheating of organ tissues that may induce malfunction of the temperature-control center in the brain, circulatory failure, or endotoxemia (or a combination of these).[29,30] Severe lactic acidosis (accumulation of lactic acid in the blood), hyperkalemia (excessive potassium in the blood), acute renal failure, rhabdomyolysis (destruction of skeletal muscle that may be associated with strenuous exercise), and disseminated intravascular coagulation (a bleeding disorder characterized by diffuse blood coagulation), among other medical conditions, may result from exertional heat stroke and often cause death.[25]

Exertional Hyponatremia

Exertional hyponatremia is a relatively rare condition defined as a serum-sodium level less than 130 mmol/L. Low serum-sodium levels usually occur when activity exceeds 4 hours.[19] Two, often-additive mechanisms are proposed: an athlete ingests water or low-solute beverages well beyond sweat losses (also known as water intoxication), or an athlete's sweat sodium losses are not adequately replaced.[15–18] The low blood-sodium levels are the result of a combination of excessive fluid intake and inappropriate body water retention in the water-intoxication model and insufficient fluid intake and inadequate sodium replacement in the latter. Ultimately, the intravascular and extracellular fluid has a lower solute load than the intracellular fluids, and water flows into the cells, producing intracellular swelling that causes potentially fatal neurologic and physiologic dysfunction. Affected athletes present with a combination of disorientation, altered mental status, headache, vomiting, lethargy, and swelling of the extremities (hands and feet), pulmonary edema, cerebral edema, and seizures. Exertional hyponatremia can result in death if not treated properly. This condition can be prevented by matching fluid intake with sweat and urine losses and by rehydrating with fluids that contain sufficient sodium.[31,32]

RECOMMENDATIONS

The National Athletic Trainers' Association (NATA) advocates the following prevention, recognition, and treatment strategies for exertional heat illnesses. These recommendations are presented to help ATCs and other allied health providers maximize health, safety, and sport performance as they relate to these illnesses. Athletes' individual responses to physiologic stimuli and environmental conditions vary widely. These recommendations do not guarantee full protection from heat-related illness but should decrease the risk during athletic participation. These recommendations should be considered by ATCs and allied health providers who work with athletes at risk for exertional heat illnesses to improve prevention strategies and ensure proper treatment.

Prevention

1. Ensure that appropriate medical care is available and that rescue personnel are familiar with exertional heat illness prevention, recognition, and treatment. Table 2 provides general guidelines that should be considered.[7] Ensure that ATCs and other health care providers attending practices or events are allowed to evaluate and examine any athlete who displays signs or symptoms of heat illness[33,34] and have the authority to restrict the athlete from participating if heat illness is present.

2. Conduct a thorough, physician-supervised, preparticipation medical screening before the season starts to identify athletes predisposed to heat illness on the basis of risk factors[34–36] and those who have a history of exertional heat illness.

3. Adapt athletes to exercise in the heat (acclimatization) gradually over 10 to 14 days. Progressively increase the intensity and duration of work in the heat with a combination of strenuous interval training and continuous exercise.[6,9,14,33,37–44] Well-acclimatized athletes should train for 1 to 2 hours under the same heat conditions that will be present for their event.[6,45,46] In a cooler environment, an athlete can wear additional clothing during training to induce or maintain heat acclimatization. Athletes should maintain proper hydration during the heat-acclimatization process.[47]

4. Educate athletes and coaches regarding the prevention, recognition, and treatment of heat illnesses[9,33,38,39,42,48–51] and the risks associated with exercising in hot, humid environmental conditions.

5. Educate athletes to match fluid intake with sweat and urine losses to maintain adequate hydration.* (See the ''National Athletic Trainers' Association Position Statement: Fluid Replacement in Athletes.''[52]) Instruct athletes to drink sodium-containing fluids to keep their urine clear to light yellow to improve hydration[33,34,52–55] and to replace fluids between practices on the same day and on successive days to maintain less than 2% body-weight change. These strategies will lessen the risk of acute and chronic dehydration and decrease the risk of heat-related events.

*References 9, 29, 37, 38, 40, 41, 43, 52–66.

Table 2. Prevention Checklist for the Certified Athletic Trainer*

1. Pre-event preparation
   - ______Am I challenging unsafe rules (eg, ability to receive fluids, modify game and practice times)?
   - ______Am I encouraging athletes to drink before the onset of thirst and to be well hydrated at the start of activity?
   - ______Am I familiar with which athletes have a history of a heat illness?
   - ______Am I discouraging alcohol, caffeine, and drug use?
   - ______Am I encouraging proper conditioning and acclimatization procedures?
2. Checking hydration status
   - ______Do I know the preexercise weight of the athletes (especially those at high risk) with whom I work, particularly during hot and humid conditions?
   - ______Are the athletes familiar with how to assess urine color? Is a urine color chart accessible?
   - ______Do the athletes know their sweat rates and, therefore, know how much to drink during exercise?
   - ______Is a refractometer or urine color chart present to provide additional information regarding hydration status in high-risk athletes when baseline body weights are checked?
3. Environmental assessment
   - ______Am I regularly checking the wet-bulb globe temperature or temperature and humidity during the day?
   - ______Am I knowledgeable about the risk categories of a heat illness based on the environmental conditions?
   - ______Are alternate plans made in case risky conditions force rescheduling of events or practices?
4. Coaches' and athletes' responsibilities
   - ______Are coaches and athletes educated about the signs and symptoms of heat illnesses?
   - ______Am I double checking to make sure coaches are allowing ample rest and rehydration breaks?
   - ______Are modifications being made to reduce risk in the heat (eg, decrease intensity, change practice times, allow more frequent breaks, eliminate double sessions, reduce or change equipment or clothing requirements, etc)?
   - ______Are rapid weight-loss practices in weight-class sports adamantly disallowed?
5. Event management
   - ______Have I checked to make sure proper amounts of fluids will be available and accessible?
   - ______Are carbohydrate-electrolyte drinks available at events and practices (especially during twice-a-day practices and those that last longer than 50 to 60 minutes or are extremely intense in nature)?
   - ______Am I aware of the factors that may increase the likelihood of a heat illness?
   - ______Am I promptly rehydrating athletes to preexercise weight after an exercise session?
   - ______Are shaded or indoor areas used for practices or breaks when possible to minimize thermal strain?
6. Treatment considerations
   - ______Am I familiar with the most common early signs and symptoms of heat illnesses?
   - ______Do I have the proper field equipment and skills to assess a heat illness?
   - ______Is an emergency plan in place in case an immediate evacuation is needed?
   - ______Is a kiddy pool available in situations of high risk to initiate immediate cold-water immersion of heat-stroke patients?
   - ______Are ice bags available for immediate cooling when cold-water immersion is not possible?
   - ______Have shaded, air-conditioned, and cool areas been identified to use when athletes need to cool down, recover, or receive treatment?
   - ______Are fans available to assist evaporation when cooling?
   - ______Am I properly equipped to assess high core temperature (ie, rectal thermometer)?
7. Other situation-specific considerations

*Adapted with permission from Casa.[7]

Table 3. Wet-Bulb Globe Temperature Risk Chart[62–67]*

WBGT	Flag Color	Level of Risk	Comments
$<$18°C ($<$65°F)	Green	Low	Risk low but still exists on the basis of risk factors
18–23°C (65–73°F)	Yellow	Moderate	Risk level increases as event progresses through the day
23–28°C (73–82°F)	Red	High	Everyone should be aware of injury potential; individuals at risk should not compete
$>$28°C (82°F)	Black	Extreme or hazardous	Consider rescheduling or delaying the event until safer conditions prevail; if the event must take place, be on high alert

*Adapted with permission from Roberts.[67]

6. Encourage athletes to sleep at least 6 to 8 hours at night in a cool environment,[41,35,50] eat a well-balanced diet that follows the Food Guide Pyramid and United States Dietary Guidelines,[56–58] and maintain proper hydration status. Athletes exercising in hot conditions (especially during twice-a-day practices) require extra sodium from the diet or rehydration beverages or both.

7. Develop event and practice guidelines for hot, humid weather that anticipate potential problems encountered based on the wet-bulb globe temperature (WBGT) (Table 3) or heat and humidity as measured by a sling psychrometer (Figure 1), the number of participants, the nature of the activity, and other predisposing risk factors.[14,51] If the WBGT is greater than 28°C (82°F, or ''very high'' as indicated in Table 3, Figure 1), an athletic event should be delayed, rescheduled, or moved into an air-conditioned space, if possible.[69–74] It is important to note that these measures are based on the risk of environmental stress for athletes wearing shorts and a T-shirt; if an

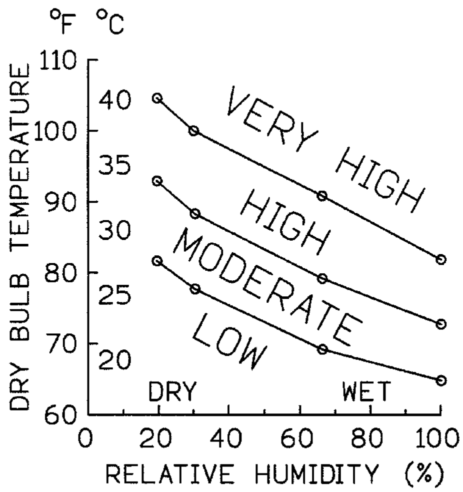

Figure 1. Risk of heat exhaustion or heat stroke while racing in hot environments. However, Figure 2 may be better suited for estimating heat-stroke risk when equipment is worn. Reprinted with permission from Convertino VA, Armstrong LE, Coyle EF, et al. American College of Sports Medicine position stand: exercise and fluid replacement. *Med Sci Sports Exerc.* 1996;28:i–vii.[31]

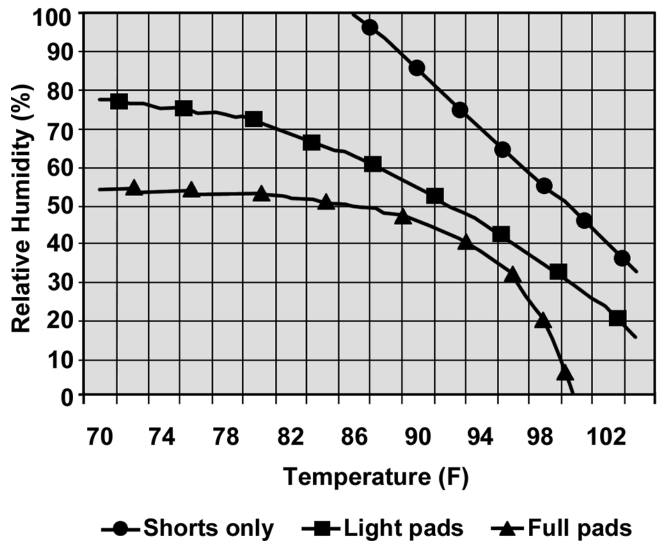

Figure 2. Heat stress risk temperature and humidity graph. Heatstroke risk rises with increasing heat and relative humidity. Fluid breaks should be scheduled for all practices and scheduled more frequently as the heat stress rises. Add 5° to temperature between 10 AM and 4 PM from mid May to mid September on bright, sunny days. Practices should be modified for the safety of the athletes to reflect the heat-stress conditions. Regular practices with full practice gear can be conducted for conditions that plot to the left of the triangles. Cancel all practices when the temperature and relative humidity plot is to the right of the circles; practices may be moved into air-conditioned spaces or held as walk-through sessions with no conditioning activities.

Conditions that plot between squares and circles: increase rest-to-work ratio with 5- to 10-minute rest and fluid breaks every 15 to 20 minutes; practice should be in shorts only with all protective equipment removed.

Conditions that plot between triangles and squares: increase rest-to-work ratio with 5- to 10-minute rest and fluid breaks every 20 to 30 minutes; practice should be in shorts with helmets and shoulder pads (not full equipment).

Adapted with permission from Kulka J, Kenney WL. Heat balance limits in football uniforms: how different uniform ensembles alter the equation. *Physician Sportsmed.* 2002;30(7):29–39.[68]

athlete is wearing additional clothing (ie, football uniform, wetsuit, helmet), a lower WBGT value could result in comparable risk of environmental heat stress (Figure 2).[75,76] If the event or practice is conducted in hot, humid conditions, then use extreme caution in monitoring the athletes and be proactive in taking preventive steps. In addition, be sure that emergency supplies and equipment are easily accessible and in good working order. The most important factors are to limit intensity and duration of activity, limit the amount of clothing and equipment worn, increase the number and length of rest breaks, and encourage proper hydration.

Modify activity under high-risk conditions to prevent exertional heat illnesses.[19,21] Identify individuals who are susceptible to heat illnesses. In some athletes, the prodromal signs and symptoms of heat illnesses are not evident before collapse, but in many cases, adept medical supervision will allow early intervention.

8. Check the environmental conditions before and during the activity, and adjust the practice schedule accordingly.[29,38,41,42,60] Schedule training sessions to avoid the hottest part of the day (10 AM to 5 PM) and to avoid radiant heating from direct sunlight, especially in the acclimatization during the first few days of practice sessions.[9,29,33,34,38,40,50,60]

9. Plan rest breaks to match the environmental conditions and the intensity of the activity.[33,34] Exercise intensity and environmental conditions should be the major determinants in deciding the length and frequency of rest breaks. If possible, cancel or postpone the activity or move it indoors (if air conditioned) if the conditions are "extreme or hazardous" (see Table 3) or "very high" (see Figure 1) or to the right of the circled line (see Figure 2). General guidelines during intense exercise would include a work:rest ratio of 1:1, 2:1, 3:1, and 4:1 for "extreme or hazardous" (see Table 3) or "very high" (see Figure 1), "high," "moderate," or "low" environmental risk, respectively.[41,77] For activities such as football in which equipment must be considered, please refer to Figure 2 for equipment modifications and appropriate work:rest ratios for various environmental conditions. Rest breaks should occur in the shade if possible, and hydration during rest breaks should be encouraged.

10. Implement rest periods at mealtime by allowing 2 to 3 hours for food, fluids, nutrients, and electrolytes (sodium and potassium) to move into the small intestine and bloodstream before the next practice.[34,50,77]

11. Provide an adequate supply of proper fluids (water or sports drinks) to maintain hydration[9,34,38,40,50,60] and institute a hydration protocol that allows the maintenance of hydration status.[34,49] Fluids should be readily available and served in containers that allow adequate volumes to be ingested with ease and with minimal interruption of exercise.[49,52] The goal should be to lose no more than 2% to 3% of body weight during the practice session (due to sweat and urine losses).[78–82] (See the "National Athletic Trainers' Association Position Statement: Fluid Replacement in Athletes."[52])

12. Weigh high-risk athletes (in high-risk conditions, weigh all athletes) before and after practice to estimate the amount of body water lost during practice and to ensure a return to prepractice weight before the next practice. Following exercise athletes should consume approximately 1–1.25 L (16 oz) of fluid for each kilogram of body water lost during exercise.†

†*References 6, 9, 29, 33, 38, 40, 49, 60, 77, 83.*

13. Minimize the amount of equipment and clothing worn by the athlete in hot or humid (or both) conditions. For example, a full football uniform prevents sweat evaporation from more than 60% of the body.[29,33,40,51,77] Consult Figure 2 for possible equipment and clothing recommendations. When athletes exercise in the heat, they should wear loose-fitting, absorbent, and light-colored clothing; mesh clothing and new-generation cloth blends have been specially designed to allow more effective cooling.‡

14. Minimize warm-up time when feasible, and conduct warm-up sessions in the shade when possible to minimize the radiant heat load in ''high'' or ''very high'' or ''extreme or hazardous'' (see Table 3, Figure 1) conditions.[77]

15. Allow athletes to practice in shaded areas and use electric or cooling fans to circulate air whenever feasible.[66]

16. Include the following supplies on the field, in the locker room, and at various other stations:

- A supply of cool water or sports drinks or both to meet the participants' needs (see the ''National Athletic Trainers' Association Position Statement: Fluid Replacement in Athletes''[52] for recommendations regarding the appropriate composition of rehydration beverages based on the length and intensity of the activity)[29,34,38]
- Ice for active cooling (ice bags, tub cooling) and to keep beverages cool during exercise[29,38]
- Rectal thermometer to assess body-core temperature[39,74,75,87,88]
- Telephone or 2-way radio to communicate with medical personnel and to summon emergency medical transportation[38,39,48]
- Tub, wading pool, kiddy pool, or whirlpool to cool the trunk and extremities for immersion cooling therapy[35,65]

17. Notify local hospital and emergency personnel before mass participation events to inform them of the event and the increased possibility of heat-related illnesses.[41,89]

18. Mandate a check of hydration status at weigh-in to ensure athletes in sports requiring weight classes (eg, wrestling, judo, rowing) are not dehydrated. Any procedures used to induce dramatic dehydration (eg, diuretics, rubber suits, exercising in a sauna) are strictly prohibited.[52] Dehydrated athletes exercising at the same intensity as euhydrated athletes are at increased risk for thermoregulatory strain (see the ''National Athletic Trainers' Association Position Statement: Fluid Replacement in Athletes''[52]).

Recognition and Treatment

19. Exercise-associated muscle (heat) cramps:

- An athlete showing signs or symptoms including dehydration, thirst, sweating, transient muscle cramps, and fatigue is likely experiencing exercise-associated muscle (heat) cramps.
- To relieve muscle spasms, the athlete should stop activity, replace lost fluids with sodium-containing fluids, and begin mild stretching with massage of the muscle spasm.
- Fluid absorption is enhanced with sports drinks that contain sodium.[52,60,87] A high-sodium sports product may be added to the rehydration beverage to prevent or relieve cramping in athletes who lose large amounts of sodium in their sweat.[19] A simple salted fluid consists of two 10-grain salt tablets dissolved in 1 L (34 oz) of water. Intravenous fluids may be required if nausea or vomiting limits oral fluid intake; these must be ordered by a physician.[6,7,52,90,91]
- A recumbent position may allow more rapid redistribution of blood flow to cramping leg muscles.

20. Heat syncope:

- If an athlete experiences a brief episode of fainting associated with dizziness, tunnel vision, pale or sweaty skin, and a decreased pulse rate but has a normal rectal temperature (for exercise, 36°C to 40°C [97°F to 104°F]), then heat syncope is most likely the cause.[19]
- Move the athlete to a shaded area, monitor vital signs, elevate the legs above the level of the head, and rehydrate.

21. Exercise (heat) exhaustion:

- Cognitive changes are usually minimal, but assess central nervous system function for bizarre behavior, hallucinations, altered mental status, confusion, disorientation, or coma (see Table 1) to rule out more serious conditions.
- If feasible, measure body-core temperature (rectal temperature) and assess cognitive function (see Table 1) and vital signs.[19] Rectal temperature is the most accurate method possible in the field to monitor body-core temperature.[34,74,75,87,88] The ATC should not rely on the oral, tympanic, or axillary temperature for athletes because these are inaccurate and ineffective measures of body-core temperature during and after exercise.[75,89,92]
- If the athlete's temperature is elevated, remove his or her excess clothing to increase the evaporative surface and to facilitate cooling.[6,93]
- Cool the athlete with fans,[94] ice towels,[29,38] or ice bags because these may help the athlete with a temperature of more than 38.8°C (102°F) to feel better faster.
- Remove the athlete to a cool or shaded environment if possible.
- Start fluid replacement.[6,52,93,95]
- Transfer care to a physician if intravenous fluids are needed[6,52,90,91,96] or if recovery is not rapid and uneventful.

22. Exertional heat stroke:

- Measure the rectal temperature if feasible to differentiate between heat exhaustion and heat stroke. With heat stroke, rectal temperature is elevated (generally higher than 40°C [104°F]).[19]
- Assess cognitive function, which is markedly altered in exertional heat stroke (see Table 1).
- Lower the body-core temperature as quickly as possible.[34,70,77] The fastest way to decrease body temperature is to remove clothes and equipment and immerse the body (trunk and extremities) into a pool or tub of cold water (approximately 1°C to 15°C [35°F to 59°F]).[32,91,92,97–99] Aggressive cooling is the most critical factor in the treatment of exertional heat stroke. Circulation of the tub water may enhance cooling.
- Monitor the temperature during the cooling therapy and recovery (every 5 to 10 minutes).[39,87] Once the athlete's rectal temperature reaches approximately 38.3°C to 38.9°C (101°F to 102°F), he or she should be removed from the pool or tub to avoid overcooling.[40,100]
- If a physician is present to manage the athlete's medical care on site, then initial transportation to a medical facility may not be necessary so immersion can continue uninterrupted.

‡*References 8, 9, 29, 33, 38, 40, 53, 59, 84–86.*

If a physician is not present, aggressive first-aid cooling should be initiated on site and continued during emergency medical system transport and at the hospital until the athlete is normothermic.

- Activate the emergency medical system.
- Monitor the athlete's vital signs and other signs and symptoms of heat stroke (see Table 1).[34,95]
- During transport and when immersion is not feasible, other methods can be used to reduce body temperature: removing the clothing; sponging down the athlete with cool water and applying cold towels; applying ice bags to as much of the body as possible, especially the major vessels in the armpit, groin, and neck; providing shade; and fanning the body with air.[39,95]
- In addition to cooling therapies, first-aid emergency procedures for heat stroke may include airway management. Also a physician may decide to begin intravenous fluid replacement.[87]
- Monitor for organ-system complications for at least 24 hours.

23. Exertional hyponatremia:

- Attempt to differentiate between hyponatremia and heat exhaustion. Hyponatremia is characterized by increasing headache, significant mental compromise, altered consciousness, seizures, lethargy, and swelling in the extremities. The athlete may be dehydrated, normally hydrated, or overhydrated.[19]
- Attempt to differentiate between hyponatremia and heat stroke. In hyponatremia, hyperthermia is likely to be less (rectal temperature less than 40°C [104°F]).[19] The plasma-sodium level is less than 130 mEq/L and can be measured with a sodium analyzer on site if the device is available.
- If hyponatremia is suspected, immediate transfer to an emergency medical center via the emergency medical system is indicated. An intravenous line should be placed to administer medication as needed to increase sodium levels, induce diuresis, and control seizures.
- An athlete with suspected hyponatremia should not be administered fluids until a physician is consulted.

24. Return to activity

In cases of exercise-associated muscle (heat) cramps or heat syncope, the ATC should discuss the athlete's case with the supervising physician. The cases of athletes with heat exhaustion who were not transferred to the physician's care should also be discussed with the physician. After exertional heat stroke or exertional hyponatremia, the athlete must be cleared by a physician before returning to athletic participation.[92] The return to full activity should be gradual and monitored.[8,87]

BACKGROUND AND LITERATURE REVIEW

Diagnosis

To differentiate heat illnesses in athletes, ATCs and other on-site health care providers must be familiar with the signs and symptoms of each condition (see Table 1). Other medical conditions (eg, asthma, status epilepticus, drug toxicities) may also present with similar signs and symptoms. It is important to realize, however, that an athlete with a heat illness will not exhibit all the signs and symptoms of a specific condition, increasing the need for diligent observation during athletic activity.

Nonenvironmental Risk Factors

Athletic trainers and other health care providers should be sensitive to the following nonenvironmental risk factors, which could place athletes at risk for heat illness.

Dehydration. Sweating, inadequate fluid intake, vomiting, diarrhea, certain medications,[89,101–103] and alcohol[104,105] or caffeine[106] use can lead to fluid deficit. Body-weight change is the preferred method to monitor for dehydration in the field, but a clinical refractometer is another accurate method (specific gravity should be no more than 1.020).[34,49,107–110] Dehydration can also be identified by monitoring urine color or body-weight changes before, during, and after a practice or an event and across successive days.[53,54]

The signs and symptoms of dehydration are thirst, general discomfort, flushed skin, weariness, cramps, apathy, dizziness, headache, vomiting, nausea, heat sensations on the head or neck, chills, decreased performance, and dyspnea.[52] Water loss that is not regained by the next practice increases the risk for heat illness.[110]

Barriers to Evaporation. Athletic equipment and rubber or plastic suits used for ''weight loss'' do not allow water vapor to pass through and inhibit evaporative, convective, and radiant heat loss.[111,112] Participants who wear equipment that does not allow for heat dissipation are at an increased risk for heat illness.[113] Helmets are also limiting because a significant amount of heat is dissipated through the head.

Illness. Athletes who are currently or were recently ill may be at an increased risk for heat illness because of fever or dehydration.[114–116]

History of Heat Illness. Some individuals with a history of heat illness are at greater risk for recurrent heat illness.[8,117]

Increased Body Mass Index (Thick Fat Layer or Small Surface Area). Obese individuals are at an increased risk for heat illness because the fat layer decreases heat loss.[118] Obese persons are less efficient and have a greater metabolic heat production during exercise. Conversely, muscle-bound individuals have increased metabolic heat production and a lower ratio of surface area to mass, contributing to a decreased ability to dissipate heat.[119–121]

Wet-Bulb Globe Temperature on Previous Day and Night. When the WBGT is high to extreme (see Table 3), the risk of heat-related problems is greater the next day; this appears to be one of the best predictors of heat illness.[121] Athletes who sleep in cool or air-conditioned quarters are at less risk.

Poor Physical Condition. Individuals who are untrained are more susceptible to heat illness than are trained athletes. As the $\dot{V}O_2max$ of an individual improves, the ability to withstand heat stress improves independent of acclimatization and heat adaptation.[122] High-intensity work can easily produce 1000 kcal/h and elevate the core temperature of at-risk individuals (those who are unfit, overweight, or unacclimatized) to dangerous levels within 20 to 30 minutes.[123]

Excessive or Dark-Colored Clothing or Equipment. Excessive clothing or equipment decreases the ability to thermoregulate, and dark-colored clothing or equipment may cause a greater absorption of heat from the environment. Both should be avoided.[113]

Overzealousness. Overzealous athletes are at a higher risk for heat illness because they override the normal behavioral adaptations to heat and decrease the likelihood of subtle cues being recognized.

Lack of Acclimatization to Heat. An athlete with no or minimal physiologic acclimatization to hot conditions is at an increased risk of heat-related illness.[8,37,83,124]

Medications and Drugs. Athletes who take certain medications or drugs, particularly medications with a dehydrating effect, are at an increased risk for a heat illness.[101–106,125–136] Alcohol, caffeine, and theophylline at certain doses are mild diuretics.[106,137,138] Caffeine is found in coffee, tea, soft drinks, chocolate, and several over-the-counter and prescription medications.[139] Theophylline is found mostly in tea and anti-asthma medications.[140]

Electrolyte Imbalance. Electrolyte imbalances do not usually occur in trained, acclimatized individuals who engage in physical activity and eat a normal diet.[141] Most sodium and chloride losses in athletes occur through the urine, but athletes who sweat heavily, are salty sweaters, or are not heat acclimatized can lose significant amounts of sodium during activity.[142] Electrolyte imbalances often contribute to heat illness in older athletes who use diuretics.[143,144]

Predisposing Medical Conditions

The following predisposing medical conditions add to the risk of heat illness.

Malignant Hyperthermia. Malignant hyperthermia is caused by an autosomal dominant trait that causes muscle rigidity, resulting in elevation of body temperature due to the accelerated metabolic rate in the skeletal muscle.[145–147]

Neuroleptic Malignant Syndrome. Neuroleptic malignant syndrome is associated with the use of neuroleptic agents and antipsychotic drugs and an unexpected idiopathic increase in core temperature during exercise.[148–151]

Arteriosclerotic Vascular Disease. Arteriosclerotic vascular disease compromises cardiac output and blood flow through the vascular system by thickening the arterial walls.[115,152]

Scleroderma. Scleroderma is a skin disorder that decreases sweat production, thereby decreasing heat transfer.[149,153]

Cystic Fibrosis. Cystic fibrosis causes increased salt loss in sweat and can increase the risk for hyponatremia.[154,155]

Sickle Cell Trait. Sickle cell trait limits blood-flow distribution and decreases oxygen-carrying capacity. The condition is exacerbated by exercise at higher altitudes.[156,157]

Environmental Risk Factors

When the environmental temperature is above skin temperature, athletes begin to absorb heat from the environment and depend entirely on evaporation for heat loss.[113,158,159] High relative humidity inhibits heat loss from the body through evaporation.[61]

The environmental factors that influence the risk of heat illness include the ambient air temperature, relative humidity (amount of water vapor in the air), air motion, and the amount of radiant heat from the sun or other sources.[2,9,41] The relative risk of heat illness can be calculated using the WBGT equation.[2,43,50,69,77,160,161] Using the WBGT index to modify activity in high-risk settings has virtually eliminated heat-stroke deaths in United States Marine Corps recruits.[159] Wet-bulb globe temperature is calculated using the wet-bulb (wb), dry-bulb (db), and black-globe (bg) temperature with the following equation[49,62,85,162,163]:

$$\mathrm{WBGT} = 0.7\mathrm{T}_{\mathrm{wb}} + 0.2\mathrm{T}_{\mathrm{bg}} + 0.1\mathrm{T}_{\mathrm{db}}$$

When there is no radiant heat load, $T_{db} = T_{bg}$, and the equation is reduced[62] to

$$\mathrm{WBGT} = 0.7\mathrm{T}_{\mathrm{wb}} + 0.3\mathrm{T}_{\mathrm{db}}$$

This equation is used to estimate risk as outlined in Table 3.[13,40,50,61,85] This index was determined for athletes wearing a T-shirt and light pants.[158] The WBGT calculation can be performed using information obtained from electronic devices[42] or the local meteorologic service, but conversion tables for relative humidity and T_{db} are needed to calculate the wet-bulb temperature.[50,162] The predictive value from the meteorologic service is not as accurate as site-specific data for representing local heat load but will suffice in most situations. When WBGT measures are not possible, environmental heat stress can be estimated using a sling psychrometer (see Figures 1, 2).

Several recommendations have been published for distance running, but these can also be applied to other continuous activity sports. The Canadian Track and Field Association recommended that a distance race should be cancelled if the WBGT is greater than 26.7°C (80°F).[39] The American College of Sports Medicine guidelines from 1996 recommended that a race should be delayed or rescheduled when the WBGT is greater than 27.8°C (82°F).[31,72,73] In some instances, the event will go on regardless of the WBGT; ATCs should then have an increased level of suspicion for heat stroke and focus on hydration, emergency supplies, and detection of exertional heat illnesses.

Thermoregulation

Thermoregulation is a complex interaction among the central nervous system (CNS), the cardiovascular system, and the skin to maintain a body-core temperature of 37°C.[9,43,51,164] The CNS temperature-regulation center is located in the hypothalamus and is the site where the core temperature setpoint is determined.[9,43,82,158,164–166] The hypothalamus receives information regarding body-core and shell temperatures from peripheral skin receptors and the circulating blood; body-core temperature is regulated through an open-ended feedback loop similar to that in a home thermostat system.[158,165,167,168] Body responses for heat regulation include cutaneous vasodilation, increased sweating, increased heart rate, and increased respiratory rate.[38,43,51,164,165]

Body-core temperature is determined by metabolic heat production and the transfer of body heat to and from the surrounding environment using the following heat-production and heat-storage equation[166,167]:

$$S = M \pm R \pm K \pm Cv - E$$

where S is the amount of stored heat, M is the metabolic heat production, R is the heat gained or lost by radiation, K is the conductive heat lost or gained, Cv is the convective heat lost or gained, and E is the evaporative heat lost.

Basal metabolic heat production fasting and at absolute rest is approximately 60 to 70 kcal/h for an average adult, with 50% of the heat produced by the internal organs. Metabolic heat produced by intense exercise may approach 1000 kcal/h,[51,164] with greater than 90% of the heat resulting from muscle metabolism.[9,40,42,166]

Heat is gained or lost from the body by one or more of the following mechanisms[9,85]:

Table 4. Physiologic Responses After Heat Acclimatization Relative to Nonacclimatized State

Physiologic Variable	After Acclimatization (10–14 Days' Exposure)
Heart rate	Decreases[46,145]
Stroke volume	Increases[145,147]
Body-core temperature	Decreases[145]
Skin temperature	Decreases[152]
Sweat output/rate	Increases[46,47,149]
Onset of sweat	Earlier in training[46,145]
Evaporation of sweat	Increases[47,152]
Salt in sweat	Decreases[9,50]
Work output	Increases[46,50]
Subjective discomfort (rating of perceived exertion [RPE])	Decreases[50,145]
Fatigue	Decreases[50]
Capacity for work	Increases[46,50]
Mental disturbance	Decreases[50]
Syncopal response	Decreases[9,50]
Extracellular fluid volume	Increases[50]
Plasma volume	Increases[50,150]

Radiation. The energy is transferred to or from an object or body via electromagnetic radiation from higher to lower energy surfaces.[9,43,51,85,166]

Conduction. Heat transfers from warmer to cooler objects through direct physical contact.[9,43,51,85,166] Ice packs and cold-water baths are examples of conductive heat exchange.

Convection. Heat transfers to or from the body to surrounding moving fluid (including air).[9,43,51,85,166] Moving air from a fan, cycling, or windy day produces convective heat exchange.

Evaporation. Heat transfers via the vaporization of sweat§ and is the most efficient means of heat loss.[51,158,169] The evaporation of sweat from the skin depends on the water saturation of the air and the velocity of the moving air.[170–172] The effectiveness of this evaporation for heat loss from the body diminishes rapidly when the relative humidity is greater than 60%.[9,20,164]

Cognitive performance and associated CNS functions deteriorate when brain temperature rises. Signs and symptoms include dizziness, confusion, behavior changes, coordination difficulties, decreased physical performance, and collapse due to hyperthermia.[168,173] The residual effects of elevated brain temperature depend on the duration of the hyperthermia. Heat stroke rarely leads to permanent neurologic deficits[51]; however, some sporadic symptoms of frontal headache and sleep disturbances have been noted for up to 4 months.[168,174,175] When permanent CNS damage occurs, it is associated with cerebellar changes, including ataxia, marked dysarthria, and dysmetria.[174]

Heat Acclimatization

Heat acclimatization is the physiologic response produced by repeated exposures to hot environments in which the capacity to withstand heat stress is improved.[14,43,75,176,177] Physiologic responses to heat stress are summarized in Table 4. Exercise heat exposure produces progressive changes in thermoregulation that involve sweating, skin circulation, thermoregulatory setpoint, cardiovascular alterations, and endocrine adjustments.[29,43,178] Individual differences affect the onset and decay of acclimatization.[29,45,179] The rate of acclimatization is related to aerobic conditioning and fitness; more conditioned athletes acclimatize more quickly.[43,45,180] The acclimatization process begins with heat exposure and is reasonably protective after 7 to 14 days, but maximum acclimatization may take 2 to 3 months.[45,181,182] Heat acclimatization diminishes by day 6 when heat stress is no longer present.[180,183] Fluid replacement improves the induction and effect of heat acclimatization.[184–187] Extra salt in the diet during the first few days of heat exposure also improves acclimatization; this can be accomplished by encouraging the athlete to eat salty foods and to use the salt shaker liberally during meals.

Cumulative Dehydration

Cumulative dehydration develops insidiously over several days and is typically observed during the first few days of a season during practice sessions or in tournament competition. Cumulative dehydration can be detected by monitoring daily prepractice and postpractice weights. Even though a small decrease in body weight (less than 1%) may not have a detrimental effect on the individual, the cumulative effect of a 1% fluid loss per day occurring over several days will create an increased risk for heat illness and a decrease in performance.[110]

During intense exercise in the heat, sweat rates can be 1 to 2.5 L/h (about 1 to 2.25 kilograms [2 to 5 pounds] of body weight per hour) or more, resulting in dehydration. Unfortunately, the volume of fluid that most athletes drink voluntarily during exercise replaces only about 50% of body-fluid losses.[188] Ideally, rehydration involves drinking at a rate sufficient to replace all of the water lost through sweating and urination.[60,77] If the athlete is not able to drink at this rate, he or she should drink the maximum tolerated. Use caution to ensure that athletes do not overhydrate and put themselves at risk for the development of hyponatremia. However, hydration before an event is essential to help decrease the incidence of heat illnesses. For more information on this topic, see the ''National Athletic Trainers' Association Position Statement: Fluid Replacement in Athletes.''[52]

Cooling Therapies

The fastest way to decrease body-core temperature is immersion of the trunk and extremities into a pool or tub filled with cold water (between 1°C [35°F] and 15°C [59°F]).[39,88,91,97] Conditions that have been associated with immersion therapy include shivering and peripheral vasoconstriction; however, the potential for these should not deter the medical staff from using immersion therapy for rapid cooling. Shivering can be prevented if the athlete is removed from the water once rectal temperature reaches 38.3°C to 38.9°C (101°F to 102°F). Peripheral vasoconstriction may occur, but the powerful cooling potential of immersion outweighs any potential concerns. Cardiogenic shock has also been a proposed consequence of immersion therapy, but this connection has not been proven in cooling heat-stroke patients.[39] Cold-water immersion therapy was associated with a zero percent fatality rate in 252 cases of exertional heat stroke in the military.[89] Other forms of cooling (water spray; ice packs covering the body; ice packs on axillae, groin, and neck; or blowing air) decrease body-core temperature at a slower rate compared with cold-water im-

§*References 9, 40, 43, 50, 51, 85, 159, 165, 166.*

mersion.[97] If immersion cooling is not being used, cooling with ice bags should be directed to as much of the body as possible, especially the major vessels in the armpit, groin, and neck regions (and likely the hands and feet), and cold towels may be applied to the head and trunk because these areas have been demonstrated on thermography[173,189] to have the most rapid heat loss.

SPECIAL CONCERNS

Most research related to heat illness has been performed on normal, healthy adults. Child athletes, older athletes, and athletes with spinal-cord injuries have been studied less frequently. The following are suggestions for special populations or those with special conditions.

Children (Prepubescents)

Exercise in hot environments and heat tolerance are affected by many physiologic factors in children. These include decreased sweat gland activity,[190] higher skin temperatures,[191–193] decreased cardiac output (increased heart rate and lower stroke volume) due to increased peripheral circulation,[194] decreased exercise economy,[195] decreased ability to acclimatize to heat (slower and takes longer),[192] smaller body size (issues related to body surface-to-mass ratio), maturational differences,[190] and predisposing conditions (obesity, hypohydration, childhood illnesses, and other disease states).[190,192,196]

- Decrease the intensity of activities that last longer than 30 minutes,[197] and have the athlete take brief rests[50] if the WBGT is between 22.8°C and 27.8°C (73°F and 82°F); cancel or modify the activity if the WBGT is greater than 27.8°C (82°F).[31,69–73] Modification could involve longer and more frequent rest breaks than are usually permitted within the rules of the sport (eg, insert a rest break before halftime).
- Encourage children to ingest some fluids at least every 15 to 30 minutes during activity to maintain hydration, even if they are not thirsty.[197]
- Use similar precautions as listed earlier for adults.

Older Athletes (>50 Years Old)

The ability of the older athlete to adapt is partly a function of age and also depends on functional capacity and physiologic health status.[198–206]

- The athlete should be evaluated by a physician before exercise, with the potential consequences of predisposing medical conditions and illnesses addressed.[9,34–36] An increase has been shown in the exercise heart rate of 1 beat per minute for each 1°C (1.8°F) increase in ambient temperature above neutral (23.9°C [75°F]).[207] Athletes with known or suspected heart disease should curtail activities at lower temperatures than healthy athletes and should have cardiovascular stress testing before participating in hot environments.
- Older athletes have a decreased ability to maintain an adequate plasma volume and osmolality during exercise,[198,208] which may predispose them to dehydration. Regular fluid intake is critical to avoid hyperthermia.

Athletes with Spinal-Cord Injuries

As sport participation for athletes with spinal-cord injuries increases from beginner to elite levels, understanding the disability,[209,210] training methods, and causes of heat injury will help make competition safer.[211] For example, the abilities to regulate heart rate, circulate the blood volume, produce sweat, and transfer heat to the surface vary with the level and severity of the spinal-cord lesion.[208,212–218]

- Monitor these athletes closely for heat-related problems. One technique for determining hyperthermia is to feel the skin under the arms of the distressed athlete.[211] Rectal temperature may not be as accurate for measuring core temperature as in other athletes due to decreased ability to regulate blood flow beneath the spinal-cord lesion.[218–220]
- If the athlete is hyperthermic, provide more water, lighter clothing, or cooling of the trunk,[211,213] legs,[211] and head.[213]

HOSPITALIZATION AND RECOVERY

After an episode of heat stroke, the athlete may experience impaired thermoregulation, persistent CNS dysfunction,[221,222] hepatic insufficiency, and renal insufficiency.[39,223] For persons with exertional heat stroke and associated multisystem tissue damage, the rate of recovery is highly individualized, ranging up to more than 1 year.[8,86,221] In one study, 9 of 10 patients exhibited normal heat-acclimatization responses, thermoregulation, whole-body sodium and potassium balance, sweat-gland function, and blood values about 2 months after the heat stroke.[8] Transient or persistent heat intolerance was found in a small percentage of patients.[83] For some athletes, a history of exertional heat stroke increases the chance of experiencing subsequent episodes.[39]

An athlete who experiences heat stroke may have compromised heat tolerance and heat acclimatization after physician clearance.[35,224,225] Decreased heat tolerance may affect 15% to 20% of persons after a heat stroke-related collapse,[226,227] and in a few individuals, decreased heat tolerance has persisted up to 5 years.[35,224,228] Additional heat stress may reduce the athlete's ability to train and compete due to impaired cardiovascular and thermoregulatory responses.[115,228–230]

After recovery from an episode of heat stroke or hyponatremia, an athlete's physical activity should be restricted[8,86] and the gradual return to sport individualized by his or her physician. The athlete should be monitored on a daily basis by the ATC during exercise.[86] During the return-to-exercise phase, an athlete may experience some detraining and deconditioning not directly related to the heat exposure.[8,86] Evaluate the athlete over time to determine whether there has been a complete recovery of exercise and heat tolerance.[8,86]

CONCLUSIONS

Athletic trainers and other allied health providers must be able to differentiate exercise-associated muscle (heat) cramps, heat syncope, exercise (heat) exhaustion, exertional heat stroke, and exertional hyponatremia in athletes.

This position statement outlines the NATA's current recommendations to reduce the incidence, improve the recognition, and optimize treatment of heat illness in athletes. Education and increased awareness will help to reduce both the frequency and the severity of heat illness in athletes.

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International Paralympic Committee position stand—background and scientific principles of classification in Paralympic sport

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ABSTRACT

The Classification Code of the International Paralympic Committee (IPC), inter alia, mandates the development of evidence-based systems of classification. This paper provides a scientific background for classification in Paralympic sport, defines evidence-based classification and provides guidelines for how evidence-based classification may be achieved.

Classification is a process in which a single group of entities (or units) are ordered into a number of smaller groups (or classes) based on observable properties that they have in common, and *taxonomy* is the science of how to classify. Paralympic classification is interrelated with systems of classification used in two fields:

- *Health and functioning*. The *International Classification of Functioning, Disability and Health* is the most widely used classification in the field of functioning and health. To enhance communication, Paralympic systems of classification should use language and concepts that are consistent with the *International Classification of Functioning, Disability and Health*.
- *Sport*. Classification in sport reduces the likelihood of one-sided competition and in this way promotes participation. Two types of classification are used in sport—performance classification and selective classification. Paralympic sports require selective classification systems so that athletes who enhance their competitive performance through effective training will not be moved to a class with athletes who have less activity limitation, as they would in a performance classification system.

Classification has a significant impact on which athletes are successful in Paralympic sport, but unfortunately issues relating to the weighting and aggregation of measures used in classification pose significant threats to the validity of current systems of classification.

To improve the validity of Paralympic classification, the IPC Classification Code mandates the development of evidence-based systems of classification, an evidence-based system being one in which the purpose of the system is stated unambiguously; and empirical evidence indicates the methods used for assigning class will achieve the stated purpose. To date, one of the most significant barriers to the development of evidence-based systems of classification has been absence of an unambiguous statement of purpose. To remedy this, all Paralympic systems of classification should indicate that the purpose of the system is to promote participation in sport by people with disabilities by *minimising the impact of eligible impairment types on the outcome of competition*. Conceptually, in order to minimise the impact of impairment on the outcome of competition, each classification system should:

- describe eligibility criteria in terms of:
  - type of impairment and
  - severity of impairment;
- describe methods for classifying eligible impairments according to the extent of activity limitation they cause.

To classify impairments according to the extent of activity limitation they cause requires research that develops objective, reliable measures of both impairment and activity limitation and investigates the relative strength of association between these constructs in a large, racially representative sample.

The paper outlines a number of objective principles that should considered when deciding how many classes a given sport should have: the number of classes in a sport should not be driven by the number of athletes in a sport at a single time point.

The International Paralympic Committee (IPC) is the global governing body of the Paralympic Movement, as well as the organiser of the Summer and Winter Paralympic Games. There are 20 Summer and 4 Winter Paralympic sports, and these are presented in table 1, together with Wheelchair Dance Sport, which is not contested at the Paralympic Games but which is governed by the IPC. As indicated, the IPC acts as international federation for eight sports (seven Paralympic and one non-Paralympic), whereas the remaining 17 Paralympic sports are governed by international federations that are structurally independent but have been admitted to the membership of the IPC. These international federations comprise the International Organizations of Sport for the Disabled (IOSDs), which provide sports opportunities for people with specific disabilities (eg, cerebral palsy or vision impairment), and the International Sport-specific federations (eg, Union Cycliste Internationale or International Wheelchair Basketball Federation).

In November 2007, the General Assembly of the IPC approved the IPC Classification Code. The code provides comprehensive guidelines, policies and procedures for the conduct of classification in sports governed by the IPC or its member federations.

From a sports science perspective, the code is significant because it explicitly mandates the development of evidence-based classification

Table 1 Sports governed by the IPC and its member federations as of January 2009

	Sports governed by IPC member federations			
	IOSDs		International Federation Sports	
Sports governed by IPC	Sport	Organisation	Sport	Organisation
Alpine skiing (W)	Boccia	CPISRA	Archery	Fédération International de Tir à l'Arc
Athletics	Football 5-a-side	IBSA	Cycling	Union Cycliste Internationale
Ice sledge hockey (W)	Football 7-a-side	CPISRA	Equestrian	International Equestrian Federation
Nordic skiing (biathlon and cross-country skiing) (W)	Goalball	IBSA	Rowing	International Rowing Federation
Powerlifting	Judo	IBSA	Sailing	International Foundation for Disabled Sailing
Shooting	Wheelchair fencing	IWAS	Table tennis	International Table Tennis Federation
Swimming	Wheelchair rugby	IWAS	Volleyball (sitting)	World Organization for Volleyball for Disabled
Wheelchair dance sport			Wheelchair basketball	International Wheelchair Basketball Federation
			Wheelchair tennis	International Tennis Federation
			Wheelchair curling (W)	World Curling Federation

CPISRA, Cerebral Palsy International Sport and Recreation Association; IBSA, International Blind Sport Association; IPC, International Paralympic Committee; IOSDs, International Organizations of Sport for the Disabled; IWAS, International Wheelchair and Amputee Sports Federation; W, Winter sport.

systems (Code Section 15.2). This position stand has a twofold purpose:

- to provide a theoretically grounded description of the scientific principles underpinning classification in Paralympic sport;
- to define the term *evidence-based classification* and provide guidelines for how it may be achieved.

WHAT IS CLASSIFICATION?

Classification is a process in which a single group of entities (or units) are ordered into a number of smaller groups (or classes) based on observable properties that they have in common.[1 2] Taxonomy is the science of how to classify, its principles, procedures and rules.[2] It is applied in most scientific fields to develop systems of naming and ordering that facilitate communication, understanding and identification of inter-relationships.

Swedish biologist Carl Linnaeus (1707–1778) is considered the father of taxonomy in the natural sciences.[3] In the 10th edition of *Systema Naturae* (1758), Linnaeus introduced a system of binomial nomenclature that was parsimonious yet informative, vastly improving communication in botanical science. For example, the Linnaean term for the European Red Current, *Ribes rubrum*, is a considerably more useful term than *rossularia*, *multiplici acino: seu non spinosa hortensis rubra*, *seu Ribes officinarium*, the most widely accepted alternative of the day. Linnaean classification is still the basis upon which life on earth is classified.

As a science in its own right, taxonomy is made meaningful through its application in other fields of science,[2] such as pathology, botany and zoology for classification of diseases, plants and animals, respectively. The Paralympic movement provides competitive sporting opportunities for people with a range of impairments and, as such, is interrelated with systems of classification used in two fields:

1. health and functioning
2. sport

The following sections describe taxonomic principles from these two fields that are relevant to classification in Paralympic sport.

Classification in health and functioning

The first internationally recognised system for classification of health and functioning was the *International Classification of Impairments, Disabilities, and Handicaps*, published by the World Health Organization in 1980. In 2001, the *International Classification of Impairments, Disabilities, and Handicaps* was revised and renamed the *International Classification of Functioning, Disability and Health* (*ICF*). Internationally, the *ICF* is currently the most widely accepted classification of health and functioning. It is a broad, multipurpose classification that provides a standardised language and structure that may be applied to describing and understanding health-related functioning in a wide variety of contexts and sectors. Further information, including copies of the *ICF*, is available online (http://www.who.int/classifications/icf/en/).

In 2002, Tweedy[4] described the taxonomic relationship between the *ICF* and Paralympic classification. The relationship is presented graphically in fig 1, which maps the domains relevant to Paralympic sport against the comprehensive *ICF* structure. Tweedy[4] proposed applying the language and structure of the *ICF* to the context of Paralympic classification and identified several advantages of doing so, including:

- *ICF* definitions for key terms are clear, unambiguous and internationally accepted. It has been empirically demonstrated that clear definitions enhance the inter-rater reliability of classification systems, particularly when the systems are used by people from a variety of professional and cultural backgrounds;[2]
- the concepts of functioning and disability that are described in the *ICF* are contemporary and internationally accepted, including the inter-relationship between impairment and activity that is central to Paralympic classification;
- the key terms and concepts of the *ICF* are described in six languages—English, French, Spanish, Russian, Chinese and Arabic—and therefore people from a range of non-English-speaking backgrounds can learn about the key aspects of this system in their own language, thereby removing a significant barrier to international understanding of Paralympic classification.

Because of these advantages, the IPC Classification Code uses the language and definitions of the *ICF*. To be consistent, Paralympic classification systems should also conform to *ICF* language and structure. The remainder of this paper uses terms as defined by the *ICF*, the most important of which are presented in the Glossary which is available online.

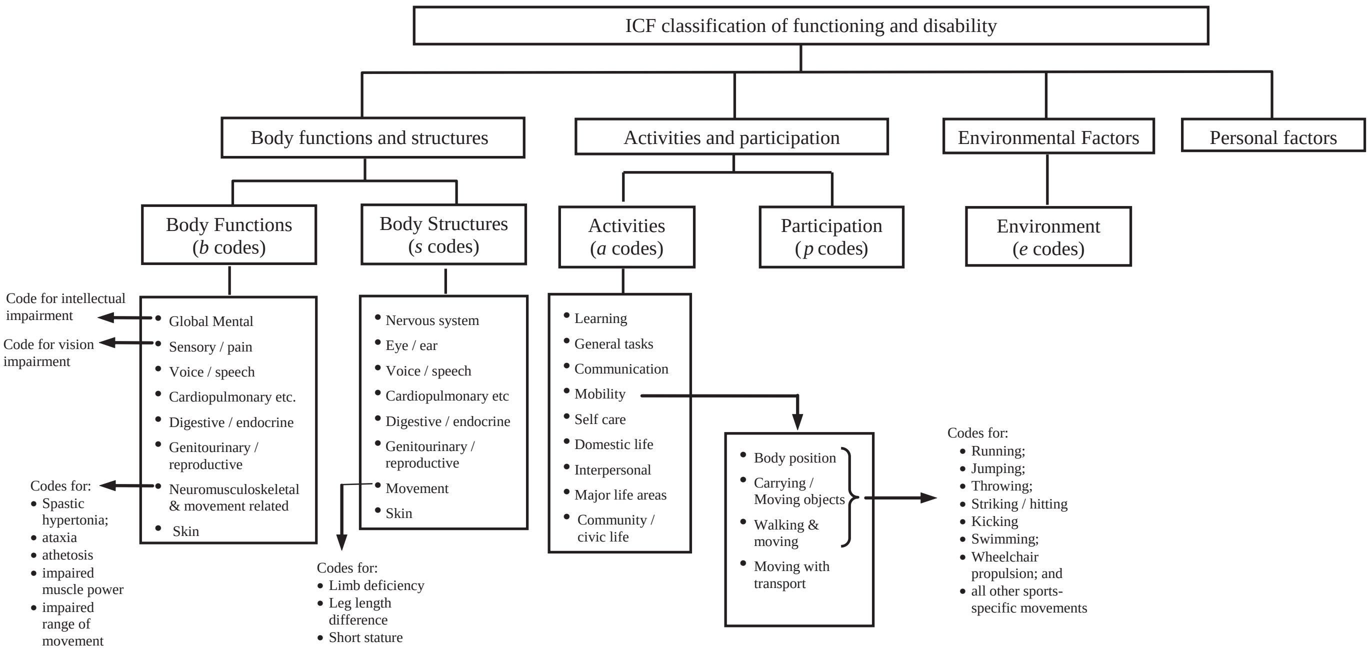

Figure 1 The structure of the International Classification of Functioning, Disability and Health with domains of Paralympic sport mapped.

Classification in sport

Competition is a defining feature of sport and one of several factors that differentiates sport from other physical activities such as exercise, activities of daily living or recreation.[5] Moreover, competition is known to be a potent social factor that motivates many thousands of people to play sport.[6] However, when competition is one-sided or predictable, motivation to participate in sport is reduced, particularly among the unsuccessful.

Classification in sport reduces the likelihood of one-sided competition and in this way promotes participation. Two main forms of classification are used in sport:

- performance classification
- selective classification

Performance classification

Examples of performance classification include the handicap system used in golf, the belt system used in several martial arts and the grading system used to organise competition in football codes (eg, soccer, rugby and American football). These systems of classification group competitors according to their performance in that sport—competitors who perform very well compete together and those who are less accomplished also compete together. In taxonomic terms, the unit of classification is sports performance. Although competitors within a class have a common level of performance, they may vary widely in age and body size, be males or females and, in principle, be disabled or non-disabled. In a performance classification system, competitors who improve their performance through enhanced fitness, skill acquisition or other means are reclassified to a higher performing class. Furthermore, because performance is the basis upon which competitors are placed into classes, competition is usually close and competition results can be used to assess the validity of the classification methods—when competition is close and results are not predictable, the methods used to classify are valid.

Note that many performance classification systems have a "ceiling"—once competitors have reached a certain level of accomplishment, they are no longer classified. For example, golf players with a handicap of zero—or scratch—all compete together. They are not divided into players who only just able to make par and those who shoot well below par.

Selective classification

In contrast to performance classification, the unit of classification in selective classification is not performance but a specified performance determinant or set of determinants (ie, factors known to be strongly predictive of performance). Three types of selective classification are commonly used in modern sports: age-based classification (eg, age divisions in junior sport and masters sport), size-based classification (eg, weight divisions in boxing, wrestling or judo) and sex-based classification (eg, any sport in which males and females compete separately). The units of classification in these examples are, respectively, age, body weight and sex.

The effect of selective classification systems is to minimise the impact of the unit(s) of classification on the outcome of competition. For example, in an 800-m footrace for girls aged 13 years, the impact of sex- and age-related maturation on the outcome of competition is minimised, and the relative impact of other performance determinants—training background, psychology and physiology—is increased. Note that selective classification does not eliminate the impact of the units of classification—maturation among 13-year-old girls can vary considerably—but their impact is typically reduced.

There are other important differences between performance classifications and selective classifications. First, there is generally no ceiling in selective classification systems—they are applied from grass-roots participation to the highest international level. Second, if a competitor in a selective classification system improves their performance through training, their class does not change, as it might in a performance classification system. In selective classification systems, effective training increases a person's competitive standing within their class. Finally, because selective classification systems only control for the effect of a small number of specified performance determinants, performance levels within a given class may vary widely. Consequently, although competition results can be used to evaluate the validity of methods used in a performance classification system, they provide only weak evidence in relation to selective classification systems. The following hypothetical example from the sport of rowing illustrates this point.

Rowing has two weight-based classes: light weight (mean crew weight ≤70 kg and maximum individual weight of 72.5 kg) and heavy weight (no weight restriction). In a given season, an excellent light-weight rowing crew might consistently finish three boat lengths in front of their nearest competitors and may even row faster times than some heavy-weight rowing crews. However, these results do not constitute evidence that the crew has been misclassified. To determine whether the crew had been classified correctly would require that a suitably qualified official weighed each crew member on a correctly calibrated set of scales. The results would then be checked to see whether the individual and combined body weights of the crew members met the guidelines determined by the International Rowing Federation.

As the descriptions above make clear, both performance classification systems and selective classification systems can be said to promote participation by providing a framework for fair and equitable competition. However, the IPC is committed to the development of selective classification systems, not performance systems.

CLASSIFICATION IN PARALYMPIC SPORT

Background

Founded by Dr Ludwig Guttmann in the 1940s, Paralympic sport originated as an extension of the rehabilitation process, and during the early years of the Paralympic movement, classification was medically based. Note that the term *medically based system* is used in this document because it is currently the term most widely used to describe early classification systems. However, the term is problematic because it is not strictly accurate. For example, athletes with spinal cord injury, polio myelitis and spina bifida all competed together despite the fact that these are three separate medical conditions. The structure of medically based classification systems reflected the structure of a rehabilitation hospital, with separate classes for people with spinal cord injuries, amputations, brain impairments and those with other neurological or orthopaedic conditions. Athletes received a single class based on their medical diagnosis and competed in that class for all sports—athletics, swimming, archery and any other sports offered. An athlete with a complete L2 spinal cord injury—resulting in lower limb paresis but normal arm and trunk power—would compete in a separate wheelchair race from a double above-knee amputee because their medical diagnosis was different. The fact that the impairments resulting from their medical condition caused roughly the same activity limitation in wheelchair propulsion was not considered in the classification process because classification was based on medical diagnosis.

As the Paralympic Movement matured, sport ceased to be a mere extension of rehabilitation and became important in its own right. The focus on sport, rather than rehabilitation, drove the development of functional classification systems. (Note that the term *functional classification system* is used in this document because it is currently the term most widely used to describe systems of classification used in Paralympic sports. However, the term *functional classification* is problematic for three reasons: (a) it implies that athletes are placed into classes according to their function, which is misleading (this point is expanded in table 2); (b) the term *function* as it is defined in the *ICF* is a very general umbrella term that be used to refer to any or all of the components of the *ICF*, including body structures, activity or participation in society (see the definition of functioning in the online Glossary). Because it is so general, it is not a useful term for describing classification in Paralympic sport; and (c) within the Paralympic movement the meaning of the term *functional classification system* varies from sport to sport. For example, the functional system in swimming is used to classify athletes with physical impairments, but vision impairment is classified separately; the functional system in athletics separates athletes affected by hypertonia, ataxia and athetosis from those affected by limb deficiency, impaired strength or impaired range of movement (ROM); the functional system in sailing is used to classify athletes with vision and physical impairments.)

In functional systems, the main factors that determine class are not diagnosis and medical evaluation, but how much the impairment of a person impacts upon sports performance. For example, in athletics, an athlete with a complete L2 spinal cord injury now competes in the same class as a double above-knee amputee (class T54). This is because these impairments have an impact on wheelchair propulsion that is approximately the same. Currently, most Paralympic sports use systems of classification that are described as functional, a notable exception being the classification system used by the International Blind Sports Federation, which remains medically based.

In contrast to the medical classification approach, in which athletes competed in the same class for all sports, functional systems of classification are necessarily sports-specific. This is because any given impairment may have a significant

Table 2 Previously proposed statements regarding the conceptual basis of Paralympic classification and why they are unsuitable

Conceptual basis	Problem with this conceptual basis
Place athletes into classes according to their degree of function	Although function is affected by impairment, a range of other factors also affect how well a person functions. These factors include age, fitness and motivation. A person who is old, unfit and unmotivated will not function as well as when they were young, fit and motivated. Moreover, we know that training affects function—if it did not, then athletes would not train. If athletes were placed into classes according to function, then an athlete who was young, motivated and well trained would be placed in a more functional class than someone who was older, unmotivated and poorly trained. Paralympic systems of classification should ensure that young, well-trained athletes should gain a competitive advantage and therefore classifying athletes according to their degree of function is not a suitable conceptual basis for classification in Paralympic sport.
Place athletes into classes according to their degree of performance potential or innate potential	The performance potential or innate potential of an athlete is determined by an array of natural attributes including, but not limited to, impairment. For example, in discus, performance potential or innate potential is obviously negatively influenced by impaired strength. However, performance potential is enhanced by increased standing height, arm span and increased proportion of type II (fast twitch) muscle fibres. If athletes were classified according to such constructs, then tall athletes with long arms and an ideal muscle fibre composition would compete in higher classes than short, endurance-type athletes. Paralympic classification systems should ensure that athletes with the best combination of natural attributes have a competitive advantage over others; therefore, classifying athletes according to their performance potential is not a suitable conceptual basis for classification in Paralympic sport.

impact in one sport and a relatively minor impact in another. For example, the impact that bilateral below elbow amputation has on swimming is relatively large compared with the impact on distance running. Consequently, in sport-specific, functional classification systems, an athlete with such an impairment would compete in a class that had relatively greater activity limitation in swimming than they would in track athletics.

Historically, the transition from medical- to sports-specific functional classification systems began in the late 1970s, but there was considerable debate surrounding the relative merits of the medical and functional approaches, and consequently, the transition was slow.[7] One feature of early functional systems was that they comprised less classes than the existing medical systems.[8] Event organisers favoured fewer classes because the complexity of event organisation was significantly reduced. In 1989, the bodies responsible for organising the Barcelona Paralympic Games—the IPC and the Barcelona Paralympic Organizing Committee—signed an agreement that stipulated that all Paralympic sports contested at the 1992 Barcelona Paralympic Games were to be conducted using sports-specific functional classification systems.[7] This administrative decision greatly accelerated the transition to functional classification systems.

At the time of this decision, many sports had not begun to develop functional systems so, given the short time frame and the absence of relevant scientific evidence, the classification systems that were developed were necessarily based on expert opinion. Within each of the sports, senior Paralympic classifiers from a diverse range of backgrounds—medical doctors, therapists, athletes and coaches—lead the development of functional systems of classification.

Current Paralympic classification

Since the widespread adoption of functional systems of classification, Paralympic sport has continued to mature rapidly. Currently, there are >15 000 registered competitors with the international governing bodies of the 25 Paralympic sports, and a much larger (but indeterminate) number of athletes compete at local and regional levels in their home countries but are not registered internationally. At the elite level, successful Paralympic athletes are receiving increasing peer and community recognition and many receive commercial sponsorship and other financial rewards.

It is well recognised that the classification an athlete is assigned has a significant impact on the degree of success they are likely to achieve. Unfortunately, however, Paralympic classification and classification research have not matured as rapidly as other areas of Paralympic sport and current Paralympic classification systems are still based on the judgement of a small number of experienced classifiers rather than on empirical evidence. As a consequence, the validity of the methods used in functional classification systems is often questionable.

Threats to the validity of current classification methods

In some instances, classification methods have considerable face validity. For example, in a range of Paralympic sports (eg, wheelchair tennis, swimming, sailing and athletics), athletes with a complete spinal cord injury at C7 all compete in the same class, and this is a justifiable grouping because the nature and distribution of impairments caused by a C7 injury will be approximately the same for all people and therefore the injury will have a similar impact on performance in sport. Moreover, lower lesion level is associated with reduced activity limitation and, consequently, athletes with a complete T8 lesion will compete in a different class to those with a C7 lesion. The methods for assigning class in the cases described is based on medical diagnosis and confirmatory clinical evaluation of muscle strength, together with observation of the athlete performing a range of sports-specific and non-sports-specific tests. These methods are typical of those used in many functional classification systems and, for the cases described, the methods appear to be valid. However, as the following paragraphs illustrate, closer scrutiny indicates that there are significant threats to the validity of these methods.

In general, threats to the validity of functional classification methods result from two separate but related measurement issues:

- measurement weighting
- measurement aggregation

The following illustrations of weighting and aggregation issues are based on the current classification system for wheelchair racing for athletes affected by impaired strength.[10] However, the principles apply across the classification systems used in Paralympic sports.

There are four class profiles for wheelchair track racing—T51, T52, T53 and T54—the T indicating the classes are for track racing and 51–54 indicating progressively decreasing severity of impairment. The class profiles are written in terms of loss of strength and may be summarised as follows:

- T51: equivalent activity limitation to person with complete cord injury at cord level C5–6 (elbow flexion and wrist dorsiflexion strength to grade 5, a decrease of shoulder strength especially pectoralis major and triceps strength from grade 0 to 3);
- T52: equivalent activity limitation to person with complete cord injury at cord level C7–8 (normal shoulder, elbow and wrist strength, poor to normal finger flexors and extensors and wasting of the intrinsic muscles of the hands);
- T53: equivalent activity limitation to person with complete cord injury at cord level T1–7 (normal arm strength with little or no innervation of abdominals and lower spinal muscles);
- T54: equivalent activity limitation to person with complete cord injury at cord level T8–S4 (normal arm strength with a range of trunk strength extending from partial trunk control to normal trunk control).

Measurement weighting

Measurement weighting refers to the relative influence of individual measures of impairment on the classification outcome. Based on the profiles above, classification of an athlete who presents with a complete cord injury at T2 would entail confirmatory diagnostic tests and clinical evaluation of strength using manual muscle testing as described by Daniels and Worthingham,[10] and the resulting class would be T53. However, the case of a person with a C6 incomplete injury who has some innervation of abdominal and lower spinal muscles, as well as impaired strength in the upper limbs, is more complicated. Such a person has the same type of impairment as described in the class profile—impaired strength. However, the distribution of the impairment is a mixture of the class descriptions. Consequently, three main outcomes are possible:

- T52: this class will be assigned if the disadvantage caused by having less arm strength than T53 athletes is considered to be greater than the advantage conferred by superior trunk strength;
- T53: this class will be assigned if the disadvantage caused by having less arm strength than T53 athletes is considered to be equal to the advantage conferred by superior trunk strength;
- T54: this class will be assigned if the disadvantage caused by having less arm strength than T53 athletes is considered to be less than the advantage conferred by superior trunk strength.

In the case described, evidence-based decision making requires knowledge of the relative importance—or "weight"—of the trunk and arm muscles in relation to wheelchair propulsion. This knowledge would permit individual strength impairment scores to be meaningfully combined into a single "wheelchair-specific strength impairment score", allowing athletes with different patterns of impairment to be meaningfully compared. Currently, no such evidence exists and therefore decisions are made based on expert opinion. Opinion is usually informed by manual muscle testing of individual muscle groups, observation of sports-specific and non-sports-specific tasks, and assessment of training history.[9]

Figure 2 presents a hypothetical data set, plotting "wheelchair-specific strength impairment" (x-axis) against wheelchair racing performance (y-axis). These data indicate that increasing impairment is associated with slower wheelchair racing time, but that the relationship is curvilinear: small changes in impairment on the left side of the graph are associated with relatively large changes in performance, whereas changes in impairment of a similar magnitude on the right side of the graph are associated with very small changes in performance. The hypothetical strength impairment associated with a complete T2 spinal cord injury is indicated, as are the three relative strength impairment scores associated with a C6 incomplete injury: $C6_a$ causing greater impairment than T2; $C6_b$ the same; and $C6_c$ less.

Measurement aggregation

Challenges with aggregating measurements in classification are highlighted when a system classifies two or more different impairment types. Consider the case of a person with a complete spinal cord injury at T2 and right elbow extension deficit resulting from a co-occurring orthopaedic injury. In the absence of the elbow injury, the athlete would clearly fit in class T53. However, the co-occurrence of a second type of impairment—decreased ROM—leads to two possible outcomes:

- T52: this class will be assigned if the disadvantage caused by reduced elbow ROM in the right arm causes the same or more disadvantage than the bilateral arm weakness experienced by athletes in this class;
- T53 this class will be assigned if the disadvantage caused by reduced elbow ROM in the right arm is relatively minor and causes less disadvantage than the bilateral arm weakness experienced by athletes in the T52 class.

In this case, evidence-based decision making requires knowledge of the relative importance of impaired elbow ROM and strength and a valid means of summing—or aggregating—these scores, which are measured in different units: impaired ROM, measured in degrees; and impaired strength, currently measured using a 0–5 ordinal scale.[10] Evidence-based aggregation would permit results from different impairment types to be meaningfully combined into a single "wheelchair-specific impairment score", which would be the basis of class allocation. Currently, no such evidence exists and therefore expert opinion is required.

Figure 3 presents a hypothetical data set, plotting "wheelchair-specific impairment" (x-axis), a score based on aggregation of measures of wheelchair-specific strength and ROM, against wheelchair racing performance (y-axis). These data indicate increasing impairment is associated with slower racing time. The hypothetical impairment score associated with a complete T2 cord injury is indicated, as are the two relative impairment scores for T2 cord injury combined with impaired elbow ROM: T2+$elbow_1$ causing greater impairment and T2+$elbow_2$ causing a negligible increase in impairment.

DEVELOPING EVIDENCE-BASED SYSTEMS OF CLASSIFICATION—TAXONOMIC REQUIREMENTS

The challenges associated with measurement weighting and aggregation highlight the principal shortcomings in current

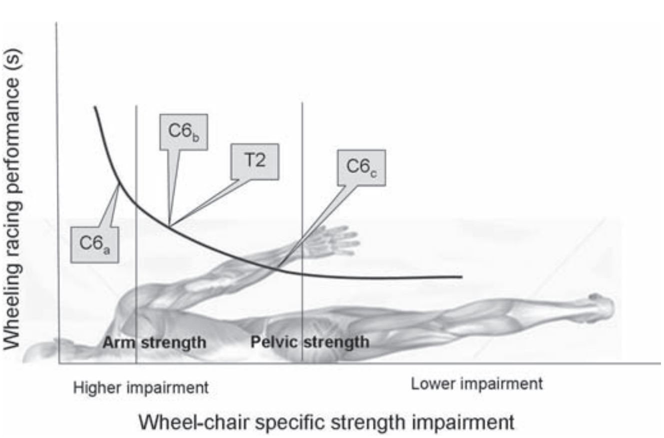

Figure 2 Illustrative graph—wheelchair racing performance versus wheelchair-specific strength impairment. The hypothetical strength impairment associated with a complete T2 spinal cord injury is indicated, as are the three relative strength impairment scores associated with a C6 incomplete injury: C6a causing greater wheelchair-specific strength impairment than T2; C6b the same; and C6c less.

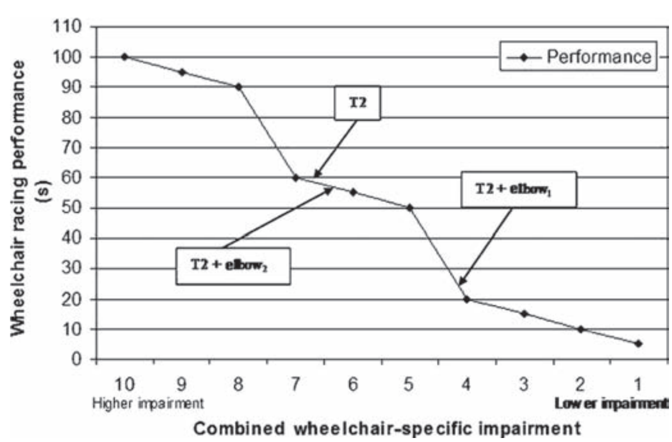

Figure 3 Illustrative graph—wheelchair racing performance versus wheelchair-specific impairment. T2 indicates wheelchair-specific impairment caused by T2 cord injury with no other impairments; T2+elbow1 indicates wheelchair-specific impairment caused by T2 cord injury with elbow extension deficit causing significantly greater activity limitation than T2 injury alone; T2+elbow2, wheelchair-specific impairment caused by T2 injury with elbow extension deficit causing negligible increase in activity limitation.

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approaches to classification. The IPC recognises the need for systems of classification that are evidence-based and explicitly mandates the development of such systems in Section 15 of the Classification Code.[11] This section establishes the taxonomic prerequisites needed for the development of sports-specific, evidence-based systems of classification.

What is an evidence-based system of classification?

In Paralympic sport, an evidence-based system of classification is one in which:

- the system has a clearly stated purpose;
- empirical evidence indicates that the methods used for assigning class will achieve the stated purpose.

To date, one of the most significant barriers to the development of evidence-based systems of classification is that many systems of classification either do not have stated purpose or have a statement of purpose that is ambiguous. For example, many classification systems simply state that the purpose is to provide "fair and equitable competition". This statement is ambiguous because, as identified previously in this paper, fair and equitable sports competition can be achieved by both performance classification systems and selective classification systems. However, the IPC is committed to the development of selective classification systems so that athletes who enhance their competitive performance through effective training will not be moved to a class with athletes who have less activity limitation—as they would in a performance classification system—but will be rewarded by becoming more competitive within the class they were allocated.

The purpose of classification

To facilitate development of evidence-based systems of classification, all Paralympic systems of classification should indicate that the purpose of the system is to promote participation in sport by people with disabilities by *minimising the impact of eligible types of impairment on the outcome of competition*. This statement of purpose was first proposed by Tweedy[4] and is consistent with Section 2.1.1 of the code, which states that "Classification is undertaken to ensure that an athlete's impairment is relevant to sports performance and to ensure that the athlete competes equitably with other athletes". From a taxonomic perspective, adopting the proposed statement of purpose is critical because "impairment" is explicitly identified as the unit of classification, clearly aligning Paralympic classification with other selective classification systems used in sport (eg, age, sex and body weight). When impairment is the unit of classification, then the relative impact of other performance determinants—for example, volume and quality of training and psychological profile—is increased and the athletes who succeed will do so because they are stronger in these areas rather than because they have an impairment that causes less activity limitation.

Conceptually, to minimise the impact of impairment on the outcome of competition, each classification system should:[4]

- describe eligibility criteria in terms of:
  - type of impairment and
  - severity of impairment;
- describe methods for classifying eligible impairments according to the extent of activity limitation they cause.

These three dimensions of the purpose of classification are expanded in the following sections.

Defining eligible types of impairment

Sports should clearly identify which impairment types are eligible and define them according to the *ICF* codes. An example of the outcome of this exercise is presented in the IPC Athletics Classification Project for Physical Impairments.[9] To date, only 10 major types of impairment have been classified in Paralympic sport, these being vision impairment, impaired strength, impaired ROM, limb deficiency, leg length difference, hypertonia, ataxia, athetosis, short stature and intellectual impairment (see fig 1). Section 5 of the code indicates that the type of impairment must be permanent,[11] indicating that it should not resolve in the foreseeable future regardless of physical training rehabilitation or other therapeutic interventions.

It is important to note that many health conditions that cause eligible impairment types affect multiple body structures and functions. For example, in addition to impaired strength, spinal cord injury may also result in impaired sensation (tactile sensation, proprioception or pain), impaired thermoregulatory function and impaired cardiac function. Although some of these associated impairment types may have a significant impact on sports performance, expansion of the types of impairment that are classified in Paralympic sport has the potential to have a significant impact on the culture and fabric of Paralympic sport and should therefore be approached cautiously. Furthermore, every Paralympic sport does not classify all major impairment types and nor are they obliged to. For example, vision impairment is not currently classified in wheelchair sports, and loss of strength is not assessed in judo or goalball. Which of the 10 impairment types is classified in a given Paralympic sport is a matter for each sport to decide. Once decided, the impairment types classified should be clearly stated.

Note that although it is theoretically possible to develop systems of classification in which people with all 10 types of impairment compete together, this approach is not favoured by the IPC. Rather, as Tweedy[12] has previously proposed, there are sound taxonomic reasons for treating the 10 eligible impairment types as at least three distinct groups: (a) biomechanical impairments, comprising the eight impairments that cause activity limitations that are biomechanical in nature—impaired strength, impaired ROM, limb deficiency, leg length difference, hypertonia, ataxia, athetosis and short stature; (b) vision impairments; and (c) intellectual impairments. Biomechanical impairments may also be referred to as neuromusculoskeletal impairments (which is consistent with the *ICF* but which is less informative in a sports context) or physical impairments (which is simple but less precise).

Defining eligible impairment severity

Section 5 of the code indicates that to be eligible, an impairment must impact on sports performance.[11] To ensure that only impairments that impact on the sport are eligible, each Paralympic sport should develop minimum disability criteria. More specifically, each Paralympic sport should identify those activities that are fundamental to performance in that sport and then operationally describe criteria for each eligible impairment type that will impact on the execution of those fundamental activities. For example, determination of minimum disability criteria for vision impairment in alpine skiing should be set by analysing the vision requirements for optimum downhill performance—visual acuity, visual field, contrast sensitivity etc—and then, once they have been identified, developing an operational description of the minimum vision impairment(s) that will sufficiently compromise those requirements to be considered eligible.

There are two important consequences arising from accurately described minimum disability criteria:

- It will be possible for an athlete to have an eligible type of impairment but to be ruled ineligible because the impairment does not meet the relevant minimum disability criterion. For example, although a person who has had a single toe amputated is technically an amputee (an eligible type of impairment), the impairment does not cause sufficient activity limitation in running and therefore does not meet the minimum disability criteria for IPC Athletics.[9]
- Minimum disability criteria will be specific to each sport. Thus, it will be possible for a person to have an impairment that is eligible in one sport but not in another.

Note that minimum disability criteria should describe impairments that directly cause activity limitation in the sport and should exclude impairments that may cause activity limitation in training but do not directly impact on activities that are fundamental to a sport. For example, although the loss of the fingers on one hand will cause activity limitation in certain resistance training exercises considered important in sprinting (eg, the snatch and the power clean), the impairment will cause negligible activity limitation in the sprint events and therefore such an impairment is not eligible in IPC Athletics.[9]

To some extent, determining how much activity limitation will be sufficient is affected by sports culture and more than one view may sometimes be considered valid. Consequently, determination of minimum disability criteria should draw on empirical evidence when it is available but also ensure that it reflects the views of key stakeholders in the sport—athletes, coaches, sports scientists and classifiers.

Classifying impairments according to extent of activity limitation caused

Impairments that meet the eligibility criteria should be divided into classes according to how much activity limitation they cause. To date, a number of other phrases have been used to describe the conceptual basis of classification in Paralympic sports. Table 2 identifies two of the main ones and illustrates why each is not suitable. Note that although it is common to refer to "classifying athletes", the IPC takes this opportunity to reinforce that the unit of classification in Paralympic systems should be impairments, not athletes. This distinction is important because it reinforces that each athlete is a unique, sentient human being whose diversity and individuality cannot be captured by assigning a label or a class.[4 12]

Practical implications

A sound taxonomic structure is a necessary prerequisite for the development of evidence-based systems of classification because it permits the formulation of research questions that can be addressed using conventional experimental science. Paralympic sports seeking to develop evidence-based systems of classification should revise their current systems in light of the information presented in this section. The opening sections of the IPC Athletics Classification Project for Physical Impairments; Final Report—Stage 1[9] provide a working example of how a classification manual can be taxonomically structured so as to permit the experimental research needed to develop an evidence base.

DEVELOPING EVIDENCE-BASED SYSTEMS OF CLASSIFICATION—RESEARCH NEEDS

When systems of classification have the necessary taxonomic structure, including identification of the unit(s) of classification and an unambiguous statement of purpose, the task of developing and empirically evaluating methods of classification through research can be addressed. Fleishman and Quaintance[2] identify two types of classification research:

- product-focused research, which evaluates the relationships between and within the formal set of classes or categories that results from classification;
- process-focused research that includes theoretical work establishing the taxonomic principles underpinning classification systems and empirical research that evaluates the validity of the methods used to place the units into classes.

Development of evidence-based systems of classification requires process-focused research. The remainder of this section illustrates why product-focused research has limited capacity to contribute to development of evidence-based systems of classification and expands upon the process-focused research that is required.

Product-focused research

Product-focused research is of value, but only once evidence-based systems of classification are in place. Examples of previously conducted product-focused research include evaluation of intraclassifier and interclassifier reliability and interclass performance comparisons.[13–16] Figure 4 presents a typical product-focused analysis—a performance comparison of male athletes in four wheelchair racing classes. The y-axis indicates performance (seconds) for four distances—100, 200, 400 and 800 m; and the x-axis indicates wheelchair racing class, T51 being the most impaired and T54 being the least. Although these data clearly demonstrate an inverse relationship between class and performance, they provide only weak evidence that classification in wheelchair racing is valid. This is because there are at least three possible explanations for the results, these being that athletes are classified according to:

- how much their impairment affects performance;
- racing performance alone; or
- a combination of the above.

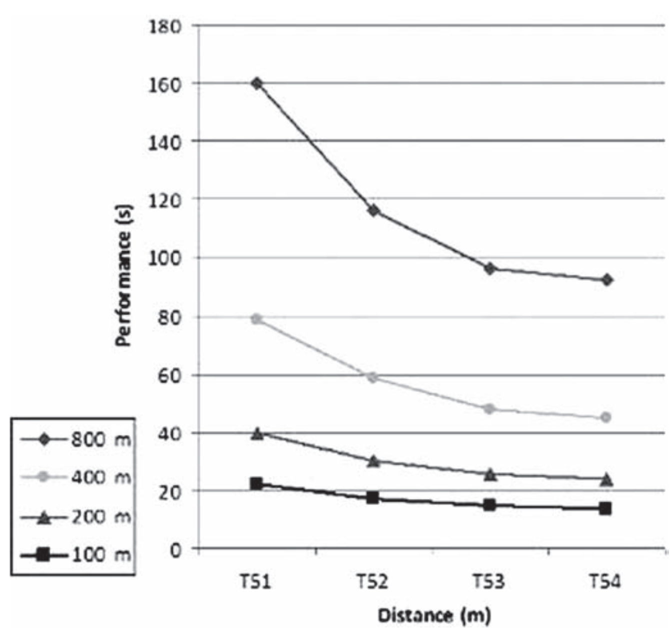

Figure 4 World record times for the four male wheelchair racing classes in Paralympic Athletics for four distances—100, 200, 400 and 800 m.

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It is critical that when researchers aim to develop and validate evidence-based classification systems, they use research designs that validate a classification process rather than evaluate classification product.

Process-focused research—what is required?

It has already been established that a necessary prerequisite for the development of evidence-based systems of classification is an unambiguous statement indicating that the aim of the system is to classify eligible impairments according to the extent of activity limitation they cause. This statement of purpose provides clear direction to researchers aiming to develop evidence-based systems of classification. The initial step requires development of objective, reliable methods for measuring both of the core constructs—impairment and activity limitation:

- *Measurement of impairment*. To date, measurement of impairment in classification has largely been non-instrumented and has depended heavily on clinical judgement, particularly in the biomechanical impairments. In some instances these may still be the most appropriate methods; however, researchers should explore the use of instrumented measures that are simple, readily available, which are more objective and less dependent on user judgement. Criteria for valid tests of impairment are as follows:
  - *Impairment specific*. The test should measure effect of only one impairment type without "contamination" from other impairment types. For example, a tapping test for coordination should require minimal ROM, balance and strength be executed. As far as possible, the test should also exclude the impact of non-eligible impairment types, such as problems with motor planning.
  - *Account for greatest variance in sports performance*. Within the constraints implied by the first criterion, a given test of impairment should account for the maximum possible amount of variance in performance by:
    - assessing the body structures that will impact performance (eg, elbow ROM will impact wheelchair racing; ankle ROM will not);
    - assessing in body positions relevant to sports performance (eg, in tests of impaired coordination for wheelchair racing, participants should be tested in a seated position and movements of the arm should be in the sagittal plane;
    - using composite/multi-joint measures wherever possible.
  - *Where possible, the measure should be resistant to training*. For example, in the sport of athletics, many athletes use plyometric and power training drills to enhance performance. Therefore, if strength impairment was assessed using a plyometric or power measure, it is likely that a well-trained athlete would perform better than untrained athlete of comparable impairment severity, creating the possibility that the well-trained athlete would be placed in a class for athletes with less severe impairments. Isometric strength is not usually trained by athletes and evidence indicates that isometric measures do not respond to power-type training,[17] making it a more suitable measure of strength impairment for the purposes of classification in Paralympic athletics.

Criteria 1 and 2 will lead to tests of impairment that are likely to have modest correlations with performance - correlations being reduced by the fact that only a single performance determinant is being measured, and increased by the fact that only structures that are important to performance are assessed.

- *Measurement of activity limitation*. Methods for evaluating activity limitation will vary according to the sport of interest and the impairment group of interest—biomechanical impairment, vision impairment or intellectual impairment. One approach is to identify the vision, intellectual or biomechanical activities that have the greatest impact on performance in the sport of interest and use these activities as the basis for the development of highly standardised, sports-specific activity limitation test protocols. For example, to push a racing wheelchair rapidly requires two biomechanically distinct activities or techniques—the technique used to accelerate from a stationary position and the technique used to maintain top speed. When athletes with eligible biomechanical impairments (eg, impaired strength, impaired ROM or hypertonia) perform these activities—acceleration from stationary and maintenance of top speed—to the best of their ability, then decreasing performance (measured in seconds) will directly reflect increasing activity limitation in wheelchair racing. To evaluate the impact of impairment on a sports activity, researchers must ensure that all athletes perform exactly the same, highly standardised activity (ie, same equipment, positioning etc): if athletes are permitted to adopt individualised positioning and use strapping and other aids, the activity is effectively changed to a new activity in which the impact of impairment is reduced, making comparison of results across participants problematic.

When appropriate measures have been developed, researchers can acquire measures of impairment and activity limitation from a sample of athletes and analyse the results using appropriate multivariate statistics. The result of the multivariate analysis will be a regression equation that reflects the relative strength of association between the various measures of impairment and activity limitation. The sample of athletes upon which the regression equation is based should be racially representative and as large as practical.

Once a regression equation has been derived and verified through research, it will form the basis of classification process. Classifiers will evaluate athletes using the standardised measures of impairment validated through research, and results from each impairment measure will be entered into the relevant regression equation to obtain a single impairment score. The impairment score will have a relationship to activity limitation in the sport of interest that is based on empirical evidence. In this way the current problems associated with weighting and aggregating measures of impairment will be addressed.

Note that the research methods described above quantify the relative impact of impairment on highly standardised activities that permit very minimal variation in terms of individualised positioning and equipment, and that classification methods that will be used in practice will be based on the relative impact of different impairments on performance of these activities. In the competitive arena, many sports permit classified athletes to use individualised positioning and techniques, as well as strapping and other aids, which effectively alter the activity that each individual does in a way that minimises the impact of an individual's impairment, thereby enhancing performance. Use of individualised adaptations should not affect the class that an athlete is allocated. Sports technical officials must be cognisant of the impact that each individualised adaptation will have and ensure that technical rules governing permissible techniques and aids (including the materials that aids are made of) regulate their use so that the integrity of the sport is maintained.

Dividing impairments into classes

The task of creating classes can be addressed once the relationship between impairment and activity limitation in a given sport has been described. In some instances the data may indicate "natural" classes.[2] Natural classes may be indicated by a single, empirically verifiable critical feature. For example, in lower limb amputees, amputation above the knee causes significantly greater activity limitation in running than amputation below the knee, indicating that athletes with a knee joint should compete in a different class to those without a knee joint. Natural classes may also be indicated where the data indicate a clear cut-point in a continuous variable. Figure 3 illustrates the presence of two cut points in a hypothetical data set that plots wheelchair racing performance (y-axis) against wheelchair-specific impairment (x-axis), a single, continuous score derived from a number of measures of impairment that have been weighted and aggregated according to an evidence-based regression equation. The graph indicates that decreasing impairment score is associated with improved racing performance (ie, decreased activity limitation); however, the decline is not uniform—a decrease in impairment from 10 to 8 is associated with a decrease in race time from 100 to 90 s, whereas a decrease in impairment from 8 to 7 is associated with a decrease of 30 s in race time. A similar drop occurs when impairment increases from 5 to 4. These data suggest two cut points and therefore three natural classes: class 1 for athletes with impairment scores from 10 to 8, class 2 for impairment scores from 7 to 5 and class 3 for impairment scores from 4 to 1.

In instances when the relationship is strictly linear and does not suggest natural classes, setting the boundaries of classes will be more challenging. Because extent of activity limitation is a continuous variable, it is mathematically impossible to create a classification system in which classes only comprise athletes experiencing exactly the same degree of activity limitation. Given that classes must always span a range of activity limitation, the most important guiding principle for setting the number of classes should be that within any given class, the range of activity limitation should never be so large that athletes with impairments causing the greatest activity limitation are significantly disadvantaged when competing against those with impairments causing the least activity limitation.[4] For example, tetraplegic and paraplegic athletes should not compete in the same wheelchair racing class because the range of activity limitation resulting from impairment in such a class would be too large. However, to ensure the competitive field for each class is as large as possible, the range of activity limitation within a class should also be as large as possible without disadvantaging those most severely impaired.

It is critical that the number of classes in a given sport is based on these objective principles. When the number of classes has been determined, it is the role of sports federations and their administrators to put in place effective promotion and retention strategies to maximise participation and ensure large, competitive fields in each class. If numbers in a particular class are low, this is an indication that a sport needs to use more effective promotion and retention strategies: it is not an indication that the number of classes should be reduced. The notion that the number of classes in a given sport should be driven by the number of athletes competing in that sport at a single time point will lead to long-term instability in classification systems and runs counter to the aim of developing evidence-based systems of classification.

Other research needs

As has been identified, there is a critical need for research that will describe the extent to which impairments of varying type, severity and distribution impact on performance in the Paralympic sports. However, measurement of impairment for the purposes of Paralympic classification poses at least two further significant challenges.

Identifying intentional misrepresentation of abilities

It is well recognised that to obtain valid measures, many tests of impairment require the athlete to attempt the test to the best of their ability. Anecdotal evidence indicates that some athletes try to obtain a more favourable classification by intentionally misrepresenting their abilities (ie, not attempting all tests to the best of their ability to appear to exaggerate the severity of the impairment). To deter athletes and support staff from conspiring to intentionally misrepresent abilities, the Classification Code[11] contains severe sanctions, up to and including a lifetime ban from Paralympic sport. Objective methods for identifying intentional misrepresentation of abilities would provide an important, empirical basis for enforcing sanctions, and research developing and validating such methods is required. Such methods are an important means of assuring all Paralympic stakeholders—athletes, coaches, administrators, the public and the media—that the fairness and integrity of Paralympic competition are protected by sanctions that are both severe and enforceable.

Training responsiveness of impairment measures

Although measures of impairment will be largely training resistant, complete training resistance cannot be guaranteed. For example, strength impairment resulting from incomplete spinal cord injury can be influenced by behaviour: chronic disuse can compound strength loss in affected muscles, and strength can be increased through resistance training. It is vital that athletes who have positively influenced their impairment scores by training are not competitively disadvantaged by being placed into a less impaired class.

One important means of guarding against this possibility is to use modalities of impairment measurement that are not sports specific. For example, measurement of strength using an isometric modality would reflect strength impairment but would also be more resistant to sports-specific strength training than dynamic modalities of strength measurement.[17]

A further safeguard will be the development of activity limitation test batteries that can be used by classifiers to differentiate untrained from well-trained athletes. These batteries should comprise the activity of interest—for example, a 30-m sprint performance for runners in athletics—as well as supplementary tests of activity limitation.[18] The standing broad jump is a good example of a supplementary test of activity limitation for running, because it (a) highlights the impact of one of the eligible impairment types for running (impaired muscle strength); (b) is biomechanically distinct from the activity of interest (running), but is closely correlated with running performance;[19] and (c) is inexpensive and easily administered, which would facilitate international dissemination and implementation. Valid, reliable tests of activity limitation can provide classifiers with an objective indication of an athlete's level of training that is, as far as possible, independent of the effects of impairment[18]—that is, for a given impairment level, a well-trained athlete will do better on supplementary tests of activity limitation than an untrained athlete. In this way, supplementary tests of activity limitation can be used to ensure that well-trained athletes are not competitively disadvantaged by Paralympic classification methods.

GLOSSARY

The *ICF*: The *ICF* is the acronym for the *International Classification of Functioning, Disability and Health*, published in 2001 by the World Health Organization.[20] The *ICF* is an international standard for describing the functioning and disability associated with health.

Health conditions are diseases, disorders and injuries and are classified in the *International Classification of Diseases, 10th Revision*[21], not in the *ICF*. Cerebral palsy, spina bifida and multiple sclerosis are examples of health conditions.

Body functions are the physiological functions of body systems (eg, cardiovascular functions and sensory functions). The body functions of central concern in Paralympic sport are neuromusculoskeletal function, visual function and intellectual function (see fig 1).

Body structures are anatomical parts of the body such as organs and limbs and their components. The body structures of central concern in Paralympic sport are those related to movement and include the motor centres of the brain and spinal cord, as well as the upper and lower limbs (see fig 1).

Impairments are problems with body functions or body structures. A person with a contracture at the right elbow would be described as having *impaired* range of movement. Paralympic classification systems should specify eligibility in terms of *ICF* impairment types (eg, in the sport Judo, the classification system should specify that only vision impairments are classified).

Activity: An activity is the execution of a task or action by an individual. The term *activity* encompasses all sports-specific movement, including running, jumping, throwing, wheelchair pushing, shooting and kicking (see fig 1).

Activity limitations are difficulties an individual may have in executing an activity. In Paralympic sport activity, limitations refer to difficulty executing the sports-specific movements required for a particular sport. Running is a core activity in the sport of athletics and a person who has difficulty running is said to have an *activity limitation* in running.

Function and disability In the *ICF*, the terms *function* and *disability* are non-specific umbrella terms that refer to several components of the *ICF*. For example, function can refer to neurological function (eg, nerve conduction velocity), the ability to perform an activity (eg, ability run or jump) or functioning of a person in the community (eg, to conduct financial affairs or access health services). To minimise ambiguity, the terms *functioning* and *disability* should be avoided when describing the purpose and conceptual bases of Paralympic classification.

Handicap The term *handicap* is not used in the *ICF* because of its pejorative connotations in English.

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What is already known on this topic

Competition in Paralympic sport is based on systems of classification. The recently published IPC Classification Code mandates development of evidence-based systems of classification. Development of such systems is difficult because consensus regarding what constitutes evidence-based classification do not exist and because, to date, classification in Paralympic sport has been largely atheoretical.

What this paper adds

This paper provides a theoretically grounded overview the scientific principles underpinning classification, as well as an authoritative position on what constitutes evidence-based classification and guidelines for how evidence-based systems can be developed.

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Injury Report Form

CONFIDENTIAL

NAME____ DOB______________ GENDER__________

ATHLETE_______ COACH________ OFFICIAL________ PARENT________ OTHER_________________

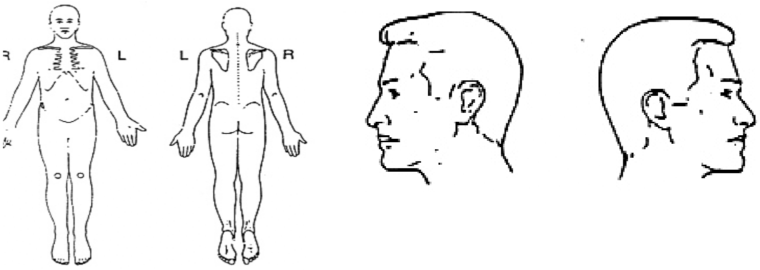
DATE & TIME OF INJURY________________________ STATE/COUNTRY OF RESIDENCE_______________

NAME & YEAR OF COMPETITION ____

INJURY NATURE: ACUTE____ CHRONIC ______ RE-INJURY______ -- DATE OF 1ST INJURY_____________
OCCASION: WARM-UP____ COMPETITION______ NON-SPORT___________________________________

WEIGHT CLASS_____________ BELT COLOR/DAN____________________
CLASSIFICATION: PRE-ADOL___ JR___ SR__EXEC SR__ NON-ATHLETE________________
===

Mark area injured:



Head Injuries with potential for concussion:
____ **SAC Score**
____ **Glascow Coma Score**
____ **Cranial Nerves Intact**
____ **LOC**
____ **PEARL**

Complete page 3 of this form

VITALS (as needed): TEMPERATURE________ BP_________ PULSE________ RESPIRATION_____________

ALLERGIES____

DIAGNOSIS/EVALUATION____

HISTORY & EVALUATION____

____

____

____

____

____

____

SENT TO HOSPITAL___ X-RAY____ RECOMMEND FURTHER EVAL _______ FOLLOW-UP_____________

TREATMENT____

CLEARED FOR PARTICIPATION_________ 30-DAY OUT HEAD INJURY________ RETURN DATE_________

SIGNATURE______________________________________ATC MD DO DC PA PT MEDIC RN EMT

PRINT NAME ______________________________________ STUDENT ___________________________

Injury Report Form

BODY PART (mark all that apply):

- Head/brain/skull
- Face
- Eyes/Orbit/Eyebrow/eyelid
- Nose
- Ears
- Jaw/mouth/teeth/chin
- Neck/throat
- Back/spine
- Shoulder
- Upper arm
- Elbow
- Lower arm
- Wrist
- Hand
- Fingers/thumb
- Clavicle/Collarbone
- Chest/sternum
- Ribs
- Abdomen/internal organs
- Pelvis/SI Joint/Buttocks/Tailbone
- Hip/IT band
- Genitals/Genital Region
- Upper leg
- Knee/patella
- Lower leg
- Ankle
- Foot/arch/heel
- Toes
- Other: ______________

INJURY TYPE:

- Laceration/abrasion/avulsion
- Blister/wound care
- Sprain
- Strain
- Rupture ligament/tendon
- Cartilage/meniscus injury/disc injury
- Tendonitis/bursitis/faciitis
- Dislocation/subluxations
- Fracture/stress fracture/avulsion fracture
- Contusion/hematoma
- Inflammation
- Concussion
- Compartment syndrome
- Organ damage/failure/contusion
- Teeth fracture/dislodged/injury from braces
- Nosebleed
- Retinal detachment/eye or orbit damage
- Dehydration/heat illness
- Illness
- Asthma attack/lung related illness/injury
- Diabetic shock
- Seizure
- Heart related illness/injury
- Allergic reaction
- Finger/toenail injury
- Headache

Other: __________________

Body Side (mark all that apply):

Right
Left
Bilateral
Anterior
Posterior
Superior
Inferior
Distal
Proximal
Medial
Lateral

Treatment (mark all that apply):

Ice
Tape/wrap
Splint/sling/immobilize/brace
Wound/blister/bleeding care
Observation
Medication/IV/Oxygen
Backboard/C-collar/Transport
Suture
SAC/head injury eval
DC Adjustment
Reduced/traction
Pad/Pack
Massage/deep tissue
Stretch
Vitals monitored
Dental/Orthodontic care
Respiratory Care
Shock/Anaphylactic Care
Seizure Care
Drilled nail
Systemic Illness Evaluation

Other: ___________________

Injury Report Form

CIRCLE ONE FOR EACH:

Was the injury sustained from:
- blocking a kick
- blocking a punch
- attacking with a kick
- attacking with a punch
- charging opponent, no kick or punch
- unblocked kick or punch (being attacked, no defense)
- stepped into kick
- stepped into punch
- recovering from missed kick
- attacked with back turned
- kicked/punched while falling
- kicked after fall/on the ground
- hitting playing surface
- colliding/clashing with opponent
- warming up
- unknown origin
- non-sport related

Was the injury sustained during:
- previous injury prior to event
- 1st round
- 2nd round
- 3rd round
- warm up/between fights
- non-sport related

Was the injury sustained during:
- previous injury prior to event
- 1st fight
- 2nd fight
- 3rd fight
- 4th fight
- 5th fight
- 6th fight
- 7th fight
- warm up/between fights
- non-sport related

Type of kick causing injury:
- spinning/swing
- thrust
- axe
- punch/no kick
- non-sport related
- fell onto, no kick involved

Has athlete ever sustained a head injury before? YES NO
- Date(s) of head injury______________________
- Type of head injury________________________
- Evaluated at hospital YES NO
- Stayed overnight at hospital YES NO
- Complications____

____

____

FOR HEAD INJURIES ONLY

Injury Nature:___________________________

(refer to NAIRS Listing)

If concussion, what grade:_______________

(Refer to reference card on grading)

Wearing mouthpiece? **YES** **NO**

Brand of headgear ___________________________

Brand of chest protector _____________________

Athlete, due to injury (circle one):

lost fight

bowed out of fight due to injury

won fight

won fight but could not continue

won due to illegal hit/move of opponent

Did athlete receive any bye matches?

yes no

How many?_______________

Number of Times Competing at the

Local Level__________________

State Level__________________

Regional Level_______________

National Level_______________

International Level__________

Time Loss

Could no longer compete

Completed tournament fights

Recommended time off following tournament -- how many days off?__________________

To see doctor before return to athletic participation