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BRAIN INJURY AUSTRALIA

Policy Paper:

CONCUSSION IN SPORT

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1. EXECUTIVE SUMMARY AND RECOMMENDATIONS

At its last meeting, in 2008, the international authority on this paper's subject – the "Concussion in Sport Group" – defined **concussion as "a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces", which "typically results in the rapid onset of shortlived impairment of neurologic function that resolves spontaneously".**[1] The "suspected diagnosis of concussion can include one or more of the following clinical domains: symptoms – somatic (e.g. headache), cognitive (e.g. feeling like in a fog) and/or emotional symptoms (e.g. lability[2]); physical signs (e.g. loss of consciousness, amnesia); behavioural changes (e.g. irritablity); cognitive impairment (e.g. slowed reaction times); and sleep disturbance (e.g. drowsiness)".[3]

Brain Injury Australia has been unable to identify any national surveys of concussion incidence, whether in sport specifically or across all causes. There were around 3,000 *hospitalisations* for concussion from sport during 2004-2005.[4] Hospitalisations radically underestimate the incidence of concussion in the community: as few as one in every four people who experience concussion will seek medical attention, and then only if their symptoms persist.[5] The number of unreported concussions in sport may be as many as 10 times the number disclosed to team doctors annually.[6]

The only established treatment for concussion is physical, and cognitive, rest. While "the majority (80-90%) of concussions resolve in a short (7-10 day) period",[7] physical, psychological-behavioural and cognitive symptoms – including headache, dizziness, irritability, anxiety, depression, aggression, mood swings, anger, impaired attention, concentration and memory – may persist for the minority. Publicity surrounding the more than 3,000 former gridiron players engaged in class action lawsuits against the National Football League (NFL) in the United States – who generally allege that the NFL either knew, or should have known, about the long-term consequences of repeated concussions – has led to increased research, and media, interest in the potential cumulative effects of concussions. The link between a lengthy career's worth of bouts in professional boxing, for example, and resultant neurodegeneration is generally well-accepted. "Based on the combat sport literature alone, there appears to be the potential for a continuum of lingering or cumulative structural and/or functional changes to the brain following repeated exposure to multiple sub-concussive events or concussions. In contact sports such as American football, ice hockey, and rugby, there appears to be some support for the effects of multiple concussions as well although more research is needed in this regard. **Researchers have reported that a history of three or more concussions is associated with changes in cognitive neurophysiology, subjective symptoms, worse neuropsychological test performance, and long-term cognitive decrements".**[8] (Examination of the notion of "sub-concussion" follows.)

Having a "history of serious"[9] or "repeated"[10] concussions has "been linked to long-term complications, including chronic traumatic encephalopathy, cognitive impairment, early onset dementia, movement disorders, psychiatric disorders, and, potentially, motor neuron disease".[11] Discussion follows about diagnoses of chronic traumatic encephalopathy (CTE) in former gridiron players. The evidence that mild traumatic brain injury (MTBI) is a risk factor for dementia is mixed and "not without its detractors"[12] (discussion of whether concussion is a MTBI also follows). Certainly, Brain Injury Australia shares concerns about the verifiability of research that sheets the responsibility for cognitive impairment generally, or CTE specifically, in older adults – primarily, let alone singularly - to one or more concussions in earlier life. It defies commonsense that such causality can always completely disaggregate the contribution of other potentially confounding variables; other head trauma, genetic predisposition, family history, alcohol and other drug and anabolic steroid abuse, for example. **Much of the research into the potential cumulative, long-term effects of concussion derives from gridiron, a sport with greater concussion risk exposures than the three "collision sports" the focus of this paper - Australian Rules football, Rugby League and Rugby Union.** Moreover, Brain Injury Australia acknowledges that concussion assessment and management in these three sports - at least at elite level - have improved considerably in recent years, thus reducing the risk of long-term harm to player health.

There are, however, differences – some minor, others substantive – between the concussion assessment and management policies of the three sports, involving, for example, injury definition, removal from play, and same day return-to-play after concussion. These differences are examined in detail below and, combined with the intractable subjectivity in the diagnosis of concussion, do not allow for meaningful comparisons in incidence between the three sports. **Brain Injury Australia believes these differences also jeopardise player health and, since it cannot envisage any insuperable obstacles to doing so, advocates the development of common "guidelines for the management of concussion…for adoption by all [football] codes",[13] as was recommended by Australia's National Health and Medical Research Council in 1994.**

Brain Injury Australia holds specific concerns about the increased vulnerability to concussion of the "special populations" of female, "child and adolescent" and "non-elite"[14] **athletes.** Although the "Concussion in Sport Group's" 2008 meeting "accepted that gender may be a risk factor for injury and/or influence injury severity",[15] from its examination of the current "community" concussion guidelines of the three sports – each of which have established women's competitions - Brain Injury Australia was unable to locate any reference to the potential differential concussion risks for female players. There are "no comprehensive management guidelines and conspicuously few research studies…that focus specifically on sport-related concussion in the pediatric population".[16] Brain Injury Australia welcomes the focus given to "management of pediatric (< 15 year old) concussion" as a "main topic area" for the "Concussion in Sport Group's" 2012 meeting, the "consensus statement" from which will be available in early 2013.[17]

From the submissions sought as part of this paper's preparation, Brain Injury Australia has strong, though largely anecdotal, evidence to support its core working hypothesis; that awareness of, and compliance with, "best practice" concussion assessment and management is poorer the further one ventures from professional (salaried) sport, into amateur, school, junior sports. Brain Injury Australia notes that, just as "what is the best method of knowledge transfer and education" about the "detection of concussion, its clinical features, assessment techniques and principles of safe return to play" was one of the "focus questions" that "formed the foundation" for the "Concussion in Sport Group's" 2008 "consensus statement", "knowledge transfer and education" has been retained as a "main topic area" for their 2012 meeting. **Brain Injury Australia believes that the foundation of any "knowledge transfer and education" needs to be a national cross-sport campaign in concussion awareness and best practice assessment and management, suitable for sports administrators, coaches, trainers, players and the broader community.** Brain Injury Australia agrees with the Australian Football League Medical Officers Association, in their submission to this paper, that such a campaign "at a community level is the responsibility of the sport's governing body, the local competition's governing board as well as government…Further needs exist to assist community-based football to understand and implement this material with educational programs".[18]

A number of contributors to this paper argued the need for organisations independent of, but working collaboratively with, sporting bodies to share the lead in such a campaign. The Chief Medical Officer of the Australian Rugby Union offered; **"I think this is the great opportunity for Brain Injury Australia to promote the message that concussion must be treated appropriately and consistently across all sports and that player welfare is paramount…This awareness should be targeted at players/parents/coaches/officials and medical/healthcare professionals and sports first aiders".[19] To which end, Brain Injury Australia has developed an awareness campaign built around the "5Rs" of concussion; "Recognise the injury, Removal from play, Referral to a doctor, Rest and then Return to play".**

R E C O M M E N D A T I O N S

Recommendation 1:

Brain Injury Australia recommends that the Australian Football League, the Australian Rugby League Commission, and Australian Rugby Union co-fund an independent, large-scale, prospective study – comprising cohorts from all three sports – examining the risk factors for as well as the incidence, assessment, short and long-term effects, management and potential prevention of concussion in child and adolescent players.

Recommendation 2:

Brain Injury Australia recommends that the Australian Football League, the Australian Rugby League Commission, and Australian Rugby Union co-fund an independent, large-scale, prospective study – comprising, and comparing, male and female cohorts from all three sports – to investigate whether gender is a "modifying factor" in the risks, incidence, short and long-term effects of, and recovery from, concussion.

Recommendation 3:

Brain Injury Australia recommends that the Australian Football League, the Australian Rugby League Commission, and Australian Rugby Union – in collaboration with Australia's other

major participation sports – develop and fund the dissemination of cross-sport concussion assessment and management guidelines.

Recommendation 4:

Brain Injury Australia recommends that the Australian Government, through the Sport and Recreation Ministers' Council and the Standing Committee on Recreation and Sport, develop, implement and fund a national cross-sport education campaign in awareness and best practice assessment and management of concussion, suitable for sports administrators, coaches, trainers, players and the broader community.

B R A I N I N J U R Y A U S T R A L I A

Brain Injury Australia is the national peak acquired brain injury (ABI)[20] advocacy organization representing, through its State and territory member organizations and network relationships, the needs of people with an ABI, their families and carers. The major components of Brain Injury Australia's role are:

- advocacy for Australian Government program allocations and policies that reflect the needs and priorities of people with an ABI and their families, and
- the provision of effective and timely input into policy, legislation and program development through active contact with Australian Government ministers, parliamentary representatives, Australian Government departments and agencies, and national disability organizations.

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3. PREAMBLE

"Since the year 776BC, athletes have participated in organized sports, such as wrestling and fist-fighting, which place them at risk of concussion. Symptoms of concussion have been observed at least since the time of Hippocrates. Despite such a history, the management of sport-related concussion is one of the most discussed and controversial topics in sports medicine and has become an increasingly popular topic in the lay press".[21]

What Brain Injury Australia offers here also attempts to reflect a "lay" perspective on concussion, as befits its advocacy role, detailed above. Brain Injury Australia is not familiar with any local surveys of the public's understanding of concussion, but has no reason to believe that it would be any greater than the generally low levels found in research internationally, described below. Nevertheless, Australians could be forgiven for being confused, given the significant shifts in definition and "management" guidelines as well as some sports' record of delivering mixed messages on concussion, also described below.

While Brain Injury Australia accepts the "definitions of concussion have been evolving over the past 30 to 40 years and are likely to continue to evolve with ongoing discoveries",[22] that there is "no universal agreement on the standard definition or nature"[23] of the most common neurotrauma makes concussion "knowledge transfer"[24] to the sporting and broader community a continuing

challenge, one largely unmet. Similarly with concussion "management" guidelines, Brain Injury Australia details below the sometimes "minor",[25] sometimes substantive, variations between those of Australia's three major "collision sports". Up until recently, there were "well over 20 different management guidelines"[26] used worldwide. Brain Injury Australia understands another three are being developed by the American Academy of Neurology, the American Medical Society for Sports Medicine, and the United States' National Athletic Trainers Association.[27] Overall, concussion management guidelines may need to change again to reflect the "consensus statement" from the next international "Concussion in Sport Group" meeting, to be held in Switzerland in November 2012.

In the absence of a "test", concussion – a syndrome diagnosis based on a checklist of (partly self-reported) symptoms and commonly made in retrospect (often once symptoms have resolved) – remains intractably subjective. And thus, diagnoses vary significantly, as the paper demonstrates. Brain Injury Australia has genuinely struggled to reconcile the public statements of sports administrators about the seriousness of the injury with the security of some on-field/ sideline assessments at *elite* level (discussion of "elite vs non-elite athletes"[28] follows). Just as such assessments remain in the eye of the beholder, Brain Injury Australia does not see that a general uncertainty around concussion results in trainers and doctors always erring on the side of player health and welfare.

As with its first two meetings, 2008's "Concussion in Sport Group" recognised that "research is needed across a range of areas in order to answer some critical research questions" (two of this paper's recommendations align with those "questions"), including "concussion surveillance using *consistent definitions* [italics added] and outcome measures".[29] Concussion in sport is not under-researched. A 2006 overview of the three international concussion "consensus statements" to date found that "more refereed publications on sports-related concussion have appeared [on PubMed Central[30]] since the year 2000 than in all the previous years combined".[31] But the same definitional ambiguities, above, also beset a *research* consensus on concussion. A recent review of sports neuropsychology concussion research found of the 43 studies selected: 8 failed to provide any operational definition for concussion; 19 used the definition developed by the American Academy of Neurology; and the remainder used a variety of others, including those produced by the American Congress of Rehabilitation Medicine and by the first International Conference on Concussion in Sport, held in Austria in 2001.[32] Concussion research generally faces a series of almost unique obstacles, many of those reflective of the uncertainties and ambiguities described throughout this paper. Limitations in design and methodology are almost inevitable. None of the conclusions drawn from that research is beyond question. Brain Injury Australia relies on that same research for much of what follows.

Brain Injury Australia knows that competition, between individuals, between teams, is the lifeblood of sport. It also recognises the commercial competition *between* sports - a $6.2 billion dollar industry in 2010-2011[33] - that is, in part, a participant numbers game. (Brain Injury Australia argues, below, that inconsistencies in injury surveillance do not allow the AFL, NRL and ARU to meaningfully compete on the grounds of which

sport has the lowest concussion incidence rates.) According to estimates of the annual *Exercise, Recreation and Sport Survey* - a "joint initiative of the Australian Sports Commission and the state and territory government agencies responsible for sport and recreation"[34] – more Australians play soccer than Australian Rules football and Rugby League combined. And while all three of Australia's major "collision sports" - Australian Rules football, Rugby League and Rugby Union – along with soccer, have enjoyed increases in participant numbers over the last decade, soccer's growth (34.7%) outstripped both Rugby League's (30.5%) and Rugby Union's (29%) but lagged behind Australian Rules' (38.8%).[35]

> "…we are seeing parents 'cottonwooling' their children in fear of them becoming injured. This must be put into perspective in that minor injury (yes, concussion included) is an important part of learning and development… Playgrounds are becoming less common, young children are being strongly discouraged from being involved in activities which develop their proprioception and reaction times such as climbing trees, balancing and using playground equipment…Is there a real and tangible risk of deterring children, young people, adults from sport and physical activity because of the 'risk' of sustaining a transient and non-serious injury and thereby increasing their risk of more serious conditions in later years because of lack of activity?"[36]

Administrators concerned about growing their sports need to market to increasingly risk-averse parents having fewer children. A recent study of hospital records from 14 children's hospitals in the United States found that the number of children *diagnosed* with concussion had more than doubled over the last decade, but the number of *admissions* had remained constant. "Although we can't say for certain, [it looks like] the word is getting out that concussions are important, [and] can have serious health ramifications if they're not appropriately treated and diagnosed. Teams are being penalized because of aggressive hits on other players. There's just constant chatter about concussions".[37] Any publicity, local or international, that connects "collision" or "contact" sports with concussion and, in turn, "damage" to the brain – whether to its "function" or its "structure" (see below) and regardless of how transient it is – potentially damages those sports' ability to recruit participants. A number of respondents to Brain Injury Australia said that, in effect, there's "nothing in it" for Australia's major "collision sports" to be "out in front" of concussion in the public arena.

> "We approached [a national professional sporting body] to undertake a scientific study together. While initially there was interest, when the ramifications of these proposed studies were outlined, it became increasingly apparent that there was a fear negative results could emerge, potentially discouraging participation in the sport. Gradually, [they] withdrew from discussions. There seemed to be no way to dissociate clinical research findings from a potentially negative outcome. Hopefully recent media attention will reopen the debate. For all parents of…players, surely it is better to know the real risks?"[38]

Brain Injury Australia applauds those concussion research and prevention initiatives undertaken by the AFL, NRL and ARU, noting "it has not suddenly become a topic of interest for us because of passing media attention. We have been at the forefront of global sporting efforts to better understand the condition and its short, medium and long-term impacts, and also to implement measures that seek to minimize any demonstrated or potential risks. The AFL takes very seriously the welfare of our players, past and present. Australian Football is a safe game to play and we intend to keep it that way".[39] Both the NRL and ARU have made the same case to Brain Injury Australia. However, it is undeniable that the "hysteria associated

with the [National Football League] concussion lawsuits"[40] has supplied added impetus to these "efforts". More than 3,000 former gridiron players are engaged in class action lawsuits against the National Football League (NFL) in the United States. The lawsuits generally allege that the NFL either knew, or should have known, about the long-term neurological consequences of repeated concussions, including the "phenomenon"[41] of chronic traumatic encephalopathy (CTE), discussed below. While Brain Injury Australia understands no such litigation is being prepared locally, two former AFL players are reported to have been compensated for the consequences to their health from concussion, and another is considering similar legal action.[42] While no local cases of CTE involving former AFL, NRL or ARU players (and alleged to be directly attributable to concussion) have emerged, should they do so one sports law scholar has asked; "assuming a duty of care could be established, could it be argued that governing bodies in Australia should have known of the international medical research linking multiple concussions to degenerative cognitive disorders? More specifically, as the bodies vested with the supervisory and regulatory roles of their respective codes, would the responses of the AFL and NRL over the past decade be sufficient to satisfy an examination of their actions under the legal-standards microscope?"[43]

4. RATIONALE

A number of respondents questioned whether Brain Injury Australia's "role", described above, should extend to inquiry into this paper's subject, and implied that concussion policy was the special province of sporting bodies and/or their sports medicine professionals. Some were apprehensive, perhaps, that this paper would be overly prescriptive in its recommendations, especially when "there are too many unknowns [about concussion] at present".[44] Brain Injury Australia argues its entitlement to venture into this paper's subject matter along the following lines.

First, while Brain Injury Australia's funded remit is to "contribute to public policy development" and "provide advice to Government"[45] both the foundation and ultimate aim of its everyday work is to raise public awareness about ABI to parity, at least, with other disabilities. Brain Injury Australia believes that community awareness and understanding of ABI lags around 20, 30 years behind that of other disabilities, and this is regularly cited as the most *re*-disabling aspect of living with an ABI. ABI is often referred to as the "invisible" disability. This operates in a variety of ways, the most oppressive of which is at the level of the individual: the majority of people with a brain injury – around 3 in 4 - make a good physical recovery and show no outward signs of disability. Some of the most common effects of injury - poor short-term memory, fatigue, irritability - are regularly misinterpreted as simply flaws in the person. People with an ABI are thought lazy, unintelligent, unmotivated, uncooperative or aggressive. Not only are their "invisible" disabilities not recognised as resulting from their ABI, they are seen only as a function of who they really are, have always been. These same broad statements would apply to the "miserable minority", referred to below, who make an incomplete recovery from concussion/ mild traumatic brain injury (MTBI).

> "Only in sport? The qualification would seem meaningless to many Australians. What also is there that matters as much as sport? It is only in sport that many Australians express those approaches to life that are un-Australian if expressed in any other connection."[46]

Second, Brain Injury Australia's choice of this topic for a policy paper is partly pure pragmatism. Australians' love of sport, whether as participants or spectators, may be both the shortest, and most direct, means of raising public awareness about brain injury generally. During 2010, an estimated 14.4 million Australians aged 15 years and over - 82% of the population - participated at least once in physical activity for exercise, recreation or sport; 580,000 in Australian Rules football, 240,000 in Rugby League and 135,000 in Rugby Union.[47] During the same year, 7.6 million people aged 15 years and over - 43% of the population - attended at least one sporting event; 2.8 million to watch Australian Rules, 1.6 million to watch Rugby League and 600,000 to watch Rugby Union.[48] Many more Australians watch, or listen to, sport on television or radio. An estimated 2.6 million people watched the 2011 Australian Football League final on free-to-air television, and 2 million the 2011 National Rugby League final.[49] The estimated aggregate television audience for the 2009 National Rugby League season was 128 million viewers.[50]

> "Boxers [run] a twenty-per-cent risk of dementia. Yet boxers continue to box. Why? Because people still go to boxing matches."[51]

So third, when Brain Injury Australia proposed concussion as a subject fit for a policy paper, it was keenly aware that concussion was also one of the most "hotly debated"[52] topics in sports. Insofar as sportspeople, sports followers, associate concussion with injury to the brain, the "debate" will draw attention both to the brain and the disability. This is largely due to the media attention devoted to the NFL lawsuits. While Brain Injury Australia believes that much of backlash against the media coverage of concussion smacks of "shoot the messenger", it shares some of the concerns of respondents that "complex issues have been oversimplified and distorted, causing significant alarm over putative long-term risks and concern over how an acute injury should be managed".[53]

Fourth, delivery of "increased participation" in a "high performing sport and active recreation system" is one of three goals of the first "National Sport and Active Recreation Policy Framework", agreed by the Sport and Recreation Ministers' Council – comprising Commonwealth, State and Territory Sport Ministers - in June 2011. The Framework contributes to "whole of government objectives including improved health and education outcomes (including sport in schools and higher education institutions), enhanced social inclusion and community development".[54] The first action recommended by the Australian Government's National Preventative Health Taskforce for tackling rising rates of obesity was the formation of a "Prime Minister's Council for Active Living", to "develop and implement a National Framework for Active Living encompassing local government, urban planning, building industry and developers, designers, health, transport, sport and active recreation".[55]

Fifth, with "increased participation" in sport comes rising incidence of injury. **The last national survey of sports and recreation-related injury, conducted during 2002–2003, found 45,452 *hospitalisations*.[56] Nearly one in every 10 admissions involving rugby union and Australian Rules football, and 8 per**

cent of admissions in rugby league were due to "intracranial injury".[57] While an Australian Institute of Health and Welfare's National Injury Surveillance Unit study of "football" injuries[58] found "rates of hospitalisation per 100,000 population [had] remained relatively stable across all football codes" between 2002 and 2005, this may mostly reflect increased participation, an increased awareness of concussion combined with better detection and diagnosis, or simply population growth.[59] A recent three-year survey of sports injuries in Victoria found that the "football codes" comprised two-thirds of the 12,460 hospitalisations. Injuries from Australian Rules and the two rugbies had risen between 2002 and 2010 - by 5.5% and 3.6% per annum respectively - though, in the case of Australian Rules, "increased participation explained most of the significant increase".[60]

Sixth, **sports injuries represent a significant cost impost on the community. Per annum estimates have ranged from $1 billion, in 1990, $1.5 billion in 2003, to $2 billion in 2005.[61] The Victorian study, above, calculated the total direct cost of injury hospitalisations across 16 sports over the 3-year study period at $47.8 million, almost half that cost derived from Australian Rules injuries.[62]** The National Injury Surveillance Study of football injuries, above, estimated the "total direct cost of hospital inpatient treatment of injuries sustained in all football codes" during 2004-2005 at almost $44 million, with injuries from Australian football and "Rugby" combined accounting for more than half that amount.[63]

So seventh, while Brain Injury Australia has no specific, stated remit in the area, acquired brain injury prevention is a natural, if not indispensable, counterpart to its disability advocacy. The operative national document is the Australian Government's *National Injury Prevention and Safety Promotion Plan: 2004–2014* developed in partnership with State and Territory Governments and endorsed by all Australian Health Ministers. Its "vision" includes "injuries being universally accepted as preventable by individuals, communities, health care workers, and policy makers, and across all settings (e.g. workplaces, schools, public places, residential settings, roads and sport and recreational environments).[64] The National Injury Prevention Working Group (NIPWG), comprising representatives from State, Territory and Australian governments, and reporting to the Australian Population Health Development Principle Committee (APHDPC) under the Australian Health Ministers' Advisory Council (AHMAC), was established to share joint responsibility for the implementation of the Plan. Brain Injury Australia understands that "most of the work done by NIPWG to date has been in relation to falls prevention for older people, which represents the greatest burden of injury in Australia." (Brain Injury Australia has written separately on that subject.[65]) In November 2011, APHDPC "gave NIPWG direction to broaden its scope and focus more generally on injury prevention".[66] Brain Injury Australia views this paper as a contribution to this "broadening" of "national injury prevention and safety promotion".

Eighth, Australian sport is also *publicly* funded. The last time the Australian Bureau of Statistics quantified all-government expenditure on sport and recreation activities, $2.1 billion was spent during 2000–2001. Local government provided the majority (49%) of the funding, mostly spent on "venues, grounds and facilities" (61%).[67] Between 2000 and 2010, all levels of government spent around $2 billion on "stadium infrastructure".[68] Since 2010, the Australian Government alone has spent over $550 million on 1,000 sports

facilities.[69] The Australian Government, alone, committed $300 million in its 2012-2013's budget to "support grassroots participation and high performance programs".[70] **Given governments' expenditure on both sport and sports-related injury and their policy emphasis on the *health* outcomes from physical activity, combined with both the increasing participation in organised sport and the increasing incidence of injury, Brain Injury Australia believes concussion, and its prevention, is a *public* health matter. As such, it involves "prevention, promotion and protection rather than on treatment, on populations rather than on individuals, and on the factors and behaviours that cause illness and injury".[71] Brain Injury Australia believes it should not remain the exclusive domain of professional sporting bodies or sports physicians and, as such, this alone serves as justification for the questions raised in this paper.**

Ninth, after stroke, traumatic brain injury (TBI) is the most common acquired brain injury, accounting for an estimated 22,710 hospitalisations in Australia in 2004–2005.[72] (Discussion follows, in the section entitled "Nomenclature", on whether concussion is a TBI.) **"Concussion and brief loss of consciousness (less than 30 minutes)"[73] comprised the majority of TBI admissions: 60% of "principal diagnosis" cases, and 59% of "additional diagnosis" cases.[74] Other surveys have estimated that MTBIs, including concussion, comprise 70–90% of all hospital-treated adult TBIs.[75] Sporting activity is a significant cause of TBI in Australia. In the Australian Institute of Health and Welfare's survey of TBI hospitalisations during 2004-2005, where an "activity at time of injury" was indicated, sport accounted for 16% (n=2,208) of "principal diagnosis" and 11% (n=661) of "additional diagnosis" cases. Of those, "football"[76] was the reported "activity" in 32% of "principal diagnosis" and 24% of "additional diagnosis" cases.** A review of paediatric admissions to Victoria's tertiary referral hospital during the same year found that sports were the main external cause for head injury (HI) in children aged between nine and 16. "Although there was no surprise that sport and recreation were the main causes of TBI in older children, the high rate of HI from involvement in Australian rules football was unexpected, with previous studies reporting low rates of HI. This warrants further investigation".[77]

Hospitalisations radically under-estimate the incidence of concussion in the community, across all age groups and external causes. The United States' Centers for Disease Control and Prevention estimated that 1.1 million people are seen in emergency departments each year for concussion-related injuries, and another 235,000 people hospitalized.[78] "Most individuals with concussion (approximately 75%) do not seek attention from a medical facility or medical practitioner unless the symptoms worsen or persist".[79] A 2006 study estimated the number of unreported sports-related concussions at between six and ten times the 1.6 - 3.8 million disclosed to team doctors annually in the United States.[80] Of one and a half thousand US high school gridiron players surveyed – nearly 1 in every 3 of whom reported a history of concussion, and for 1 in 6 their concussion occurred in the current season – less than half had reported their injury. The reasons most commonly given for not reporting were: that their concussion was thought not serious enough to warrant medical attention (for 2 in every 3 players); that they feared being withheld from competition (for 2 in 5); and they lacked awareness

of what constituted a probable concussion (for 1 in 3).[81] Brain Injury Australia has no reason to believe that these responses would differ greatly in school age players of Australia's three major "collision sports".

Tenth, Brain Injury Australia believes that one necessary starting position for any concussion policy in sport, particularly for those concussions that may remain "invisible" to other players, to trainers and coaching staff (see above) is that the players themselves are able to recognise the injury. Insofar as participants in all organised sport are drawn from the broader community, the general knowledge of concussion may be as low as for any other brain injury. **A survey conducted in the emergency department of a major Canadian hospital found nearly 90% of concussed patients had not recognised their injury.[82] This paper demonstrates a clear, direct and unmet need for a broad, community level campaign of concussion awareness and education.**

Eleventh, **Brain Injury Australia's disability advocacy clearly extends to those for whom the consequences of concussion/ MTBI, whether short or long-term, are neither transient nor "mild". Given the annual number of TBI *hospitalisations,* alone, potentially many thousands of Australians are living with ongoing impairments due to Post-Concussion Syndrome (PCS)/ MTBI.** While focused on sports generally, and on Australia's three major collision sports, specifically, Brain Injury Australia believes the paper's contents and recommendations have broader relevance to PCS and MTBI, regardless of external cause or age. At the last International Conference on Concussion in Sport, held in Switzerland in 2008, the "panel unanimously retained the concept that the majority (80-90%) of concussions resolve in a short (7-10 day) period".[83] The physical, psychological-behavioural and cognitive symptoms of PCS – including headache, dizziness, irritability, anxiety, depression, aggression, mood swings, anger, impaired attention, concentration and memory – may occur in 38 - 80% of cases of concussion/ mild TBI.[84] This wide variation is explained, in part – as with other research in the area - by the pure heterogeneity of the injury, differences in definitions of concussion and MTBI, in the symptom checklists used, and in study design and methodology. While several comprehensive meta-analytic reviews of people who sustain "a single uncomplicated mild traumatic brain injury have reported effect sizes for long-term outcome (i.e., greater than 3 months post-trauma) *that are not significantly different than zero*"[85] [italics added] others have uncovered "impaired subgroups"[86] – a so-called "miserable minority"[87] of between 10-20% - whose symptoms will persist beyond 3 months of injury. "The cognitive-behavioural-social dysfunction caused by mild head injury can be quite disabling, and some researchers have suggested that the severity of impact on lifestyle makes the term 'mild' inappropriate for some patients."[88] **In concentrating its advocacy on the representation of those with the highest perceived level of disability and unmet need, Brain Injury Australia has neglected this potentially very large group. This paper is intended as a contribution to their enhanced recognition and representation.**

> "Concussive episodes are a potential problem in all sports that require movement. The number of concussions is known to be higher in some sports, and there are potentially greater problems with concussions in sport where the head is 'targeted'".[89]

Twelfth, Brain Injury Australia is unable to canvass the concussion policies of all sports. Some sports clearly have higher concussion risk exposures than others. Other sports risk brain injuries of greater *acute* severity but have low participation rates.[90] They have, *prima facie*, a lesser claim to *concussion* education and primary prevention campaigning than other sports. Brain Injury Australia has also chosen not to re-examine sports where concussion is not just an occupational hazard but the "*sine qua non*"[91] of competition – professional boxing, for example.[92] Some respondents, many of them involved in the collision sports the focus of this paper, have asked why soccer – with the second highest increase, between 2001 and 2010, in "organized activities" participation (55%) after Australian Rules football (64%)[93] - was not included.[94] The answer, in part, depends on a definition of "collision" sport. The American Academy of Pediatrics cites "boxing, [American] football, and rodeo" as examples of where "athletes purposely hit or collide with each other or inanimate objects, including the ground, with great force. In 'contact' sports (e.g. basketball), athletes routinely make contact with each other or inanimate objects but usually with less force than in collision sports".[95] Soccer is a "contact" rather than a "collision" sport. It has less to do, perhaps, with the relative forces involved than that the collisions in soccer invariably occur between players competing for the ball rather than with each other, and not as their primary means of gaining field position. The same could be said of Australian Rules football, but that sport also permits tackling of the *player* in possession of the ball.

Brain Injury Australia's reservations about sports injury surveillance, generally, and concussion incidence studies, specifically, follow. Concussion incidence, though, is generally lower in soccer than in Australian Rules football and the two rugbies; at 0.4 - 0.7 concussive injuries per 1000 player hours compared to 5.9 - 9.8.[96] The National Injury Surveillance Unit study, referred to above, found "intracranial injury, including concussive injury, was prominent in rugby league (9.9%), rugby union (9.6%) and Australia football (8.7%), with these proportions of hospitalisations being more than double those of soccer and touch football".[97] Relative incidence and hospitalisation rates for concussion may, however, "favour" soccer. Because concussion is not as strongly associated with soccer as with collision sports it is perhaps more likely to go unrecognized and unreported by players, undetected by teammates, trainers and coaches and undiagnosed by team doctors. Since "soccer is unique because the unprotected head is used to direct and advance the ball",[98] some research has suggested that chronic damage to the brain may accrue from the multiple concussive blows heading the ball, though "these studies have been criticized for having small numbers, using flawed methodology, and failing to control for potential confounders".[99] One Norwegian study of 44 retired Norwegian players found those identified as "headers" had a "significantly higher frequency" of brain atrophy on CT scans.[100] A US study of 60 high school, amateur and professional players found those with the "highest lifetime estimates of heading had poorer scores on scales measuring attention, concentration, cognitive flexibility and general intellectual functioning" when compared with "non-headers" and 12 nonplaying controls.[101] Recent media coverage of research indicating that soccer is the leading cause of sports-related concussion in young women,[102] and that players who exceed 1,500 heads per year risk MTBI,[103] has led to calls to "ban" heading in junior soccer, as well as the proliferation of protective equipment such as soccer "headbands" that promise the wearer "between 50 to 80% less impact force to the brain".[104]

5. DEFINITION - MOVING GOALPOSTS

> "The term concussion is imprecise. It causes confusion in the minds of both laymen and doctors because its usage refers to different phenomena: the nature of injury; the severity of injury; and the extent, if any, of transient functional disorder or structural damage to the brain. The mechanisms remain uncertain. Attempts at definition are unsurprisingly vague but those supervising sports activities in which the head is injured are expected to apply a comprehensible term within a variety of rules and advice. Concussion is an unsatisfactory term, and cannot be diagnostically appraised unless a strict definition includes a brief period of amnesia and immediate, transient impairment of consciousness after a blow to the head, followed by rapid recovery."[105]

It is surprising - given concussion's high incidence across all external causes, combined with the high sports participants' welfare, and commercial, stakes involved as well as the burgeoning research effort – that "there is no universally accepted definition"[106] of the injury. For example, the "strict definition" offered, above, omits both those concussions caused by a "direct blow to the …face, neck or elsewhere on the body with an 'impulsive' force transmitted to the head"[107] and those without "transient impairment of consciousness". In 1966, the first modern "consensus" definition was attempted by the Committee on Head Injury Nomenclature of the Congress of Neurological Surgeons'; "a clinical syndrome characterised by the immediate and *transient* [italics added] post-traumatic impairment of neural function such as alteration of consciousness, disturbance of vision or equilibrium due to mechanical forces."[108] One leading concussion researcher, writing in 2007, referred to this definition as "by far….the most popular" for "the past 3 decades".[109] Both the American Medical Association and the International Neurotraumatology Association endorsed the Committee's definition, adding that concussion was; "a *transitory and reversible* [italics added] nervous reaction with immediate onset following physical stress of sufficient violence and brevity, and characterized by progressive recovery thereafter".[110] In 1997, the Quality Standards Subcommittee of the American Academy of Neurology defined concussion as ''a trauma-induced alteration in mental status that may or may not involve loss of consciousness. Confusion and amnesia are the hallmarks of concussion. The confusional episode and amnesia may occur immediately after the blow to the head or several minutes later".[111] The Academy's redefinition reflects an evolution in the thinking about concussion that replaces loss of consciousness – which is "relatively rare and occurs in less than 10% of concussive injuries"[112] - with amnesia and confusion as key markers of injury. Neither is symptom duration indicated. Another leading concussion researcher cites the Academy's definition as the one "most commonly accepted".[113]

Brain Injury Australia is not in a position either to judge the relative merits of the concussion definitions in current use or state a preference for one "historical" definition over another, but notes the following. The lead international entity for the "improvement of safety and health of athletes who suffer concussive injuries in ice hockey, football (soccer), and other sports" - the "Concussion in Sport Group" (CISG) - was formed at the first "International Symposium on Concussion in Sport", held in Vienna in 2001. The Symposium was organised by the International Ice Hockey Federation, the Federation Internationale de Football Association Medical Assessment and Research Centre and the International Olympic Committee Medical Commission. The CISG comprises experts in concussion "epidemiology, basic and clinical science,

grading systems, cognitive assessment, new research methods, protective equipment, management, prevention, and long-term outcome". One of the Symposium's fundamental purposes was to "discuss a unitary model for understanding concussive injury".[114] As one of the founding, and ongoing, members of the CISG – at subsequent meetings held in the Prague in 2004 and Zurich in 2008 – has noted: "a Consensus Statement obviously is just that, but the consensus is often not unanimous. Whenever writing groups are assembled from diverse organizations as well as from diverse personal and professional backgrounds, organizational or personal bias may be present, no matter how much expertise is brought to the table".[115] He judged the CISG's 2001 Vienna "Summary and Agreement Statement" the "most comprehensive of the three international *Consensus Statement*s on concussion in sport" produced before 2006.[116]

The 2001 "Statement" defined concussion as "a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces. Several common features that incorporate clinical, pathological, and biomechanical injury constructs that may be used in defining the nature of a concussive head injury include: **concussion may be caused by a direct blow to the head, face, neck, or elsewhere on the body with an "impulsive" force transmitted to the head; concussion typically results in the rapid onset of short-lived impairment of neurological function that resolves spontaneously; concussion may result in neuropathological changes but the acute clinical symptoms largely reflect a functional disturbance rather than structural injury; and concussion results in a graded set of clinical syndromes that may or may not involve loss of consciousness.** Resolution of the clinical and cognitive symptoms typically follows a sequential course; and concussion is typically associated with grossly normal structural neuroimaging studies".[117] The CISG's 2004 "Statement" left this definition unchanged, "beyond noting that in some cases post-concussive symptoms may be prolonged or persistent".[118] It noted both that "historically, concussions have been classified with a number of different grading systems" and that the 2001 "Statement" had "abandoned" such an approach. Instead, the 2004 "Statement" offered a "new classification of concussion in sport" for "management purposes" - as either "simple" or "complex".[119] An athlete sustaining a "simple" concussion "suffers an injury that progressively resolves without complication over 7–10 days. In such cases, apart from limiting playing or training while symptomatic, no further intervention is required during the period of recovery, and the athlete typically resumes sport without further problem… Complex concussion encompasses cases where athletes suffer persistent symptoms (including persistent symptom recurrence with exertion), specific sequelae (such as concussive convulsions), prolonged loss of consciousness (more than one minute), or prolonged cognitive impairment after the injury".[120] The CSIG's "writing group's decision to use these two categories of concussion was not unanimous, because some members - including me - were certain that they would not refer to a concussion with symptoms lasting 10 days as a simple concussion. The word 'simple' may, in fact, not be a good choice for describing any concussion".[121] There was "unanimous agreement" at the CISG's 2008 meeting to "abandon the simple vs. complex terminology…as the panel felt that the terminology itself did not fully describe the entities. The panel however unanimously retained the concept that the majority (80-90%) of concussions resolve in a short (7-10 day) period".[122]

Perhaps to reflect the experience of the "miserable minority" whose concussion resolution is not as "short", the CISG's 2008 definition included; "however it is important to note that in a small percentage of cases however, post-concussive symptoms may be prolonged".[123] The only other change – from 2004's "concussion is typically associated with grossly normal structural neuroimaging studies" to 2008s "no abnormality on *standard* [italics added] structural neuroimaging studies is seen in concussion" – would seem to have resulted from "emergent neuroimaging" that offers "greater sensitivity for structural abnormalities".[124]

> "The next such [CISG] conference is planned for November, 2012 and this definition may change."[125]

The definitions in current use by the AFL, NRL and ARU broadly conform to that contained in the CISG's 2008 "Statement". Each emphasises the temporary nature of symptoms and the spontaneity of recovery though, on occasion, this may only serve to draw attention to the minority of cases where symptoms persist and recovery is prolonged. The AFL's "Guidelines for the management of concussion in Australian football for trainers, first aid providers, coaches and parents" states "the changes [resulting from concussion] are temporary and the *majority of players* [italics added] recover completely if managed correctly".[126] This could create the impression that whether or not these "changes" are temporary is purely a question of "correct management", such as returning "to play before [the player] has recovered from their concussion". The definition used in the International Rugby Board's (IRB) "Concussion Guidelines", followed by the ARU, refers to concussion as a "temporary impairment of brain function". However, the "Guidelines" also include a list of "Concussion Modifiers" that "may predict the potential for prolonged or persistent symptoms", such as "prolonged loss of consciousness (>1 min)", "amnesia" and "concussive convulsions".[127] The "Club Medical Officer's Handbook" section of the NRL's Operations Manual 2012 cites the CISG's 2008 "Statement" as the source for its definition, but omits two of the "common features" of concussion listed in the 2008 "Statement", that; "no abnormality on standard structural neuroimaging studies is seen in concussion"; and "concussion may result in neuropathological changes but the acute clinical symptoms largely reflect a functional disturbance rather than a structural injury".[128] Significantly, and consistent with the emphasis placed by the other codes, the NRL's Operations Manual revises the fourth feature of the definition used in the 2008 "Statement", removing "resolution of the clinical and cognitive symptoms typically follows a sequential course *however it is important to note that in a small percentage of cases however, post-concussive symptoms may be prolonged* [italics added]".[129]

6. INCIDENCE

> "I am about to start working in my 15th season as a professional NRL team doctor but do so feeling as uneasy as I ever have at any stage of working in sports medicine… Because the NRL has just brought in a rule that if a doctor assesses a player as having had a concussion (irrespective of whether he has been deemed to have recovered), then the player must not be allowed to return to play in that game…The problem is that the NRL haven't really properly defined concussion (which doesn't distinguish them too badly as even the consensus panels struggle to give a good definition) and, more importantly, haven't defined a severity cut-off…I am either going to be put in one of the 3 following positions very soon, none of which make me comfortable: (1) that I am going to be pulling players out of the game who I have been comfortable letting continue for many years, and possibly

hurting our team's chances of winning games (2) that I am going to turn a blind eye and go out of my way to not examine or assess a player who looks as though he is fit to continue (3) that I am going to re-name something I used to call "mild transient concussion" something different like "traumatic migraine" so the player can be allowed to continue, even though deep down I think that the player has probably had a very mild concussion that has quickly recovered. I have just gone over my stats for the past 14 years to look at how many concussions I have recorded and how they were managed. I have overseen about 10,000 player games and have recorded approximately 250 concussions (about one in every 40 player games). I would also expect that maybe even second incident that could count as a concussion I wouldn't even see/record (i.e. a player wouldn't necessarily report symptoms to me). Of the 250 I did record, about 100 (less than half) left the field on the day, with 68 coming off for good and the other 32 being allowed to return to the game at some stage with a careful eye being kept on them by me and the on-field trainers. I am not aware of any of these players coming to long-term harm as a result of the concussions they have suffered."[130]

Brain Injury Australia has spent some space exploring the changing, possibly competing, definitions of concussion in the strongly held belief that it is not a boutique issue but rather tantamount to gauging the reliability of incidence data and, thus, scaling the injury and its potential threat to player health and welfare. The above quote, alone, raises a series of interlocking questions about not only the acceptability and utility of the prevailing definitions of concussion but also the truth, or at least the verifiability, of club-reported, sporting code-sponsored injury surveillance.

First, it betrays - as with the spectrum on which brain injury occurs - that defining and diagnosing concussion is almost impossible to disentangle from markers of severity, such as "grading scales". In the case of the above, some players' concussions are deemed so mild and/ or so transient as to not require their removal from play, potentially placing the team doctor in breach of "NRL Rules" aimed at more "conservative" management of concussion. Second, it demonstrates not only that a "universally accepted definition"[131] of concussion may still remain out of reach, but that sports physicians within individual sporting codes remain in some disagreement. Third, since the key inclusion criterion for the purposes of NRL injury surveillance is whether players "missed game time", many of these concussions would go unrecorded. **In an area of such general uncertainty in diagnosis, Brain Injury Australia can only admire the confidence with which some team doctors and trainers – "against the backdrop of a noisy sports ground where there may be pressure from coaches and players to return the injured player to the field as quickly as possible or for them to not leave the field at all"[132] - are so readily able to determine concussion *severity* (that a given player *is* not*/ was* not concussed enough to require removal from play) while keeping player "health, welfare and safety" their "over-riding responsibility".[133]**

Fourth, Brain Injury Australia welcomes the "complete review of the management of concussion" undertaken by the NRL as part of the preparation of its *2012 Operations Manual*. It notes that, as a "Schedule to NRL Rules", if the new concussion "recommendations and advisories" are not "properly discharged or performed", a "penalty for breach may be imposed by the NRL" on clubs, reported to be up to $500,000.[134] It also notes that the same "recommendations and advisories" are "not prescriptive and, in that sense, [function] as a reference guide".[135] At the time of writing, the 2012 season had already

illustrated the continuing variability in the *diagnosis* of concussion, even with stricter guidelines in place carrying the threat of considerable financial penalty. Two clubs had been asked to explain allowing ostensibly concussed players to remain on the field. "The NRL Chief Medical Officer discussed the treatment of both players with club medical staff to ensure the proper procedures were followed. The media reporting of the issue included a journalistic diagnosis of concussion. The Chief Medical Officer was satisfied after consultation with the Doctor that the correct procedures had been followed".[136] In the case of a third player, also ostensibly concussed, the Chief Medical Officer has stated that "at the time I think he probably should have [been removed from play] and the club was asked about that…There have been a couple of apparent, not so much ignoring of the rules, but where the rules have seem not have been followed and questions have been asked of those particular clubs".[137]

> "'If someone gets knocked out in [State of] Origin, we're in strife,' [NSW team doctor David] Givney admitted. 'The onus is heightened because it is a major game. If someone gets knocked out in a grand final, are they going to stick to exactly the same rules as if you are playing at Campbelltown Oval or Shark Park?'"[138]

At the time of writing, the Australian Rugby League Commission[139] had "called for a report from the NSW Rugby League detailing the process followed by medical staff" after NSW State of Origin player Robbie Farah was allowed to continue playing after "suffering a concussion"[140] in the third State of Origin game for 2012. David Givney, above, was reported saying; "I examined Robbie when he came in at half-time and, although he said he couldn't remember the incident in which he got hurt, he was well aware of how the game was going. He correctly answered all of the questions that we ask players in these circumstances, and he passed all of the standard tests, so he went back out there for the second half and nothing more was thought about it from our point of view. He wasn't a worry. After the game, he said he still had a bit of a headache, but nothing much".[141] Farah was subsequently ruled unfit to play in his NRL club's game the next weekend. His club coach has been reported as saying; "obviously, there are different rulings as to what you can do at club and rep[resentative] level. But I don't think there should be any extra leeway given there to rep players or rep doctors"[142] and "at the end of the day I'm not concerned about him finishing the game, but the fact *we're not allowed to do that at club level is an issue* [italics added]*".*[143]

> "When amateur and junior sports participants see that professional athletes on television staggering after tackles and obviously concussed are left on the field or return to the play in the same game and/or the next week, why would they believe their own Trainers at local clubs who say they require a doctors clearance and a mandatory 10-14 day rest from play?"[144]

Fifth, while Brain Injury Australia is in no position to second-guess concussion diagnoses, or question the judgment of sports administrators in levying penalties, it wonders what example of "best practice" concussion management, let alone rules enforcement, these cases set for amateur-"community" and junior play. It notes that part of what prompted the AFL Medical Officers' Association's most recent "revision" of its "guidelines for the management of concussion" was a "player being allowed to compete while concussed" as well as "incidents in junior sport where poor management of head injury has been related to *how the AFL manages these injuries* [italics added]".[145] The AFL Medical Officers'

Association portrays the AFL's role thus, "the elite AFL competition also has an obligation as a role model for amateur, junior and community leagues to demonstrate a consistent and clear strategy for concussion management (e.g. no return to play on the day of injury). Whilst it is acknowledged that at the elite AFL level, there is the constant presence of experienced medical personnel, this is not the case at other levels of football. As such, a consistent, evidence-based approach at all levels of Australian rules football sets an example for trainers and others involved in the medical care of all footballers".[146]

> "The [NRL concussion] guidelines say that any player with a head injury has to be assessed by the club trainer and if he shows signs of concussion he has to be further evaluated by the club doctor. Leaving it to club officials is never going to work. Can you imagine a star player copping a knock to the head in a grand final and the club doctor ruling him out for the match? If the NRL is serious about this issue, they need to have independent doctors at each game, to make sure the players' health always comes first."[147]

Sixth, Brain Injury Australia believes that reliable injury surveillance remains hamstrung for as long as it is the responsibility of doctors, trainers etc. in the direct or indirect employ of their clubs and while the sporting codes themselves sponsor data collection. Some sports injury researchers have lobbied for the creation of a "federal government body dedicated to monitoring and preventing sports injuries",[148] though the question of its independence – from clubs and the sporting codes – is not raised. Instead, they envisage such a body being the first step towards a "New Zealand-style national sports injury insurance scheme"[149] and "instituting injury prevention programs".[150] Due to "the perception out there that the team doctors are more lenient in management of concussion, but no-one's ever proven that",[151] the IRB trialed the use of independent doctors during the 2012 Junior World Championships in the United States.

Seventh, a "missed match" definition of injury will result in the systematic under-counting of concussion in surveillance reporting. A 2007 review of the sports injury literature found studies that recorded all injuries using a "missed game" classification showed that between 70% and 92% of all injuries "fell into the transient (less than 1 game missed) category".[152] The AFL's 2010 Injury Report acknowledged its "definition of concussion is the one definition most frequently challenged in the context of only capturing those concussions which cause a week to be missed." However, "any change to the definition of concussion for the survey would compromise the ability to detect long-term trends based on the historical data. There are reports from other codes of football where retired players concede that on some occasions when they received concussions they did not report the full extent of symptoms to team medical staff. For this reason, trying to achieve a record of 'all' concussions for all teams would be very difficult".[153]

All three of the sports the focus of this paper have produced annual injury surveillance reports, though the ARU ceased doing so in 2010, and "is currently in the process of reviewing all aspects of its medical structures and injury surveillance is part of this review. There is currently no formal injury surveillance conducted by or on behalf of the ARU".[154] **This, combined with both the limitations outlined above and the codes' different measures of injury, makes meaningful "apple-to-apple" comparisons of**

concussion incidence between these three sports impossible. It also casts doubt over any one sporting code claiming a lower incidence rate of concussion than its rivals. The ARU's last survey (that included adult players) sampled 1,979 "elite", "grade", "country" "colts", and "schoolboy" players, (though injury data for the Australian Wallabies, as part of the "elite" total, had "not been received" in time for publication). The survey uses what seems to be the preferred denominator for injury risk exposure - per 1,000 player-hours - though training time was not included. An injury was defined as "occurring during a game and causing a player to miss at least one match". As argued above, the "missed match" definition, alongside the exclusion of hours in training, could lead to a significant under-ascertainment of concussion. Regardless, from a 2008 season total of 829 injuries, 33 concussions were identified with a "mean injury rate" (across the 5 player groups) of 1.5 per 1,000 player-hours.[155] "Elite" rugby "experienced the greatest percentage of concussion".[156] Other surveys - though using different player groups, from different countries, and different definitions of concussion and injury exposure measures – have consistently found higher incidence rates, up to 7.1/ 1,000 player-hours.[157] A 2009 study of 3207 "nonprofessional" rugby union players in Australia arrived at a rate of 7.97 MTBI[158] per 1000 player [game] hours, with almost 1 in 10 players sustaining "1 or more MTBIs during the study".[159]

The NRL defines an injury as any "that was sustained during a first grade NRL game…or training session that resulted in missed game time". "Therefore if a player was concussed and left the field for any period of time (or missed the following [game]) this was reported as a concussion".[160] During the 2011 season, there were 35 concussions at a rate of 4.2 per 1000 playing hours. Though the number "includes game and training concussions…*this is a more extensive measure than is used in other codes* [italics added]",[161] the calculation of 2011's player-hours excluded training. The NRL Injury Report for 2010 was also constrained because "clubs did not indicate training hours…For this reason injuries that were sustained outside NRL games were not used in the calculation of incidence rates".[162] Similarly, with 2009's season "injury incidence was only calculated for injuries that were sustained during games as exposure hours for training could not be calculated".[163] A 2003 systematic review of 23 concussion studies across a variety of sports included surveys of rugby league with incidence rates as high 9.05 per 1000 player-hours.[164] A 1997 study of four seasons' worth of injuries in one professional rugby league club found concussions comprised 7.1% of all injuries with an incidence rate of 8.1 per 1000 player-hours.[165] A 2004 study of 175 professional league players over three competitive seasons found the incidence of concussion ranged from 5.9 to 9.8 per 1000 player-hours.[166] The "professional NRL team doctor", quoted above, has recently compiled concussions in his players over 14 years. He has calculated the incidence rate during the 2011 season at 31.3 per 1,000 player hours, with a 14-year average of 24.43.[167]

The AFL defines an "injury or medical condition" as any "which causes a player to miss a match". The concussion incidence rate for the 2011 season was 1.1 "unit of new injuries per club per season (where a club is defined as 40 players and a season is defined as 22 rounds)".[168] The AFL Medical Officers' Association considers concussion "a common problem in the AFL with a reported incidence of approximately 5-6 concussions per 1000 player hours (*which equates to an average of 6-7 injuries per team per season* [italics added])."[169] A study of all AFL players over four seasons found 199 "concussive

injuries" in 158 players at an incidence rate of 5.6 per 1000 player-[game] hours.[170] A 10-year survey of concussions in one AFL team found an average rate of 9.4 per 1000 player-[game] hours.[171]

7. INCIDENCE - TREND

Given the vagaries of definition and diagnosis of concussion, detailed above, any speculation about incidence trends is thus imperiled. Moreover, any suggestion of a perceived increase in concussions is susceptible to the perennial question of whether it is due to more injury or better diagnosis or detection combined, perhaps, with an increased preparedness of players to disclose their injury. The ARU's reported mean concussion incidence rate during 2008 is unchanged from seasons 2002, 2003 and 2004 – 1.5 per 1,000 player-hours though, during that period, they "occurred at higher rates in schoolboys than in other groups (2.1 per 1,000 player-hours)".[172] "Preliminary results" for the 2005 season did not include data for concussion.[173]

While the NRL's reported concussion incidence rate has remained almost static for the last 3 seasons – 35 concussions during 2011 (4.2 per 1000 player-hours), 30 during 2010 (4.3 per 1000 player-hours), and 31 during 2009 (4.3 per 1000 player-hours) – this is a marked increase on 2008's rate, at 2.5 per 1000 player hours.[174] The 14-year study of one NRL club, referred to above, "found a statistically significant increase in the concussion incidence. A low of 12.85 concussions per player match hours was found in 2001, which ranged to a high of 42.26 concussions per 1000 player match hours in 2008".[175] The NRL's Chief Medical Officer maintains "*in the last four years* [italics added] there has been no increase in the incidence of concussion".[176]

> "Concussions in the AFL doubled last year, as concerns continue to grow about the long term effects of repeated head injuries among the footballing elite."[177]

The AFL's reported "missed match" incidence rate for the 2011 season - 1.1 "new" concussions per club - was not only more than "double" the rate of 2010, but was "significantly higher than the seasons 2006-2010 inclusive",[178] higher than the 10-year average for 1992-2001 and more than double the 10-year average for 2002-2011. The AFL explains the "rise" by citing the "more conservative clinical approach" of "Concussion Management guidelines" introduced by the AFL Medical Officers Association at the beginning of the season - part of a "global shift…which may have led to a more cautious decision about return to play the week after injury".[179] Perhaps mindful of the chilling effect that a more "conservative" approach to return-to-play might have on player disclosure of concussion, the AFL's 2011 Injury Report includes "there are many occasions and reports from other codes of football where retired players concede that on occasions when they received concussions they did not report the symptoms to team medical staff. AFL players are strongly encouraged by clubs to report all instances of suspected concussion".[180]

8. NOMENCLATURE

> "Panel discussion regarding the definition of concussion and its separation from mild traumatic brain injury was held. Although there was acknowledgement that the terms refer to different injury

constructs and should not be used interchangeably, it was not felt that the panel would define MTBI for the purpose of this document".[181]

As part of the preparation of this paper, Brain Injury Australia sent the following question to concussion researchers, clinicians in neurotrauma, sports physicians and trainers: "some education materials use 'concussion' and '[mild traumatic] brain injury' interchangeably (for example, that the former is a class of the latter). Some advocates for player health and welfare argue for sole use of the latter; that it more truthfully represents the nature of the injury. Others argue the two injuries are qualitatively different, and that use of the latter term will not only discourage player disclosure of concussion but also player participation in these sports. Do you have a view on these issues?" **In the main, sports physicians were adamant that the two "are not interchangeable" because "it was made clear" by the 2008 CISG *Consensus Statement* that they "refer to different injury constructs";[182] namely, that concussions "reflect a functional disturbance rather than structural injury",[183] ("although structural injury may result through sport concussion"[184]) – a "debate [that] has been going on for more than 300 years without definitive resolution."[185] Clinicians working in general neurotrauma were generally perplexed that concussion could be considered anything other than a brain injury towards the "mild-er" end of the MTBI spectrum: "traumatic brain injury is on a continuum in terms of severity. The most mild of TBI (or concussion) is on this continuum. This is a discussion of semantics so that people can down play the consequences of concussion, which I feel is unethical".[186]** Others interpreted the "discussion of semantics" as a continuation of sports medicine's "colonisation" of concussion. "Unfortunately, the position on concussions from the sports medicine groups has not been officially adopted by practitioners in other fields, including neurologists, neurosurgeons and family doctors, groups that are often called upon to diagnose and manage concussions".[187]

Brain Injury Australia is not qualified to buy into the neuroscience of this "ongoing debate"[188] but rather notes the following. First, for an organisation such as Brain Injury Australia - dedicated to raising awareness about an "invisible" disability - what concussion is "called" is clearly crucial; whether the name is conducive to disclosure, creates expectations of recovery, expectations of symptoms and their persistence and/or predetermines treatment. A 2010 study sought to examine whether children diagnosed with MTBI were increasingly likely to have it "labeled" a concussion. Its analysis of 434 hospitalisations suggested "clinicians may use the concussion label because it is less alarming to parents than the term mild brain injury, with the intent of implying that the injury is transient with no significant long-term health consequences".[189] The strongest predictor of a diagnosis of concussion was a normal Computed Tomography (CT) scan, which "likely implies to parents that their child has no brain injury. Is this what is intended by physicians when they apply the concussion diagnosis?"[190] A diagnosis of concussion was also "strongly predictive" of both earlier discharge from hospital and return to school.

"Until fairly recently we used to emphasize that a concussion IS a MTBI (which it is) in order to get people to take it seriously. Now that there is so much publicity regarding the deleterious effects of multiple concussions, we tend to use the term concussion to refer to transient cognitive sports injuries. We want to emphasize that IF properly managed, sports concussions are typically a transient

> event. We've seen patients with some iatrogenic [induced inadvertently by a physician's examination, manner or discussion] effects from being held out excessively long from all activity, when they would in fact benefit from returning to supervised and graded physical activity".[191]

Conversely, Brain Injury Australia is aware of the potential - in a person sustaining a single uncomplicated concussion and where their health professionals emphasise, say, the consequences of *brain injury* over and above a prognosis of positive outcome and full recovery – for that person to "misidentify common daily cognitive, somatic, and affective phenomena, which covary with stress, as 'postconcussive', [that] can reify these 'symptoms' and in someone prone to being excessively focused on bodily sensations may create a disorder where none would otherwise exist".[192]

Second, the choice of an ideal name has to marry the often competing needs for; the highest level of public recognition, accuracy and honesty in description; and an acceptability that will prompt disclosure and not discourage sports participation. Concussion has higher name recognition, particularly in sport, than MTBI: "there have been marked efforts over the years to educate and raise awareness about concussion. Renaming it MTBI may lose some of the momentum that is finally being gained in sports and in state legislation".[193] Brain Injury Australia seeks that any concussion awareness-raising efforts would demand that the injury be viewed and taken seriously by everyone with an interest in player health and welfare. "If 'concussion' is seen as a more benign word then it is potentially misleading for people who otherwise would not willingly submit themselves to repeated brain injuries - however mild".[194]

Third, Brain Injury Australia admires the confidence with which some physicians are able both to determine - given more than 90% of CT scans for mild head injury are negative[195] and "less than 1% of concussions will have any [CT] findings"[196] – where concussion's "functional disturbance" ends and "structural [brain] injury" begins, and to delineate between concussion and mild TBI in the absence of "definitive or pathognomonic biomarkers for a concussion".[197]

> "I think from a practical perspective, the clinician faced with a [concussed] patient who is not taking the injury seriously may use MTBI to describe it, while when faced with a family that is overly alarmed, the more reassuring term concussion could be used – this is more the art of medicine".[198]

9. "SUBCONCUSSION"

> "The recent revelations regarding head trauma in the [National Football League] suggest that it's not the diagnosed concussions that cause the long-term problems, it's the repeated, day-to-day banging, the subconcussive collisions that mince the brain".[199]

Brain Injury Australia has been unable to locate the first use of "subconcussion" as a descriptor for this purportedly discrete injury, though there are references to "subconcussive" "impacts" and "blows" in animal experimentation with primates and rats as early as 1945.[200] The real impetus for recent interest in this "sub-clinical trauma"[201] derives from study of American footballers whose helmets were fitted with sensors

capable of relaying measures of accelerative force and the locations for each head impact to a remote computer. **A 2009 study of 21 high school footballers recorded 15,264 "collision events" across the 48 practices and games during 1 season, an average of "15.5 collision events per player per organized activity".[202] All players received pre-season baseline neuropsychological testing. The researchers "expected and observed subjects in two previously described categories: no clinically-diagnosed concussion and no changes in neurological behavior; and clinically-diagnosed concussion with changes in neurological behavior". *Undiagnosed* players with "collision event distributions similar to those diagnosed with concussion were intended as controls" for the study, but half of those "demonstrated both neurocognitive and neurophysiologic deficits" as well. The researchers refer to this group as a "previously undiscovered third category who exhibited no clinically-observed symptoms associated with concussion, but who demonstrated measurable neurocognitive (primarily visual working memory) and neurophysiologic…impairments".[203]** Furthermore, the study's "finding of degraded neurological performance in the absence of classical symptoms of concussion is consistent with prior observation of [Chronic Traumatic Encephalopathy (CTE), see below] in the absence of a commensurate history of concussion in two ex-NFL offensive linemen and a defensive back. Given the dire outcomes observed as a consequence of CTE, and given that such a functional observation suggests that present clinical practice does not succeed in detecting the neurological deficits in these individuals, it is important that we develop a means to detect when such injury occurs or, perhaps more importantly, to predict and prevent injuries of this nature".[204]

Brain Injury Australia does not seek to yoke American football together with Australia's "collision sports". They have clearly different concussion risk exposures: for example, helmeted gridiron players routinely use their heads as "battering rams".[205] It also notes the study's small sample as well as the potentially confounding role played by adolescents' increased vulnerability to brain trauma. "One of the difficulties in these studies is that other sports that have far higher rates of sports concussion (e.g., Australian football, rugby) and are equally well studied do not show the same short or long term problems that seem to be evident in the reports from American football research…The reasons for these differences are unclear, but may reflect the different nature of injuries in US sportsmen (e.g., helmeted athletes, head contact with artificial turf surfaces and/or protective equipment) or other unrelated confounders (e.g., use of ergogenic supplements or anabolic steroids)".[206] As part of the preparation of this paper, Brain Injury Australia sent the following question to stakeholders. "It seems…that there are two kinds of concussion (at least, if you exclude "subconcussions") - those that are observable (in their effects on the player) and those that are not (where assessment and diagnosis relies almost entirely on the player both knowing and recognizing the effects of concussion and being prepared to disclose them)". A number responded with "I am not aware of any definition or any entity titled 'subconcussion'"[207] or "there is no such condition as 'subconcussion'".[208]

> "I think of a concussion as a physiological brain disturbance that results in neurological dysfunction, but in many/most cases can resolve completely if managed properly. Now some physiological disturbances cause symptoms (and thus can be recognized as concussions) and others, which might impart the same physiological problems but don't cause symptoms – would be the possible

> ‘subconcussive injury’. It is likely that some athletes for whatever reasons (genetics? etc.) may not manifest concussive symptoms as readily as others...just like some people seem more prone to back pain than others. If subconcussion exists then it is potentially most worrisome because how can we identify it?”[209]

As far as Brain Injury Australia can determine, no local study into sports “subconcussion” has been conducted. However, researchers have expressed interest in trialing United States-designed mouthguards - specially fitted with accelerometers - on cohorts of AFL and NRL players. Both the AFL and the Australian Rugby League Commission have shown preliminary interest.[210] Brain Injury Australia also understands that the CISG will examine the question of “subconcussion” at its November, 2012 meeting.

> “There is no clear evidence that sub-concussive injuries cause permanent brain damage leading to disastrous sequelae, outcomes - but we have to have an open mind about it and I've got an open mind about it but, I think that if you were to say that multiple sub-concussive injuries do have this, then that's going mean considerable change to the way we all lead our lives”.[211]

10. CUMULATIVE EFFECTS

There “appears to be some support for the effects of multiple concussions… in a dose-response manner. Researchers have reported that a history of three or more concussions is associated with changes in cognitive neurophysiology, subjective symptoms, worse neuropsychological test performance, and long-term cognitive decrements”.[212] As stated in the Preamble, studies into the potential cumulative effects of multiple concussions are multiply susceptible to the methodological pitfalls inherent to this area of research. Some are retrospective in design, reliant upon uncorroborated and undocumented player self-report of concussion. Others fail to take into account the period between injuries, markers for severity, the developmental age of the players, how concussions may have been managed or many other, potentially confounding, variables. In addition, the bulk of research derives from the North America and gridiron. The “first study” to suggest a cumulative effect of concussion in high school age athletes compared 60 players from a variety of sports with no concussion history, with 28 athletes with a history of three or more concussions. The study found that the concussed group, when sustaining a concussion “in-study”, was more likely to experience loss of consciousness, anterograde amnesia (the inability to lay down new memory) and confusion than the non-concussed group. The concussed group was almost 10 times more likely than the non-concussed group to “demonstrate three to four abnormal on-field markers of concussion severity”. The concussed group was also slower to recover. Thirty per cent of those in the concussed group reported symptoms lasting for longer than 7 days compared with 14.6% of those with only one previous concussion.[213] One recent local study compared 34 Rugby Union players with a self-reported history of three or more concussions, with 39 “well-matched”, non-concussed controls. It found the concussed group demonstrated “significantly reduced performance on a computerized measure of visual motor speed and a traditional measure of processing” compared to the controls.[214]

Another specific concern reflects evidence that, having sustained their first concussion, sportspeople are at increased risk of further concussions. A 2003 study of 2905 college football players participating in the

United States' National Collegiate Athletic Association (NCAA) competition found those sustaining three or more concussions in a 7-year playing period were at 3 times the risk of subsequent concussions than fellow players.[215] There may also be a relationship between the *severity* of concussion and an increased risk of subsequent concussions. A study of 289 Canadian gridiron players found that concussed players who had lost consciousness were 6 times more likely to sustain another concussion than those who had not lost consciousness.[216] The risk of recurrent concussion may be greatest within a week or so of the first - significantly, within the typical recovery period after concussion. Of 12 repeat concussions within one season of the NCAA study, referred to above, nine occurred within 7 days of the first injury.[217] Reasons for the increased risk have ranged between the individual's style of play, player position, player age and the level of play which may expose certain participants to greater injury potential than those who do not sustain concussions. (Brain Injury Australia has written separately, as part of a policy paper on people with an ABI in the criminal justice system, on the increased risk of subsequent TBIs deriving from the first injury, and the potential effects on the brains "executive" functions – on behaviour regulation and impulse control.[218]) "Despite the increasing body of literature on this topic, debate still surrounds the question of how many concussions are enough to recommend ending the player's career. Some research suggests that the magic number may be 3 concussions in a career".[219] Brain Injury Australia notes that the 14-year survey of 155 concussions in one NRL team, referred to above, included 23 players who sustained a second concussion, two players who sustained a third, and one a fourth concussion during the one season. Moreover, "up to 6 concussions to the same player were recorded" during the survey period.[220] Of the 94 concussions recorded by one AFL team over 10 seasons, referred to above, 17 players were concussed twice in the one season, three players three times.[221]

There's mixed evidence for whether TBI is a potential risk factor for neurodegenerative disorders such as the dementias or Parkinson's disesase. One study of 2,233 people with Alzheimer's disease suggested that the magnitude of the risk is proportional to TBI severity and that TBI involving loss of consciousness almost doubled the risk of Alzheimer's disease when compared to a history of TBI without loss of consciousness.[222] A 2005 survey of 2,552 retired professional American football players found that the 24% of respondents who reported at least three concussions during their career had five times the prevalence of mild cognitive impairment[223] compared to counterparts without a concussion history. They were also twice as likely to develop mild cognitive impairment compared to counterparts who reported only one or two concussions.[224] "Although there was not an association between recurrent concussion and Alzheimer's disease, we observed an earlier onset of Alzheimer's disease in the retirees than in the general American male population".[225] In 2008, the NFL's Player Care Foundation commissioned the University of Michigan to survey 1,063 retired players. The researchers "did not administer cognitive tests and did not conduct neurological examinations. The only information we collected about dementia was to ask the respondent (or proxy) if they had ever been diagnosed with 'dementia, Alzheimer's disease, or other memory-related disease'".[226] 6.1 per cent of retired players aged 50 and over and 1.9 per cent aged between 30 and 49 responded positively, compared with 1.2% and 0.1% of respondents to the US National Health Interview Survey,[227] respectively. The Foundation's survey results "served as an impetus" for the Commissioner of the NFL, Roger Goodell, to be called before the US' House of Representatives

Committee on the Judiciary hearings into "Legal Issues Relating to Football Head Injuries" in October, 2009. At that time, the NFL was spending $88,000 per annum on "more than 100 members of the NFL family"; retired players diagnosed with dementia, "regardless of family history or other possible non-football links to these diseases." The NFL had also committed "$5 million in research on this one issue [concussion] in the last 15 years."[228]

12. CHRONIC TRAUMATIC ENCEPHALOPATHY

Chronic traumatic encephalopathy (CTE) is a progressive degenerative neurological disease. Researchers who have found evidence of CTE in the brains of retired athletes state that it "results in a progressive decline of memory and cognition, as well as depression, suicidal behavior, poor impulse control, aggressiveness, parkinsonism, and, eventually, dementia".[229] The most recent exploration of CTE has its origins in the work of a New York pathologist, Harrison Martland. His 1928 survey of 23 boxers on a "List of Fighters Known by One Promoter to be 'Punch Drunk'" described a spectrum of symptoms including memory loss, tremors, impaired speech and gait.[230] It was later termed "dementia pugilistica"[231] and "the psychopathic deterioration of pugilists".[232] As there is no test for CTE, the only available diagnosis is *post mortem*.[233] Up until 2009, more than half of the 49 published autopsy cases of CTE involved boxers.[234] The lead international research centre for the study of CTE, based at Boston University, states "pathologically verified CTE has been reported in professional football players, a professional wrestler and a soccer player, as well as in epileptics, head bangers and domestic abuse victims".[235] While the majority of autopsy-confirmed cases reviewed by the Center for the Study of Traumatic Encephalopathy have been in boxers, more recently "five were [American] football players, with one soccer, professional wrestling, and ice hockey case also described".[236] These cases have "generated a significant amount of attention within the media, advisory boards for the professional sports leagues, and within the amateur levels of sport perhaps because CTE was reported to have been connected to, or caused the death of these athletes".[237] The publicity surrounding these cases has also led, in part, to 95 lawsuits against the United States' National Football League (NFL) involving over 3,000 former players, many of those lawsuits now consolidated into one "master complaint" filed in federal court in Pennsylvania.[238] Brain Injury Australia is in no position to respond to some of the "primary criticisms" of this CTE research - that, for instance, the "neuropathological findings" are inconsistent with the "CTE literature on boxers" or that "adequate clinical case histories were not provided"[239] – except to note the following.

Firstly, of the "2,000 current players and 10,000 retirees associated with the [National] football league",[240] it would seem not all gridiron professionals are at equal risk of CTE. The same would seem to apply to both the 50,000 or so college[241] and "one million young males" playing high school football in the United States, approximately 67,000 of the latter group are "clinically-diagnosed with a concussion"[242] each year. In 2010, the Center for the Study of Traumatic Encephalopathy recorded early stage CTE in a 21-year-old former college footballer – the youngest person diagnosed with the condition – and in the absence of any documented record of concussion.

> "I know that the argument is often made that there are hundreds of thousands of former football players, including former professional football players, with no signs of any cognitive decline or memory loss or personality change. [But] what I don't understand is why are we expecting that this exposure to repetitive head trauma will have 100% penetrance into the population and cause disease in every football player? Do we expect 100% of cigarette smokers will develop lung cancer? Do we expect 100% of children who play with matches or even chain saws will get hurt? No. Even if the percentage of affected players is 20%, or 10%, there are still thousands of kids and adults out there, right now, playing football at all levels who will eventually come down with this devastating and debilitating disorder. And as a doctor and as a mother, I think this calls for immediate action".[243]

Secondly, that CTE could be attributable to "asymptomatic subconcussive hits to the head"[244] radically opens the brain injury risk exposure from all *contact* sports, as does its progressive nature; "one of the key features of CTE is that the disease continues to progress decades after the activity that produced traumatic injury has stopped. It is most likely that multiple pathological cascades continue to exert their effects throughout the individual's lifetime once they are triggered by the repetitive trauma; *the longer the survival after the initial events and the more severe the original injuries, the greater the severity of the neurodegeneration* [italics added]".[245]

Thirdly, Brain Injury Australia questions whether post-mortem diagnoses, based largely on pathological findings, can always completely disaggregate the relative contributions of, for example, other non-sports-related neurotrauma (motor vehicle accidents, assaults etc.), alcohol and other drug abuse, anabolic steroid use and ordinary age-related cognitive decline, brain atrophy, family history of dementia etc. Statements as definitive as "CTE is the only known neurodegenerative dementia with a specific identifiable cause; in this case, head trauma"[246] may, Brain Injury Australia agrees, prove "possibly premature".[247]

Fourthly, while the differences between gridiron and Australian Rules and the two rugbies have been noted above, local sports administrators seeking refuge in bald declarations that their sports present no risk of CTE since they are "not NFL"[248] are perhaps being naïve, given the rapid evolution in concussion science, the potential spread of litigation and the increasing tally of former players prepared to donate their brain to Boston University's "brain bank" (the NRL's Shaun Valentine is reported to be the first Australian donor) that may result in more "confirmed" cases of CTE.[249]

> "I think I was concussed about 15 times over about a 15-year period. The first time it happened, I played the whole game (at school) and then found myself alone in the change room still in my rugby clothes. Later on that night, I had intended to drive to a friend's place but ended up parked in a bus depot with the engine and lights off…The last few times I could monitor myself slipping out of and then back into consciousness, which I have to admit wasn't a bad feeling at all… I ended up in hospital about 3 or 4 times. I probably should add that I can't taste or smell for the last five years or so".[250]

Lastly, while neurotrauma research in Australia has benefited from some of the best longitudinal surveys of outcomes from traumatic brain injury,[251] there are fewer local long-term follow-up studies of concussion, and specifically in sport. Brain Injury Australia understands that the AFL has engaged neuropsychologist Dr. David Maddocks to repeat his 1985 tests of "cognitive and psychosocial function" on a cohort of "former

players and umpires (control group)", the results of which will be available later this year.[252] The AFL has also instituted a "medical protocol", to: conduct baseline neuropsychological testing with every player involved in its "National Draft Combine"; repeat baseline testing with each pre-season, using the results "following injury to assist with return to play decisions"; and then re-test retiring players "as part of their exit interview [which] will further build our library of data on the subject to assist in making further modifications if necessary to our approach to concussion management".[253] The National Rugby League Research Board has adapted the AFL's approach to include questions about concussion in an injury questionnaire sent to 400 former "State of Origin" players.[254] The New South Wales Sporting Injuries Committee has funded the University of Newcastle to undertake a prospective study of concussion in Newcastle Knights NRL players. The study will utilize the latest neuroimaging technologies to detect CTE in the "living brain" and "follow up…subjects longitudinally to observe any degeneration that may occur".[255] It will also test genetic markers for increased risk of CTE.

The 19,000 member strong "Men of [Rugby] League Foundation" – supporting "former players, coaches, administrators, referees, officials and their families who have fallen on hard times"[256] – sees "no conclusive evidence that any members who may suffer from issues such as Parkinsons or Dementia may be a result of any concussions experienced during the course of playing the game".[257] One geriatrician has noted a much higher rate of Dementia with Lewy bodies - often more closely associated with Parkinson's, by dint of degradation of motor control, than the other vascular, or frontotemporal, dementias, and Alzheimer's disease - in a cohort of "ex-high performing League players" among his patients. "This is not so surprising given the experience of boxers. This is not a prospective study and is more anecdotal. I am sure that it is also the tip of an iceberg".[258]

He noted the players were "especially from forward scrum positions". [259] The research evidence on the frequency, and severity, of concussions by player position is mixed. One study of concussion in two professional rugby league teams over three seasons found no significant differences in rates between forwards and backs, between defensive and offensive positions.[260] Another study of one professional rugby league team over four seasons found forwards had twice the risk of concussion as backs.[261] The NRL's Injury Surveillance Report Season 2009 found that "front-row"[262] and "back-row"[263] forwards sustained more than double the rate of concussion as "halves/ hookers" and more than triple that of "backs".[264] This conforms to findings from American football, suggesting that defensive and offensive "linemen" and defensive "linebackers" – who control the line of scrimmage; an imaginary transverse line determined by where the ball has reached by the end of the preceding play – have much higher concussion risk exposures than players in "skill positions". One study of the over 60,000 "head impacts" that occurred during a season in one high school and one college football team, found players in "skill positions" experienced less than one quarter of the total.[265] Research into "sub-concussive" impacts in high school American football, referred to above, found the "functionally (but not clinically) impaired group was primarily comprised of linemen, who experience helmet-to-helmet contact on nearly every play from scrimmage, often to the top front of the head. This finding of degraded neurological performance in the absence of classical symptoms of concussion is consistent with prior observation of CTE in the absence of a

commensurate history of concussion in two ex-NFL offensive linemen and a defensive back".[266] The lead researcher observed; "our lead lineman, so to speak, accumulated over 1,700 blows to 1,800 blows in each of the two seasons that we studied [him]. So for one of our players, he's taken about 3,600 blows over the course of two seasons that exceeded 14.4gs".[267]

> "I am aware that there is now a massive question mark over the long term effects of concussion, in that ex-footballers seem to have a higher rate than normal of erratic behaviour, including depression and suicide. The problem is whether you can pin these characteristics on concussion or simply playing a sport which attracts risk-taking behaviour…We obviously need some well-conducted case-control studies (by well-conducted I mean where players with depression aren't prompted to remember their previous concussions any more than players who are living happily). Sadly we aren't going to get much further high quality research before we get the hysteria associated with the NFL concussion lawsuits, where retired players who have managed to blow their post-football life are going to have a crack at arguing that the concussions they received in the NFL were responsible."[268]

13. "SPECIAL POPULATIONS: THE CHILD AND ADOLESCENT ATHLETE"[269]

> "The real worry is what would you do with a kid? What would I do if my nine-year-old were badly concussed? I have to say I would take him off for the rest of the season. And if it happened a second time to any young kid I would probably say, 'You'd better find another sport.'"[270]

Alongside "non-elite athletes" and "retired football players" reported to have sustained "Chronic Traumatic Brain Injury" the result of concussion, the CISG accorded "the child and adolescent athlete" "special population" status at its 2008 meeting. A 2006 review of the clinical management of this "oft-neglected population" noted that, while there were ">20 different published expert guidelines geared toward managing athletic concussion more generally", **there were "no comprehensive management guidelines and conspicuously few research studies…that focus specifically on sport-related concussion in the pediatric population".[271] This is in spite of evidence that "brain tolerance to biomechanical forces differs between adults and children" and that, "in broad terms, a two to threefold greater impact force is required to produce clinical symptoms in children compared to adults…This means that if a child exhibits clinical symptoms after head injury, then it is reasonable to assume that they have sustained a far greater impact force compared to an adult with the same postconcussive symptoms".[272]** (Brain Injury Australia has written separately on the general uncertainty about the thresholds of force necessary to produce a brain injury in young children.[273]) This is also in spite of an evolution in the neuroscientific view of the young brain's plasticity and the "Kennard Principle" – named after an American neurologist whose experiments with primates in the 1930s suggested the younger the brain, the better its recovery from injury – with a growing body of researching demonstrating not only that the young brain is more vulnerable to injury but also that the younger the athlete the more protracted the recovery from concussion, "often 7 to 10 days or longer…compared with college-aged or professional athletes".[274]

The CISG's 2008 *Consensus Statement* reflects this change, recommending a "more conservative return to play approach" in children aged under 10 years.[275] It also cites "specific risks…related to head impact during childhood and adolescence"; for example, "diffuse cerebral swelling" which "may be the consequence of a repeated minor head injury, the so-called second impact syndrome".[276] A 2007 review of 94 instances of severe head injuries from American football over 13 years found diffuse brain swelling in 15 of the players. In more than half of the instances, the player had a history of a previous head injury, 71% of which occurred previously in the same season. The researchers contend that 39% of those with a prior head injury would have resumed playing with residual neurological symptoms. Eight players died, 46 sustained permanent brain injuries, and 36 made a full recovery. Most players sustained their injuries from either tackling or being tackled. The researchers conclude "the incidence of catastrophic head injuries in football is dramatically higher at the high school level than at the college level. Although the reason for this discrepancy is unclear, an unacceptably high percentage of high school players were playing with residual symptoms from a prior head injury".[277] The "so-called second-impact syndrome is unknown outside the USA despite being specifically sought".[278] Brain Injury Australia notes that the then Australian Rugby

League's "Policy Statement" on "Head Injuries" includes the following: "under no circumstance should the player be allowed to continue playing nor return to play during the same game. This will eliminate any potential second hit syndrome [sic] (and potential liability)".[279]

Australian studies of sports-related concussion in children and adolescent are also "conspicuously few". A 2006 review of 592 cases of concussion that presented to the emergency department of The Children's Hospital at Westmead, Sydney found that a "severe [closed head injury] in a child is six times more likely to have resulted from organised sport than from other leisure physical activities" and that "severe concussion is associated with collision rather than a fall".[280] Concussion studies of specific junior sports are fewer again. A 1999 injury surveillance study of junior rugby league in Western Sydney, funded by the Australian Rugby League and the New South Wales Sporting Injuries Committee, found a "reported incidence of head injury of 8.4% [compared to other injury sites]…similar to that reported by Rugby Union (8.4%) and AFL (6%) schoolboy studies". The authors observed that "concussion and head injury in the football codes raise the emotions and concerns of the public", but that "results from this study do not support public perceptions and previous findings at senior Rugby League levels of a high rate of injury in junior Rugby League".[281] Brain Injury Australia supports the 2008 CISG's identification of "paediatric injury and management paradigms" as a "key area for research". Australia's Childhood Concussion Head Injury Study Group had proposed "the first longitudinal cohort study on concussion assessment and outcomes in elite adolescent athletes". The study had the potential to include "sub-studies" to "investigate possible biomarkers of neurological dysfunction following a concussive head injury", including genetic predisposition. Brain Injury Australia understands that, after initially "showing interest in funding the pilot study", the AFL's Greater Western Sydney Giants team, the NRL New South Wales and ARU New South Wales have now withdrawn their support.[282]

Recommendation 1:

Brain Injury Australia recommends that the Australian Football League, the Australian Rugby League Commission, and Australian Rugby Union co-fund an independent, large-scale, prospective study – comprising cohorts from all three sports – examining the risk factors for as well as the incidence, assessment, short and long-term effects, management and potential prevention of concussion in child and adolescent players.

14. "SPECIAL POPULATIONS": THE FEMALE ATHLETE?

According to 2010's *Exercise, Recreation and Sport Survey* of 21,603 Australians an estimated 47,500 women played Australian Rules football (up from 46,800 in 2009), 19,800 women played Rugby League (up from 12,300)[283] and 8,900 women played Rugby Union (up from 6,400).[284] **While women's participation in Australia's three major "collision sports" may be increasing and evidence accumulates that they may be more vulnerable to concussion than men, "there are few studies of concussion in contact sports involving females".[285]** A 2000 meta-analysis of eight TBI studies found women scored worse than men in 85% of outcome variables such as headache, fatigue, depression and return to work.[286] A United States study of 71 patients with "mild head injury"[287] found "female gender…to

be associated with a higher incidence of PCS at all time intervals, which reached statistical significance at 1 month, where 68.6% of females versus 44.4% of males had PCS".[288] A recent Australian meta-analysis of 78 research papers "describing 92 independent samples of sports-related concussion" found "female athletes were, on average, more adversely affected by concussion than male athletes".[289] Alongside an "athlete's young age…fewer years of education, or high school level of competition", "clinical decision-making should take into consideration" these "key risk factors…in order to mitigate the risk of premature return to play and repeat injury…[in] these potentially vulnerable sub-groups".[290] A United States study of 155 concussed high school and college athletes found females were "cognitively impaired approximately 1.7 times more frequently than males" when measured against baseline neuropsychological test results.[291] (Some research has found gender differences in baseline performances on neuropsychological tests, some not.[292])

Other research has suggested that concussion may even occur more frequently in female athletes.[293] A variety of reasons has been offered. "Female brains have been reported to demonstrate greater metabolic demands generally which, in the presence of concussive stimuli, may produce an amplified cellular response to concussion-induced metabolic demands and changes in regional cerebral blood flow".[294] Female athletes have "decreased head-neck segment mass compared with male athletes, which could result in greater angular acceleration to the head after a concussive impact".[295] Whether the oestrogens – the primary female sex hormones – have a "detrimental or a neuroprotective effect with regard to concussion" is being "currently debated".[296] Some studies have found that female athletes "tend to report more concussion symptoms than male athletes".[297]

Brain Injury Australia understands "the role of female gender as a possible modifier in the management of concussion was discussed at length" during the CISG's 2008 meeting and, "although it was accepted that gender may be a risk factor for injury and/or influence injury severity…there was not unanimous agreement that the current published research evidence is conclusive that this should be included as a modifying factor".[298] **From its examination of the current "community" concussion guidelines of Australia's three major "collision sports" – each of which have established women's competitions - Brain Injury Australia was unable to locate any reference to gender as, for example, a potential "risk factor for injury and/or influence [on] injury severity". During 2011, in Australian Rules football – "one of the fastest growing sports among women in Australia"[299] – "over 94,000 registered female participants played competitions of six weeks or more".[300]**

Recommendation 2:

Brain Injury Australia recommends that the Australian Football League, the Australian Rugby League Commission, and Australian Rugby Union co-fund an independent, large-scale, prospective study – comprising cohorts from all three sports – examining the risk factors for, the incidence, assessment, short and long-term effects, as well as the management and potential prevention of concussion in child and adolescent players.

15. "SPECIAL POPULATIONS": "NON-ELITE ATHLETES"

> "My husband played AFL for the amateur league until he was 36. I cannot tell you how many times he was concussed during footy games but it was too many, probably 6 or 7 times. Each time was assessed by my husband alone, his club had no medical staff and just players helped each other. Hubby returned to playing the following week each time, in fact attended training the following week. Hubby had no idea what was meant by concussion prevention strategies, coaching techniques, etc. when he was playing. (Importantly he was assistant coach of an adult footy team within the last 4 years and knew about them then, but no-one followed any of the guidelines; kids said they were fit to play so they did. If they didn't turn up to training on the following Tuesday night they were not picked, hence the onus was on the player)."[301]

The 2008 CISG's "[consensus] panel unanimously agreed that all athletes regardless of level of participation should be managed using the same treatment and return to play paradigm" and although "formal baseline [neuropsychological testing] screening may be beyond the resources of many sports or individuals, it is recommended that in all organized high risk sports consideration be given to having this cognitive evaluation regardless of the age or level of performance".[302] Included in the questions sent to stakeholders as part of the preparation of this paper was the following; "perhaps the policy paper's core working hypothesis is that awareness of, and compliance with, 'best practice' concussion assessment and management is poorer the further one ventures from professional (salaried) sport, into amateur, school, junior sports. If true, who do you believe should bear the responsibility - and the cost - of this player health and welfare; specifically, education in, and provision of testing materials in concussion assessment, management, and ensuring compliance with return-to-play guidelines?" In the absence of compelling research evidence - apart from the "community" Rugby Union "compliance" study, referred to above - there was general consensus agreement to the question's premise. The following response was typical: "unfortunately in the rural and regional areas of Australia, with which I am most familiar, there are very few if any management programs in relation to concussion in most sporting codes. Codes that have concussion guidelines are unfortunately only very loosely upheld at the amateur and junior level therefore exposing this group to the potential of adverse outcome. Unless recommended guidelines are more stringently enforced by the governing codes at the junior and amateur levels of their sports then change is unlikely to occur".[303] Opinion was mixed as to who should bear the responsibility for concussion assessment and management in non-professional play, but many respondents thought that "government" had a role: "in professional sport, clubs should bear the responsibility and cost associated with player health and welfare and provision of testing in concussion assessment. Government should fund (or subsidise) these costs at amateur and sub-elite levels".[304] **Some saw, in Brain Injury Australia, a voice for concussion education independent of both sport and government: "I think this is the great opportunity for Brain Injury Australia to promote the message that concussion must be treated appropriately and consistently across all sports and that player welfare is paramount. By highlighting this message, all sports will have a greater opportunity of implementing their concussion strategies".[305]**

16. CONCUSSION "MANAGEMENT"

Brain Injury Australia has examined the concussion "management" guidelines of the three sports the focus of this paper. There are "minor variations"[306] between them. Examination of some of those variations follows. **All three sports use the CISG's 2008 *Consensus Statement* as their guiding authority. Each generally requires: removal of the concussed player (same-day return-to-play only after assessment, and ongoing supervision, by a suitably qualified medical/ other health professional); individualised assessment and ongoing "management" for return to physical activity (as opposed to mandatory exclusion periods) and, in the case of the National Rugby League and Australian Football League, the player's return to his baseline neuropsychological test scores conducted pre-season; and a graded return to physical activity, training, competition.**

SPORT CONCUSSION ASSESSMENT TOOL 2 (SCAT2)

Though in the form of an appendix the SCAT2, the "Pocket" version of which is shown above, "forms part of the Zurich *Consensus Statement*" produced by the CISG in 2008. Like the 2008 "Statement", "this tool has been developed by a group of international experts" in concussion. The intended use of the SCAT2 is "assessment of the concussive injury…once the first aid issues are addressed". It was "designed for the use of [sic] medical and health professionals" and "represents a standardized method of evaluating injured athletes for concussion and can be used in athletes aged from 10 years and older".[307]

All three of Australia's major "collision sports" recommend the use of SCAT2. The ARU, one of the "Member Unions" of the IRB - the "world governing and Law making body for the Game of Rugby Union"[308] and one of four "enlightened sport groups" whose "support and endorsement" of concussion "knowledge transfer"[309] includes such efforts as the SCAT2 - suggests use of SCAT2 "where an injury event with the potential to cause a head injury or concussion occurs and there is a Medical Practitioner[310] or Healthcare Professional[311] present" or "to assist in the identification of suspected concussion where a medical

practitioner is not present at the time of the incident.[312] If the player exhibits any of the "common early signs and symptoms of concussion…and/or…fails to answer correctly the five memory questions in Pocket Scat 2…[the] Player MUST be removed from the field of play for a comprehensive medical evaluation".[313]

The AFL recommends use of SCAT 2 as part of a "medical assessment…where the diagnosis of concussion is obvious". When the diagnosis is "uncertain, the assessment should include a symptom checklist and tests of balance and cognitive function (e.g. Maddocks questions, SCAT2)...For practical purposes, the Pocket SCAT2 can be utilised on-field or on the sideline to screen for concussion. If there is no disturbance of mental status or cognitive function following assessment, then the player may be returned to play. These players should be monitored by the medical staff for the duration of the game and reassessed at the conclusion of the game (e.g. SCAT2). Players who have brief neurological symptoms (e.g. blurred vision, dizziness, unsteadiness) but have normal mental status and cognitive function when tested and have recovered following detailed medical assessment (e.g. SCAT2), may be allowed to return to play with serial monitoring for delayed symptoms and/or signs of concussion. The clinical significance of these lower grade transient neurological injuries currently remains unclear. The results of the serial monitoring (including SCAT2) will be submitted for audit and research to assist with understanding and long term management of concussion in AFL".[314]

As part of the NRL Chief Medical Officer's "complete review of the management of concussion", its *Operations Manual 2012* recommends the "SCAT2 tool…be used in the clinical assessment of concussion on game day", specifically as part of "sideline neuropsychometric testing [by Club Medical Officers] if symptom-free (SCAT 2)".[315]

The "memory", or "Maddocks", "questions", referred to above, were developed as part of 7-year prospective study of 28 concussions in one AFL club that tested the sensitivity of orientation (to place and time) versus recent memory questions in the diagnosis of concussion. The study found that questions directed at "post-traumatic memory disturbance...the only pathognomonic symptom in concussion"[316] were more sensitive in the assessment of concussion. The questions asked were: "which ground are we at?"; "which team are we playing today?"; "who is your opponent at present?"; "which quarter is it?"; "how far into the quarter is it?"; "which side scored the last goal?"; "which team did we play last week?" and "did we win last week?"[317] The "Maddocks questions", named after the study's lead author, were "modified" for the SCAT2, as per the above. Apart from noting the tortured grammar of the first "modified" question – "*At* what venue are we *at* today? [italics added]" - Brain Injury Australia questions its comprehensibility to the already confused/ concussed player. A concussion "assessment" tool is only meaningful, and any resulting "score" valid, if the player understands the questions. While the neuropsychologist after whom the questions were named agrees the question could have been "worded differently...the experience in practice is that comprehension has not been a significant issue. In addition, if there appears to be a comprehension issue, as opposed to an orientation issue, the person administering the SCAT can clarify or explain the question as necessary, without it contaminating the result in any way".[318]

Moreover, the "tester" using SCAT2 must know the correct answers. Brain Injury Australia doubts, when rapidity in concussion assessment is required, when the intended use of the SCAT2 is as a first response after "first aid",[319] and when the "Medical Practitioner" or "Healthcare Professional" administering SCAT2 is not in the employ of team of the concussed player (the typical circumstance in amateur sport), that the "tester" is always going to know the correct answers to; "what team did you play last?" or "did you win your last game?"

Brain Injury Australia notes that the 2008 CISG *Consensus Statement* recognises "other similar tools" to SCAT2 for the assessment of concussion. Brain Injury Australia also understands that administration of the "modified Maddocks questions" is but one of the assessment tools included in SCAT2 and that a "Maddocks score is validated for sideline diagnosis of concussion only".[320] It also accepts that the "modified Maddocks questions" are commonly not asked verbatim: "I modify those questions to the level of the player 'Where we at bro?'; 'What part of the game?'; 'Who got the last try?'…I use them to see how they are thinking and typically they answer all of the questions in some form. If they pause for a while I just move on and that's a fail".[321] "I have not witnessed a GP use the Scat 2 PC/Medical cards!!! They usually have their own questions or ways to ascertain 'concussion'".[322] However, strict adherence to, for example, the IRB's *Guidelines on Concussion* has clear, and potentially dramatic, consequences for the player and the game played: failure "to answer any of the memory questions correctly" means "the Player must be removed from play".[323] In the NRL, "failure on any of" the "assessments" – "the Maddock's modified questions…", "balance" and "cooperation" is "an indication for removal from the field for further assessment".[324] "It could only lead to conservative diagnoses. That is, any problem with comprehension would only make it more likely to falsely diagnose a concussion rather than miss a concussion."[325] The very nature of a "Pocket SCAT2", depicted above, "for use by non-medical persons such as Referees or Coaches if concussion occurs during a game",[326] is its portability and "a bit like remembering to have a first aid kit available",[327] Brain Injury Australia thinks it unlikely the "tester" will be regularly checking on last week's opponent, or game result. "It is obviously important in any training or education of those involved in community competitions to appreciate the importance of being prepared in relation to these questions."[328]

> "One of the things we are realising…is that researchers need to become better at disseminating research findings in a way that is relevant to the whole sporting community, not just at the elite level".[329]

Brain Injury Australia's purpose here is not to nitpick but rather point out the potential disconnect between clinical and research concussion expertise and the end use, "real world", application of its recommended "tools", by laypeople, especially in "non-elite" sports settings. It notes, from the CISG's 2008 *Consensus Statement*, that "definitive normative data for a SCAT2 'cut-off' score [including a 'Maddocks Score' out of 5] is not available at this time and will be developed in prospective studies" as part of the "validation of the SCAT2"; one of the "key areas of research identified" by the 2008 meeting of the CSIG. Brain Injury Australia understands that work has begun on development of a "version of the SCAT" for children under 10 years, one of the "special populations" identified at the 2008 CISG meeting.[330]

"Consideration has been given to making the language and terminology appropriate for children. So overall, I understand [Brain Injury Australia's] concerns about comprehension".[331]

REMOVAL FROM PLAY

The CISG's 2008 *Consensus Statement* includes "a concussion should be suspected" if a player is assessed or self-reports positively in "one or more of the following clinical domains: symptoms – somatic (e.g. headache), cognitive (e.g. feeling like in a fog) and/or emotional symptoms (e.g. lability); physical signs (e.g. loss of consciousness, amnesia); behavioural changes (e.g. irritablity); cognitive impairment (e.g. slowed reaction times); and sleep disturbance (e.g. drowsiness)". If "any one or more of these components is present, a concussion should be suspected and the appropriate management strategy instituted". When a player "shows ANY features of a concussion" and "no healthcare provider is available, the player should be safely removed from practice or play and urgent referral to a physician arranged". While the 2008 *Consensus Statement* does not directly state that a player with a "diagnosed concussion" should also be "safely removed from practice or play", that player "should not be allowed to return to play on the day of injury. Occasionally in adult athletes, there may be return to play on the same day as the injury".[332] (Discussion of this follows.)

Where "on-pitch / sideline assessment AND player [sic] has an injury with suspected concussion", and regardless of whether a "Medical Practitioner" or "Healthcare Professional" is "present", the IRB's *Concussion Guidelines* require a "player MUST be removed from the field of play and MUST NOT play any further part in the game".[333]

As per the above, "failure" on "any" of a NRL Sports Trainer's "assessments" including the "Maddock's modified questions" and tests of "balance" and "co-operation…is *an indication for removal* [italics added] from the field for further assessment". Then if, "after sideline/dressing room assessment by the Club Medical Officer the Player is diagnosed with 'concussion' he should not be allowed to return to the field of play on the same day".[334]

The AFL Medical Officers' Association "inherently conservative" *Guidelines for the management of concussion in Australian football* differentiates between "diagnosis of concussion" that is "obvious" or "straightforward" versus "uncertain" or "unclear". "Obvious" diagnoses include those with a "period of [loss of consciousness], confusion or disorientation and memory disturbance or other cognitive deficits". In those cases, the player should be medically assessed…and is not to be returned to play on the day of injury." In cases "when the diagnosis is uncertain, the player requires further assessment". This "typically includes a symptom checklist and tests of balance and cognitive function (e.g. Maddocks questions, SCAT2). Initial screening may involve a brief on-field assessment…If the diagnosis is still unclear and a more detailed assessment is required, the player should be removed from the playing environment and evaluated in a place free from distraction". Then "if the diagnosis of concussion is confirmed following assessment (i.e.

ongoing neurological symptoms and/or disturbance of mental status or cognitive function) then the player should not be returned to play on the day."

The CISG's 2008 *Consensus Statement* stresses "when a player shows ANY features of a concussion", once "medically evaluated onsite using standard emergency management principles", then "the appropriate disposition of the player must be determined by the treating healthcare provider *in a timely manner* [italics added]". A number of respondents identified the potential for "healthcare providers" to deliberately delay or draw out "assessments" in the hope that the injury will prove, along the lines of the above, a "very mild concussion that has quickly recovered", allowing the player to continue. The AFL Medical Officers' Association "Guidelines" allow for players with "brief neurological symptoms (e.g. blurred vision, dizziness, unsteadiness) but have normal mental status and cognitive function when tested and have recovered following medical assessment (e.g. SCAT2)" to be "allowed to return to play with serial monitoring for delayed symptoms and/or signs of concussion". One AFL team doctor notes "for professional teams who have sideline doctors available concussion injuries effectively fall into two categories. The first are those players who initially appear to have sustained a concussion but when fully assessed no longer have any symptoms or signs of concussion and so are allowed under the policy to return to the game. The second are the concussions which initially are more obvious and usually involve loss of consciousness or memory disturbance whereby recovery is slower and so these players would not return to the game on that day".[335] The same doctor's survey of the 94 concussions sustained by his players over 10 seasons showed: 36 resulted in the player "going off" the field "and coming back on" after "resolution of symptoms" and being "symptom-free" after an "off-field exertion test" but without "sideline neuropsychometric testing being performed"; in 24, the player "continued"; and in only 21 the player "did not return" to play in the same game. Even so, the survey found "no statistical difference" between concussed players' return games and their "season average coach-rated match performance".[336]

A related question is the differential access of "healthcare providers" to injured players. The AFL allows team doctors "unrestricted access to the field of play to assess and treat any injured players"[337] whereas "only players, match officials and registered Trainers are permitted on the field of play" during a NRL match. "Should an injury necessitate a doctor coming onto the field, the Head Trainer who carries out the initial assessment is to attract the attention of the nearest Touch Judge who can electronically communicate with the Referee to advise him that the injury is serious".[338]

> "A trainer, who spoke to *The Weekend Australian* on condition of anonymity, said the situation regarding concussions [in the NRL] was much better now than it was a decade ago. He said in the past he had been told by coaches to leave concussed players on the field to test if they were really hurt or 'soft'."[339]

Brain Injury Australia has anecdotal evidence that such "tests", above, are less a thing of the past than the trainer believes. NRL club doctors are reported to be lobbying for the provision of video monitors to aid on-field diagnosis of concussion. "No one has said that they were pressured to leave someone on but a couple

of guys who had fingers pointed at them said they could not get access to that player. I agree sometimes that it can look terrible and it puts the doctor in a difficult situation. He hasn't done an assessment so, in a way, he's liable".[340]

RETURN TO PLAY – SAME DAY

Under the heading "Same day RTP", the CISG's 2008 *Consensus Statement* allows for "more rapid… return to play management" with "adult athletes, in some settings, where there are team physicians experienced in concussion management and sufficient resources (e.g. access to neuropsychologists, consultants, neuroimaging etc.) as well as access to immediate (i.e. sideline) neuro-cognitive assessment. Even though the appended "SCAT2" (which "forms part of the Zurich *Consensus Statement*") states that "athletes should not be returned to play the same day of injury", the "consensus panelists…acknowledged that there is evidence that some professional American football players are able to RTP more quickly, with even same day RTP supported by NFL studies without a risk of recurrence or sequelae. There is data however, demonstrating that at the collegiate and high school level, athletes allowed to RTP on the same day *may* demonstrate NP deficits post-injury that *may* [italics added] not be evident on the sidelines and are more likely to have delayed onset of symptoms." The "young (<18) elite athlete should be treated more conservatively". Elsewhere in the *Consensus Statement* the "panelists" determined "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."[341]

The IRB's *Concussion Guidelines* are categorical: "players *suspected* [italics added] of having concussion must be removed from play and must not resume play in the match".[342]As above if, "after sideline/dressing room assessment by the Club Medical Officer" an NRL player is not diagnosed with a concussion and "returns to the field of play…he must be regularly re-evaluated by the Head Sports Trainer".[343] While the AFL Medical Officers' Association *Guidelines* allow for players "who have brief neurological symptoms…to return to play with serial monitoring for delayed symptoms and/or signs of concussion," they admit the "clinical significance of these lower grade transient neurological injuries currently remains unclear".[344]

> "I have been involved in junior and senior aussie rules football for over 17 years as a medic/trainer and the common belief that a player who has sustained a knock to the head will be okay in 5 or 10 minutes is the common consensus with the players and coaching staff. It has often led to an argument between the coach and trainer about getting a player back on the field, especially if it is their best player. The players also see the AFL stars get knocked on the head and return within 10 or 15 minutes later…The junior players also don't realise that the trainers who assess the AFL players are doctors and physios. They are not just First Aid trained as most of us are".[345]

The kinds of uncertainties in syndrome diagnosis detailed throughout this paper - such as how "brief" or "ongoing" symptoms need to be to constitute a concussion or how to "test" recovery from a "mild" concussion based on player self-report - have led to some coaches and administrators' open speculation about the risk-benefit trade-off of returning a concussed player to the field, even against the advice of the team's doctor. "What if it was a Grand Final and we're down to 17 guys and he wants to go on, what do

we do?...It's an interesting one and I don't know what the answer is. Do you get fined if you do that or does the club become liable if he gets injured again or something? I'm not sure".[346]

> "I've been saying for years that it's stupid, this idea that it's ok to send a player back out onto the field with injury, especially concussion. I get so sick of seeing injured players come back into the field of play while the bonehead commentators go on about the 'bravery' of the player, it's a real 'good on him' attitude. My son, a teenager, was concussed recently after a collision with a friend and it took a good 10 or 15 minutes for symptoms to show - he thought he was ok at first. He ended up in hospital for the night, after losing his memory, balance and speech. And he wasn't feeling right for weeks afterwards".[347]

Ready access to "team physicians experienced in concussion management and sufficient resources" notwithstanding, Brain Injury Australia questions how comfortably "Same day RTP" sits with the frequency of delayed onset of concussion symptoms. A 2004 study of 43 mildly concussed high school athletes in the United States found both significant increases in their self-reported symptoms and deficits in memory after 36 hours, when they had been symptom-free within 15 minutes of injury.[348] The NCAA study, referred to above, found that one third of concussed players who returned to play on the same day experienced delayed onset of symptoms at three hours post-injury, compared with only one in eight of those who did not return to play on the same day.[349] Such findings also challenge the reliability of the more than 40 head injury severity grading systems currently available,[350] several of which use loss of consciousness or amnesia as their primary criteria.[351]

MANDATORY EXCLUSION PERIODS

> "Several years ago, I introduced a 'head injury' rule within an amateur rugby league organisation in which I was employed. We introduced a mandatory period away from training and competition for players who had sustained suspected concussion. It actually artificially increased our concussion injury rates (resulting in a missed match), because players were automatically prevented from playing in subsequent week/s. However, the rule was unanimously supported by coaches, administrators, and players because they felt that the players' best interests were at the heart of the decision/rule".[352]

According to the CISG's 2008 *Consensus Statement*, while "the majority of [concussive] injuries will recover spontaneously over several days", the "cornerstone of concussion management is physical and cognitive rest until symptoms resolve and then a graded program of exertion prior to medical clearance and return to play". Thus, periods of exclusion from play "remain in the realm of clinical judgment on an individualized basis".[353]

The AFL Medical Officers' Association *Guidelines* concede "return to play…decisions remain difficult…Currently, however there is no single gold standard measure of brain disturbance and recovery following concussion. Instead, clinicians must rely on indirect measures to inform clinical judgment. In practical terms, this involves a multifaceted clinical approach, which includes assessment of symptoms, signs (such as balance) and cognitive function."[354] Like the AFL, the NRL has put its faith in pre-season and post-injury "neuropsychometric testing" of players to measure *cognitive* recovery from concussion "and when this has returned to normal, they may begin a gradual return to sport".[355] "Comparison to an

individual's own preseason baseline test allows the most accurate assessment of cognitive recovery post-injury. Furthermore, routine use of computerised tests in the preseason facilitates screening of players for cognitive deterioration over time".[356]

The CISG's 2008 *Consensus Statement* includes; "the application of neuropsychological testing (NP) in concussion has been shown to be of clinical value and continues to contribute significant information in concussion evaluation…It must be emphasized 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 clinical domains and investigational results".[357] **There is not the space here, neither is Brain Injury Australia qualified, to adjudge the competing neuropsychological assessment tools for concussion, specifically: whether each adequately compensates for "practice effects" (improvements in scores with repeat testing) or adequately checks for "malingering" (players boast of purposely performing poorly on pre-season tests so they will be more readily found fit to play after a concussion); how a "return-to-baseline" score approach to return-to-play works during a period of "rapid cognitive maturation"[358] for the younger athlete; whether the research findings into their accuracy are always free of competing interest (when "the vast majority of studies have been conducted by the developers of the tests"[359]); and their availability and cost outside of "elite" sport, especially when "neuropsychologists are in the best position to interpret"[360] test results.**

> "I feel strongly that if a sporting organisation actively encourages and benefits from participation in their sport financially and otherwise, that organisation has a duty of care to all the participants including the players, trainers, coaches, referees and committees of small, local clubs – not just the elite participants who attract money and recognition to the sport".[361]

The trend towards "individualized" assessment has meant that mandatory exclusion periods for concussed players have fallen out of favour. The IRB's *Concussion Guidelines*, which came into effect in May 2011, abandoned the "minimum period of three weeks from the time of injury" exclusion from "any Match or training session"[362] for all concussed players except "in extreme situations where a Player does not have access to a Medical Practitioner to diagnose concussion or to manage the [Graduated Return to Play]. In these situations if a Player has shown signs of concussion that Player must be treated as having suspected concussion and must not play until at least the 21st day after the incident…If a Medical Practitioner…is managing the recovery of the Player it is possible for the Player to return to play after a minimum of six days having successfully followed and completed each stage of the [Graduated Return to Play] protocol".[363] Brain Injury Australia understands that part of the reason for the abandonment of the universal mandatory three-week exclusion period was poor compliance, specifically the results of a 2011 study of 1,958 "community" rugby union players in Sydney. Of the 1 in 5 concussed players who were even given return-to-play advice, only two out of the 23 complied ("91% player non-compliance"). Nearly half of the concussed players returned to play in the same game and more than one-third did not leave the playing field at all.[364] A 2006 survey of 477 New Zealand high school rugby union players found that, while 60%

correctly identified the IRB's mandatory three-week exclusion period, more than half made the return-to-play decision after concussion themselves and only 1 in 5 on the advice of a "Medical Practitioner".[365]

The prospect of missing three matches may also have had a chilling effect on disclosure of concussion by elite players. The *Rugby Union Injury Surveillance Study* report on seasons 2002, 2003 and 2004 noted "the incidence rate of concussion in elite rugby is low. Only three concussions out of 145 injuries were observed in games and training". While "access to medical support" was identified as "a reason" the "possibility of under-reporting of concussion has also been raised. The reason given for the under-reporting of concussion is to avoid having to stand a player down for three weeks".[366] Brain Injury Australia recognises that the IRB's retention of a selective three-week mandatory exclusion period, above, should act as an incentive for concussed players to seek the diagnosis and return-to-play management of a "Medical Practitioner". It also notes that the ARU does not undertake neuropsychological assessments of its players. "Standardised psychometric tests have been suggested as an alternative to mandatory exclusion policies because they are easy to administer, objective, and focus on the individual case".[367]

Recommendation 3:

Brain Injury Australia recommends that the Australian Football League, the Australian Rugby League Commission, and Australian Rugby Union – in collaboration with Australia's other major participation sports – develop and fund the dissemination of cross-sport concussion assessment and management guidelines.

"MEDICAL PRACTITIONERS"

> "Most players do not read any of the [Australian Rugby League] handouts that are given to them if they sustain an injury and will brush off the seriousness of a head Injury. Coaches tell them they will be ok to play/train without consultation with trainers let alone suggesting that a Doctor take a look at them. We have even had the case at our [Senior] and [Junior] clubs that parents/players will doctor shop for a clearance and come with the said paper even though we know that they still are not right to take to the field just so they can play next week."[368]

While Brain Injury Australia accepts there are "inherent dangers"[369] in mandatory exclusion periods - particularly the over-estimation of "mild" injuries and the under-estimation of those more severe, more persistent, in their symptoms - it is also wary, in the absence of "consensus" and given the variability in diagnosis and management detailed throughout this paper, of blithely submitting concussion to the "clinical judgment" of any given "Medical Practitioner". For example, while Brain Injury Australia has no direct evidence of the "doctor shopping" referred to above, it stands to reason that, say, in regional and rural areas where specialist medical and concussion-trained allied health professionals may be in short supply, the more "liberal" than "conservative" opinions in concussion diagnosis and return-to-play would be locally known, and available for purchase. This raises the question of General Practitioner (GP) and medical specialist knowledge about concussion and "best practice" assessment and management. Brain Injury Australia is unaware of any local research that might have tested that knowledge. A 2005 British study compared knowledge of PCS in 30 people with MTBI

compared with 30 GPs and 30 laypeople using the following "vignette" with a symptom checklist as a prompt.

> "A man crashes his car after skidding on some ice but no other cars are involved. He gets a bump on the head and loses consciousness for a few minutes. He is taken to hospital and cannot remember the accident. It is nearly an hour after the crash before the man is no longer confused and his memories of this hour are patchy. Apart from some cuts and bruises, he has no physical injuries. The hospital admits him overnight for observation and discharges him in the morning, as he appears to be well. The man's GP routinely recalls all of his patients who have had a head injury for a check-up 1 month later. His GP asks him if he has suffered any side effects or symptoms since the crash. What do you think the man would say to his GP?"[370]

Using the vignette alone, only 1 of 90 participants - a GP - reported enough symptoms to achieve "caseness" (even though one third of the GPs had "personal experience of MTBI through a relative or close friend").[371] With the aid of a checklist of symptoms such as "fatigue", "irritability", "headache", "dizziness" etc., still only 60% of the GPs achieved "caseness", compared with 40% of people with MTBI, and 20% of lay controls.[372] People *hospitalised* with concussion are often given incorrect advice. A 1995 review of all sports-related closed head injury admissions to a large children's hospital in the United States over a 5-year period found that as many as one in every 10 patients was given discharge instructions that allowed for return to play too quickly and 6 in every 10 given no advice at all on return to play.[373] It may be reasonable to expect that sports physicians will be in better compliance with "best practice" management. However, a 1996 survey of members of the American Society for Sports Medicine found only 30% followed recommended guidelines.[374]

Physician concussion practice may prove resistant to change. Since 2007 the United States' Centers for Disease Control and Prevention have provided free concussion education materials to coaches, parents, and athletes, and have developed partnerships with more than 26 national health and sports organizations, as part of its *"Heads Up: Concussion in Youth Sports"* initiative. "Within the first year of this national campaign, more than 40,000 tool kits, 400,000 fact sheets, 60,000 magnets, and 40,000 posters were distributed".[375] Researchers from Washington State surveyed 414 randomly selected pediatricians, family physicians, and internists,[376] half of whom had previously been sent the *"Heads Up"* "toolkit". There were "no significant differences…for confidence in knowledge of concussion management" between those physicians who had received the "toolkit" and those who had not. Only 16 per cent "used standardized assessments of concussion." The "only difference in general concussion knowledge" between the two groups was in response to the statement; "wearing a helmet prevents concussions." Forty-two per cent of physicians who received the "toolkit" were incorrect in their agreement with the statement compared to 52% of those who had not received the "toolkit". The only noteworthy "affect" of receiving the "toolkit" was its association with "decreased likelihood of recommending next day RTP consistent with current concussion guidelines".[377] Furthermore, "some have questioned whether practice guidelines are the best means for educating physicians regarding clinical management…Multiple guidelines have been published regarding sports-related concussion management over the years. Future studies should focus on assessing whether concussion guidelines are effective for preventing further injury".[378] Brain Injury

Australia notes – as per the "Preamble", above - that, in the absence of any Australian "guidelines" for sports-related concussion management, and alongside the "*Consensus Statement*" that will emerge from the November 2012 meeting of the CISG, the American Academy of Neurology, the American Medical Society for Sports Medicine and the United States' National Athletic Trainers Association are each preparing their own "guidelines".[379]

As part of its "Quality Improvement and Continuing Professional Development", the Royal Australian College of General Practitioners has "accredited" three "workshops" that traverse concussion and one 1 and a half hour "lecture" on "sports-related concussion and mild traumatic brain injury".[380] In 2008 the Motor Accidents Authority of New South Wales, in recognition both that "everyone needs to be educated on MTBI as the diagnosis is poor so the management is poor" and the key is "GP education as most MTBI do not go to hospital",[381] produced *Summary Guidelines for Mild Traumatic Brain Injury Following Closed Head Injury for General Practitioners*. The *Guidelines* included, as part of a patient "review 1-2 weeks post injury", a "graded return to sport". The patient was "required to be symptom free at end of each stage (i.e., light aerobic activity, sport specific training, non-contact training drills, full contact training, return to play), or 'if in doubt sit them out'".[382] The *Guidelines* were sent to the then 2,000 GPs in New South Wales. As at June 2012, 256 GPs have also completed two online learning modules - "The key diagnostic features in MTBI" and "The key issues in managing MTBI" - via the "ThinkGP" website.[383] Since 2008, Sports Medicine Australia has accredited, or re-accredited, 20,618 "Sports Trainers", all of whom have received instruction in the recognition and appropriate management of concussion.[384]

16. CONCUSSION EDUCATION – COACHES

> "[Jonathan] Thurston lay flat on his back for more than a minute, with trainers removing his head gear. He was able to walk unaided to the sideline but did not return. While Thurston was up walking around and talking in the dressing sheds, he will be given a few days off training before concussion tests are performed… He cannot remember the actual tackle but had no serious side-effects in the hours after the match. "I've spoken the medical staff. My jaw feels fine and there's no major headaches - I had a little one last night but that was it," Thurston said…*[Coach Neil] Henry sees no need for scans. "He had his head gear on and he's a pretty tough character. He was quite lucid and no headaches, when I was talking with him* [italics added]*,"* Henry said. "But he certainly got a fair knock."[385]

Apart from a current research project led by Monash University in partnership with the AFL and NRL,[386] Brain Injury Australia is unaware of any local surveys of coaches' knowledge of concussion and its management. A 2007 survey of 109 high school football coaches in the United States found they "held significantly fewer misconceptions" - on questions such as "sometimes a second blow to the head can help a person remember things that were forgotten" – when compared to a "general public sample" from the same region. The concussion information source most frequently cited as "very helpful" was the US CDC's *Heads Up* "toolkit".[387] A separate evaluation of the appraisal and use of *Heads Up* found: 50% of coaches reported realising that concussions were more serious than they previously thought; 38% changed the

way that they managed concussions based on the "toolkit"; and 68% used the "toolkit" to educate other coaches, parents, and athletes about concussion.[388]

As a result of a catastrophic brain injury to a high school footballer in 2006, 39 US states and the District of Columbia have enacted youth sports concussion safety laws, commonly referred to as "Zackery Lystedt laws" (named after the footballer). Their key provisions include a requirement that local school boards develop educational materials and guidelines for coaches, parents and athletes. Brain Injury Australia has obtained a copy of the *Virginia Board of Education Guidelines for Policies on Concussions in Student-Athletes* from a leading concussion researcher who helped in its drafting.[389] It includes "each school division shall develop policies and procedures to ensure school staff, coaches, athletic trainers, team physicians, and volunteers receive current training *annually* [italics added] on: how to recognize the signs and symptoms of a concussion; strategies to reduce the risk of concussions; how to seek proper medical treatment for a person suspected of having a concussion; and when the athlete may safely return to the event or training".[390]

> "[Rugby League's] a contact sport, you clowns. [Concussion's] bound to happen. It should be up to the players and club doctors' disgression[sic], not some nanny state, arty farty policy. More rules, good on you guys."[391]

17. CONCUSSION EDUCATION – PLAYERS

> "If they're invisible injuries, what can we do but make players aware that they need to discuss their concerns with us? We can only help out if we're aware of the situation".[392]

The question that Brain Injury Australia sent stakeholders regarding the two "kinds" of concussion, referred to above, included the following: "can you identify any innovative programs of player education in concussion, proven capable of removing obstacles to disclosure; the heroic culture of 'playing through' injury, fear of exclusion from play, fear of letting the team down etc.?" The following was typical: "there are no peer-reviewed studies showing that employing any particular concussion education program results in increased reporting by athletes".[393] One respondent offered: "one approach we've found increasingly effective in the military (with many of the same motivations as an athlete), is not to make the soldier worry about themselves (many would sacrifice themselves for the team) but to get them to understand that if they return to duty/play without being 100%, they will make an error that can hurt their team. Also, they are more vulnerable to another concussion, and symptoms tend to last longer after repeated concussions, so instead of their team losing them for a few days or a week, the team might lose them for weeks or even the months…The American Academy of Neurology is even considering having 'Team Pledges' signed by all teammates promising to educate themselves about what a concussion is and to help recognize when a teammate is acting funny".[394] Another: **"I can tell you that when high-profile athletes recognize the danger regarding playing with a concussion then other amateur or lesser high-profile players now think it is 'cool' to be removed from the field of play due to concussion".[395] Brain Injury Australia**

believes the recruitment of "high-profile" current, and/or former, players as "poster children" for concussion management is an essential ingredient in any education campaign.

> "In my case I was often unaware that I had been knocked out or concussed. The main danger was that I imagine (but don't often remember) that I played on without knowing and without others around me also not knowing…In my case it was not heroic, but rather 'autopilot'"[396]

Some respondents sought to familiarise Brain Injury Australia with a potential third "kind" of concussion: "it must be noted that even when a player is educated in terms of awareness and recognition of the effects, the paradox is that the symptoms of the concussion might inhibit that awareness or recognition, at least in the acute stage. There are many documented instances of players running off and continuing to play after a collision, when it only became apparent after the game that they had been concussed (i.e. when they have little no recollection of the course of the game)".[397] These "instances", in turn, again raise the question of "subconcussion": "our data (published and in preparation) strongly suggest that many players are not aware of changes in the function and health of their brain, even when these changes are quite marked. We have a number of players who are exhibiting changes in brain chemistry consistent with those observed in longitudinal studies of traumatic brain injury patients, yet these players report no symptoms and exhibit few readily detectable neurocognitive changes, with detection by standardized tools…being sporadic, at best".[398]

Recommendation 4:

Brain Injury Australia recommends that the Australian Government, through the Sport and Recreation Ministers' Council and the Standing Committee on Recreation and Sport, develop, implement and fund a national cross-sport education campaign in awareness and best practice assessment and management of concussion, suitable for sports administrators, coaches, trainers, players and the broader community.

18. PREVENTION

> "An injury occurs when the stress applied to a tissue is greater than its ability to 'absorb' the stress acutely or chronically…Effective injury prevention programmes typically attempt to optimise the balance of applied and absorbed stress".[399]

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> "The brain is not an organ that can be conditioned to withstand concussive injury; there are relatively few means by which such injury can be minimized in sports."[400]

Even given its passing popularity with the "lay press"[401] and the new seriousness with which both the short and long-term health effects of concussion are being taken, concussion may prove to be the least preventable of sports injuries. And while Brain Injury Australia welcomes the burgeoning concussion research effort it notes research into effective prevention initiatives may not be getting the academic attention it deserves. A 2012 systematic review of the sports injury prevention literature found, while there was a "steady increase in these articles over the past 15–20 years", only 14 (out of 159) studies "examined interventions specifically designed to reduce concussions".[402] A 2010 systematic review of interventions aimed at investigating biomechanical/ physiological outcomes for the purposes of preventing sports injury found only 144 (out of 2,525) where the "interventions were designed to identify factors that would lead to

a reduction in injury risk". Of those, while 82% had studied collision or contact sports where concussion risk exposure is high, 92.1% of articles "specifically studying an injury location were restricted to the lower extremity".[403]

The 2012 review, above, found that most of the injury prevention interventions were related to equipment (41% of articles) or changes to training (32%). Concussion may also prove impervious to technical fixes such as helmets or mouthguards. **The CISG's 2008 *Consensus Statement* included "there is no good clinical evidence that currently available protective equipment will prevent concussion although mouthguards have a definite role in preventing dental and oro-facial 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".[404] A systematic review of equipment studies published the following year found "helmet use has been shown to decrease head and brain injury risk among bicyclists, and head injury among skiers and snowboarders, but the effect of helmet/headgear use specifically on concussion risk is inconclusive in these sports, as well as sports such as rugby, football (soccer) and rodeo".[405]** The results of the "first reported [randomised controlled trial] of headgear as an injury control method in rugby union football", involving over 80 clubs and almost 3,000 players over two seasons, found "padded headgear does not reduce the rate of head injury or concussion".[406] However, it also found "limited evidence that wearing headgear was associated with increased injury rates based on a 16% increased overall game injury rate for those wearing standard headgear after adjustment for level of play". While the differences in the rates of head injury "were not significant…wearers of the standard headgear did have a 14% higher incidence of game and missed game injuries than nonwearers. It is unclear whether this truly reflects an aspect of risk compensation".[407] ("Risk compensation" occurs when "the use of protective equipment results in behavioral change such as the adoption of more dangerous playing techniques, which can result in a paradoxical increase in injury rates".[408])

The concussion "guidelines" for the AFL, NRL and IRB do not mention helmets. The Australian Rugby League's "Policy Statement" on "Head Injuries" states "the misconception[sic] that headgear will prevent a concussion occurring is false". [409] In a recent "update" to the Victorian Department of Education and Early Childhood Development's *Schools Policy and Advisory Guide on Safety in the Curriculum and in Physical Education and Sport*, students are "encouraged to wear Standards Australia approved head gear" when playing Rugby League, Rugby Union or Australian Rules. Apart from reference to scrums in Rugby League and Rugby Union, the potential injuries for which "head gear" might be protective are not specified. While the prevention of concussion is nowhere implied, Brain Injury Australia is concerned that, given both the widespread "misconception" about headgear and the potential for adopting "more dangerous playing techniques", players so equipped will sport a false sense of invulnerability. Recent research has demonstrated a "differential behavioural response of children to protective equipment with some adopting increased risk taking behaviour and hence paradoxically increasing their risk of sustaining a concussive injury by wearing a 'protective' helmet".[410]

All three of Australia's major "collision sports" have made changes to their rules in order to reduce contact with, and impact to, players' heads. These include the NRL's "banning of head high tackles, careless contact with the head, raising the knees and elbows in tackles and spear tackles"[411] as well as "an adjustment to the shoulder charge rules that ensured that any contact with the shoulder to the head or neck of a player could be regarded as dangerous contact and subject to judiciary procedures".[412] At the time of writing, the NRL had also announced a review of the "shoulder charge" after the tenth penalised shoulder charge of the season left one player with a severe concussion.[413] The AFL has modified a number of rules in relation to tackling and charging as well as making the "head-high bump" a "Reportable Offence" under "Rough Conduct", where; "in the bumping of an opponent (whether reasonably or unreasonably) he causes forceful contact to be made with any part of his body to an opponent's head or neck and instead of bumping, the player had a realistic alternative to contest the ball or tackle the opponent".[414]

The AFL and NRL have also continued to refine their interchange rules as a means of reducing injury, including concussion. Allowing players to interchange freely "means that injured and/or fatigued players are not under team pressure to push through the pain of an injury and stay on the field. However, unlimited interchange (meaning that fatigued players can rest as often as required) will almost certainly increase the speed of the game, potentially increasing the risk of injury".[415] Concussion is "fundamentally an acceleration/deceleration injury and, as a matter of logic, greater speed might be associated with greater impact forces and therefore greater risk of concussive injury or more significant concussive injury".[416] (A number of respondents have noted the increase in concussion risk potential due, not only to the "greater speed" of play, but also due to the increased size and musculature of players.[417]) Interchange player use in the AFL rose to approximately 120 per team per game in 2010. Player speed, as measured by Global Positioning System (GPS) devices worn during games, increased, as did "the number of injuries".[418] At the beginning of the 2011 season, the AFL reduced the number of interchange players from four to three, and introduced one substitute player. One of the rule change's "key objectives…was to reduce the speed of players by decreasing their rest time. If the players are travelling at slower speeds, and the game is less congested, the likelihood and severity of collisions will be reduced".[419] The GPS data from the 2011 season showed that "average player speed and time spent at the highest speeds both decreased…for the first time in several years".[420] However, while there were "statistically significant falls in the 2011 incidence (compared to the previous 5 seasons) of hamstring muscle strains and all lower limb muscle strains", concussion incidence "doubled" (see above).

In 1987, the NRL introduced a 'head-bin' for players "suffering minor head injuries allowed to return to the field of play after 10 minutes without affecting team's quota of replacements". This was "during a period of limited interchange (four replacements maximum)" and the bin "suffered some abuse via players feigning injury". By 1996, the NRL had moved to unlimited interchange "making the head-bin redundant".[421] In 2001, the NRL re-introduced limited interchanges with a maximum of 12 per game "using a four man bench. This was calculated to include both tactical and injury based replacements". In 2008, this was reduced to ten interchanges per game. However, the "key difference between today and the head bin rule of the past is that players are now prohibited from *returning to play if diagnosed with concussion* [italics added]".[422] The

NRL maintains “in the last four years there has been no increase in the incidence of concussion”.[423] The IRB has recently announced a trial of a “pitch-side concussion assessment (PSCA) protocol within their elite domestic competitions”. Players who have “sustained a head injury with suspicious symptoms or signs will be able to leave the field of play for a standardised assessment undertaken over a five-minute period” and “temporarily replaced”. If the player “fails any aspect of the assessment and has relevant symptoms he will not be able to return to the field of play and the substitution becomes permanent”. Notably, the recommendation to remove a player “can be made by either[sic] the referee, the independent match day doctor or the team doctor from the player's team”.[424]

> “In a single 80-minute game of rugby league at this level, I may have an average of eight injuries that require off-field assessment before a return-to-play decision can be made…For example, my injury tally for 28th April: 1 dislocated elbow, 1 fractured clavicle, 2 concussions, 1 rib cartilage injury, 1 ankle sprain/fracture, 1 disabling cork in quadriceps, 2 biceps corks, and 1 dislocated finger)”.[425]

Limited interchange rules in amateur-“community” sport may “actually increase the risks of concussion injuries being mismanaged”.[426] The catalogue of injuries, above, was sustained in a “‘pub club’ competition – i.e. players with limited fitness, skills and training playing for ungraded, one-team clubs with limited resources for the provision of skilled trainers and coaches” trailing a limit of 15 interchanges per game. “I anticipate many players will not notify Trainers of injuries in order to keep within the interchange limit and that Trainers will be discouraged from removing injured players from the field to perform a proper assessment (each player removed for assessment counts as an inter-change) and that they will make hasty and inaccurate assessments on the field. Fatigued players will be left on the field longer and due to fatigue, become more vulnerable to sustaining injury”.[427]

A number of respondents argued that training in correct technique, especially in tackling and falling, has been discounted in investigations of concussion prevention. “Too many players do not know how to tackle a player by moving their head out of the way and too many attacking players are using their heads and necks as battering rams into defending players. This is an accident waiting to happen…Coaches need to be accountable for correct technique and be up to date in their methods”.[428]

> “There are a lot of good things about playing organized sports, even those sports that involve risks of injury. Besides entertainment, the participation builds character, learning how to lead, work with a group for a common goal, learning how to win and lose; and helps develop mature responsible adults. However, when an injury occurs to the brain, it should be given as much (and more) attention as a torn ligament, knee or bone fracture”.[429]

ENDNOTES:

1 “Consensus Statement on Concussion in Sport – the 3rd International Conference on Concussion in Sport”, South African Journal of Sports Medicine, Volume 21, No. 2, 2009, p.37 (“This document was published in simultaneously in 9 journals in May/June 2009. This document is developed for use by physicians, therapists, certified athletic trainers, health professionals, coaches and other people involved in the care of injured athletes, whether at the recreational, elite or professional level. In conjunction with this publication, the group also released the Sport Concussion Assessment Tool 2.”)

2 The state of having notable shifts in emotional state (e.g. uncontrolled laughing or crying).

3 Ibid., p.37

4 This estimate is derived from those separations for TBI as either “Principal” or “Additional” diagnosis coded – in the International Classification of Diseases, version 10, Australian modification [“ICD-10-AM”] – “S.06.00 Concussion” and where the “reported activity” was “while engaged in sports”. Helps Y. et al., “Hospital separations due to traumatic brain injury, Australia 2004–05”, Australian Institute of Health and Welfare, Adelaide, 2008.

5 Barry Willer, John J. Leddy, “Management of Concussion and Post-Concussion Syndrome”, Current Treatment Options in Neurology, 2006, p.415

6 Jean Langlois et al., “The Epidemiology and Impact of Traumatic Brain Injury: A Brief Overview”, Journal of Head Trauma Rehabilitation, September/October 2006, Volume 21, Issue 5, p. 375-378

7 “Consensus Statement on Concussion in Sport – the 3rd International Conference on Concussion in Sport”, op.cit., p.37

8 Michael W. Collins et al., “Summary: Sport-Related Concussion”, in N.D. Zasler, D.I. Katz, and R.D. Zafonte (Eds.), Brain Injury Medicine: Principles and Practice, Second Edition, New York, Demos Medical Publishing, p.11

9 http://www.fda.gov/forconsumers/consumerupdates/ucm107783.htm ("Coping With Memory Loss"), United States Food and Drug Administration – “Alzheimer's Disease…is the most common form of dementia in people older than age 65, and affects more than 5 million Americans, according to the Alzheimer's Association. AD is a progressive, neurodegenerative disease characterized in the brain by abnormal protein deposits (amyloid plaques) and tangled bundles of fibers within nerve cells (neurofibrillary tangles). The biggest risk factors are age and family history. Having a history of serious concussion is also a risk factor.”

10 www.alzheimers.gov (“the [United States] government's free information resource about Alzheimer's disease and related dementias. Here you can find links to authoritative, up-to-date information from agencies and organizations with expertise in these areas.) – “Who is most at risk for developing Alzheimer's? Age is the best-known risk factor for Alzheimer's. The older you get, the greater your chance of developing Alzheimer's. Genetics may play a role as well. In rare families, certain genes may cause the disease. For most people who develop the disease later in life, some genes may increase your risk, but do not cause the disease. Some studies suggest that the rate of Alzheimer's is higher in certain racial or ethnic groups, such as African Americans, and scientists are exploring possible explanations. People with specific medical histories are at greater risk of Alzheimer's, including people with: Down Syndrome and other intellectual and developmental disorders; repeated concussions (falls, sports injuries, and car accidents are common causes of concussions and TBI); and Traumatic brain injury (TBI and mild TBI)”

11 Jonathan T. Finnoff et al., “Biomarkers, Genetics, and Risk Factors for Concussion”, PM&R [Physical Medicine and Rehabilitation] American Academy of Physical Medicine and Rehabilitation, Vol. 3, October 2011, p.S453

12 Brandon E. Gavett et al., “The link between head trauma, Alzheimer's disease and other neurodegenerations”, Alzheimers Research and Therapy, 2010, 2(3), p.18

13 “Head and Neck Injuries in Football: Guidelines for Prevention and Management”, National Health and Medical Research Council 1994 (Rescinded), p.6

14 Consensus Statement on Concussion in Sport – the 3rd International Conference on Concussion in Sport, op.cit., p.40

15 Ibid., p.40

16 Kirkwood MW, ‘Pediatric sport-related concussion: a review of the clinical management of an oft-neglected population”, Pediatrics, 117, 2006, p.1362

17 4th International Consensus Conference on Concussion in Sport, http://concussion-in-sport.com/2012

18 “AFL Medical Officers Association Submission to Brain Injury Australia, 16.5.2012”

19 Dr. Warren McDonald, Chief Medical Officer of the Australian Rugby Union, p.3

20 Acquired brain injury (ABI) refers to any damage to the brain that occurs after birth.

21 William P. Meehan III and Richard G. Bachur, “Sport-Related Concussion”, Pediatrics, 2009;123, p.114

22 Mark Lovell, “The Management of Sports-Related Concussion: Current Status and Future Trends”, Clinical Sports Medicine, 28, 2009, p.95

23 Kevin M. Guskiewicz et al. “National Athletic Trainers’ Association Position Statement: Management of Sport-Related Concussion”, Journal of Athletic Training, 2004;39(3), p.283

24 “Consensus Statement on Concussion in Sport – the 3rd International Conference on Concussion in Sport”, South African Journal of Sports Medicine, vol. 21 No. 2, 2009, p.41

25 “Management of concussion in Australian football and rugby union”, Sport Health, Volume 29, Issue 2, Winter 2011, p.36

26 “Management Recommendations”, Dr. Michael Lee, http://impacttest.com/concussion/management

27 Personal communication email Tom Talavage, Purdue University

28 “Consensus Statement on Concussion in Sport – the 3rd International Conference on Concussion in Sport”, op.cit., p.41

29 Ibid., p.41

30 http://www.ncbi.nlm.nih.gov/pmc/ - a “free digital database of full-text scientific literature in biomedical and life sciences…As of July 2011, the archive contains approximately 2.2 million items, including articles, editorials and letters” (Wikipedia)

31 Robert C. Cantu, “An overview of concussion consensus statements since 2000”, Neurosurgery Focus, 21 (4), 2006, p.1

32 Paul Comper et al., “Evaluating the methodological quality of sports neuropsychology concussion research: A systematic review”, Brain Injury, October 2010; 24(11), 1261

33 “The Sport Organisations and Other Sports Services industry in Australia is expected to grow by 3.5% per year over the five years through 2010-11, achieving turnover of $6.2 billion”, Sport Organisations and Other Sports Services Market Research Report, IBISWorld, March 2011, (http://www.ibisworld.com.au/industry/default.aspx?indid=659)

34 Australian Sports Commission, “Participation in Exercise, Recreation and Sport; The Exercise, Recreation and Sport Survey (ERASS), 2010, p.5

35 Personal communication email Nicole Vlahovich, Australian Sports Commission

36 Personal communication email Associate Professor Shane Brun, James Cook University

37 Jeffrey Colvin, Assistant Professor of Pediatrics, Children's Mercy Hospitals and Clinics in Kansas City, Missouri, reported in a poster session – “Concussion Diagnoses Doubled But No Greater Admissions” - at the Pediatric Academic Societies 2012 Annual Meeting

38 “Wake up, the glass is almost full to the brim”, letter to the Sydney Morning Herald, May 19, 2012 Dr Matthew Kiernan Professor of Neurology, Prince of Wales Clinical School, University of NSW

39 Memorandum from Shane McCurry, Manager, Research and Football Projects, Australian Football League

40 John Orchard, “Concussion: how do we reconcile risk-averse policies with risk-taking sports?”, British Journal of Sports Medicine Group Blogs, March 3, 2012, http://blogs.bmj.com/bjsm/2012/03/15/concussion-how-do-we-reconcile-risk-averse-policies-with-risk-taking-sports/

41 Andrew H Kaye and Paul McCrory, “Does football cause brain damage? Available evidence suggests anecdotal media reports need to be assessed carefully”, MJA Online first, 14 May 2012

42 “I am aware are AFL player Daniel Bell from Melbourne is looking at suing. West Coast players Dean Kemp (retired in 2001) and and Chad Rintoul (the latter also played with Adelaide and Collingwood and retired in 2003) were allegedly paid compensation for concussion-related injuries without going to court. Evidentally Rintoul found the injury compensation process pretty good but for Kemp it was very arduous and he only received a six-figure payout after several months of tough cross-examination by a doctor appointed by the AFL”, personal communication email Andy Gibson, The Australian and New Zealand Sports Law Association

43 Annette Greenhow, "Concussion policies of the National Football League: Revisiting the 'Sport Administrator's Charter' and the role of the Australian Football League and National Rugby League in concussion management", (2011), http://epublications.bond.edu.au/slej/13, p.3

44 Personal communication email from Michael Makdissi

45 “Schedule – Standard Funding Agreement” Australian Government’s Department of Families, Housing, Community Services and Indigenous Affairs

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54 National Sport and Active Recreation Policy Framework, Commonwealth of Australia 2011, p.5

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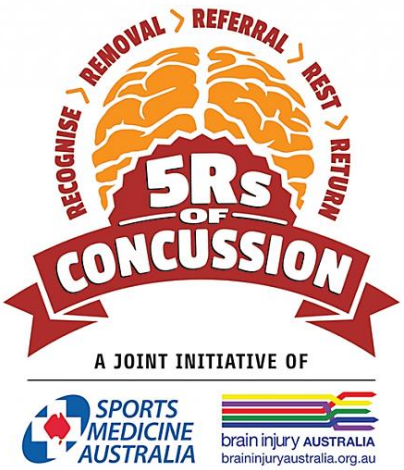

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