Laura Anderson
Clinical Neuropsychologist

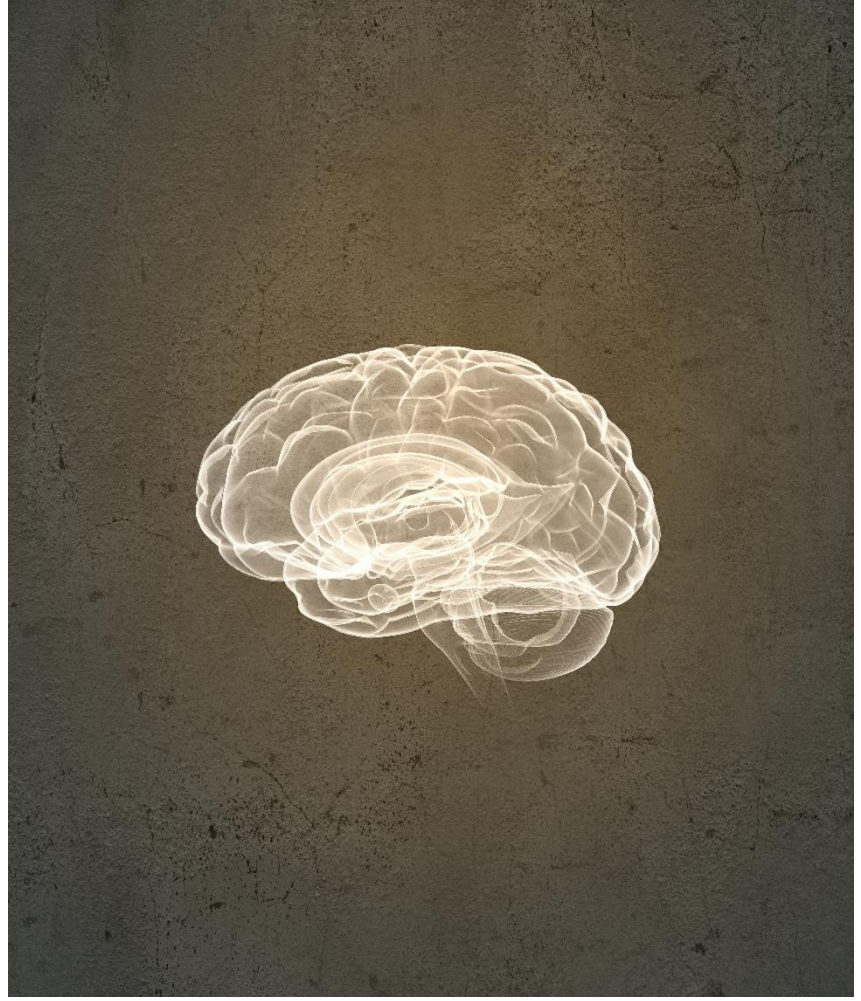
Co-founder & President,
Concussion Australia

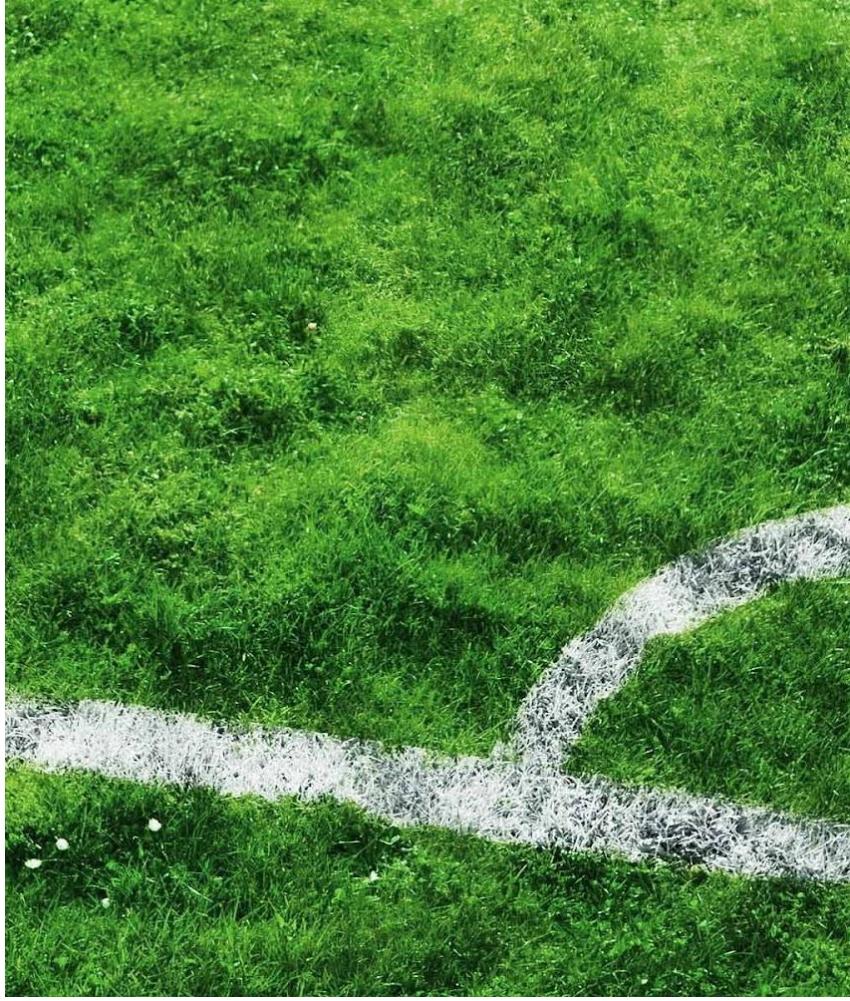
laura@jurmainehealth.com.au
(03) 9478 1810

CONCUSSION AUSTRALIA

JURMAINE HEALTH

4TH ANNUAL NATIONAL ACQUIRED BRAIN INJURY CONFERENCE





CONCUSSION:
A MILD TRAUMATIC BRAIN INJURY

CONCUSSION
AUSTRALIA

1. Mission & strategies of *Concussion Australia*

1. Concussion in Australia– Current research & understanding

1. How concussion is evaluated & managed in Australia – Issues & considerations

1. Post-concussive syndrome

1. What is the future of concussion management?

CONCUSSION AUSTRALIA: *MISSION STATEMENT*

1. Advocate for awareness of current research and evidence in concussion in a non-bias way, and assist with disseminating this information to the wider population of Australia.

2. Provide education regarding risks and protective measures associated with concussion

1. Support families, organisations and clinicians in managing concussion

DEFINITION OF CONCUSSION

- Historically….
- representing low velocity injuries that cause brain “shaking” resulting in clinical symptoms and which are not necessarily related to a pathological injury.
- Concussion is a subset of TBI
- *commotio cerebri*

IN MOST CASES:
CONCUSSION = MILD TRAUMATIC BRAIN INJURY (MTBI)

DEFINITION OF CONCUSSION

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1. may be caused either by a direct blow to the head, face, neck or elsewhere on the body with an “impulsive” force transmitted to the head.

2. typically results in the rapid onset of short-lived impairment of neurologic function that resolves spontaneously. However in some cases, symptoms and signs may evolve over a number of minutes to hours.

3. may result in neuropathological changes, but the acute clinical symptoms largely reflect a functional disturbance rather than a structural injury and, as such, no abnormality is seen on standard structural neuroimaging studies.

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

SYMPTOMS AND SIGNS OF ACUTE CONCUSSION

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can include 1 or more of the following clinical domains:

(a) Symptoms - somatic (eg, headache), cognitive (eg, feeling like in a fog) and/or emotional symptoms (eg, lability)

(b) Physical signs (eg, loss of consciousness, amnesia)

(c) Behavioural changes (eg, irritability)

(d) Cognitive impairment (eg, slowed reaction times)

(e) Sleep disturbance (eg, insomnia)

If any 1 or more of these components is present, a concussion should be suspected and the appropriate management strategy instituted.

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Table A. Common Symptoms of mTBI

Physical	Behavioural/Emotional	Cognitive
Headache Nausea Vomiting Blurred or double vision Seeing stars or lights Balance problems Dizziness Sensitivity to light or noise Tinnitus	Drowsiness Fatigue/lethargy Irritability Depression Anxiety Sleeping more than usual Difficulty falling asleep	Feeling “slowed down” Feeling “in a fog” or “dazed” Difficulty concentrating Difficulty remembering

Adapted from Willer B, Leddy JJ. Management of concussion and post-concussion syndrome. *Current Treatment Options in Neurology.* 2006;8:415-426; with kind permission from Springer Science and Business Media.

DIAGNOSTIC CRITERIA FOR CONCUSSION/MTBI

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- GCS scores can range from 3 to 15; mTBI is defined as a GCS score of 13-15, typically measured at 30 minutes post-injury or “on admission.”
- Post-traumatic amnesia (PTA), measured as the time from when the trauma occurred until the patient regains continuous memory, is another criterion used to define injury severity, and the cut-off for mild injuries is usually placed at 24 hours or less.
- Finally, a loss of consciousness of less than 30 minutes has also served as an index of mTBI. However, it should be noted that mTBI can occur in the absence of any loss of consciousness.

Ontario Neurotrauma Foundation
Fondation ontarienne de neurotraumatologie

DIAGNOSTIC CRITERIA FOR CONCUSSION/MTBI

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Table 1. Severity Indicators for Traumatic Brain Injury[a]

Indicator	Mild	Moderate	Severe
Loss of consciousness	≤30 min	>30 min and <24 h	>24 h
Alteration of consciousness/ mental state[b]	≤24 h	>24 h	>24 h
Posttraumatic amnesia	≤24 h	>24 h and <7 d	≥7 d

[a]Adapted with permission from the US Department of Veterans Affairs and Department of Defense.[4] Only 1 indicator must be met; if > 1 is met and the severity differs, assign the higher severity.
[b]Alteration of consciousness or mental state includes looking and feeling dazed or confused and difficulty thinking clearly and responding appropriately; if these symptoms last > 24 hours, use other criteria to determine severity.

Table 2. Common Acute Symptoms of Traumatic Brain Injury (TBI)[a]

Mild TBI
Loss of consciousness
Headache
Confusion
Lightheadedness or dizziness
Blurred vision or tired eyes
Tinnitus
Bad taste in the mouth
Fatigue or lethargy
Sleep pattern changes
Mood or behavioral changes
Problems with memory, concentration, attention, or thinking
Moderate or Severe TBI
Any of the above symptoms
Headache persists or worsens
Increased confusion, agitation, or restlessness
Nausea or vomiting
Seizures or convulsions
Decreased motor coordination
Inability to awaken from sleep
Dilation of pupil(s)
Slurred speech
Weak or numb extremities
Loss of coordination

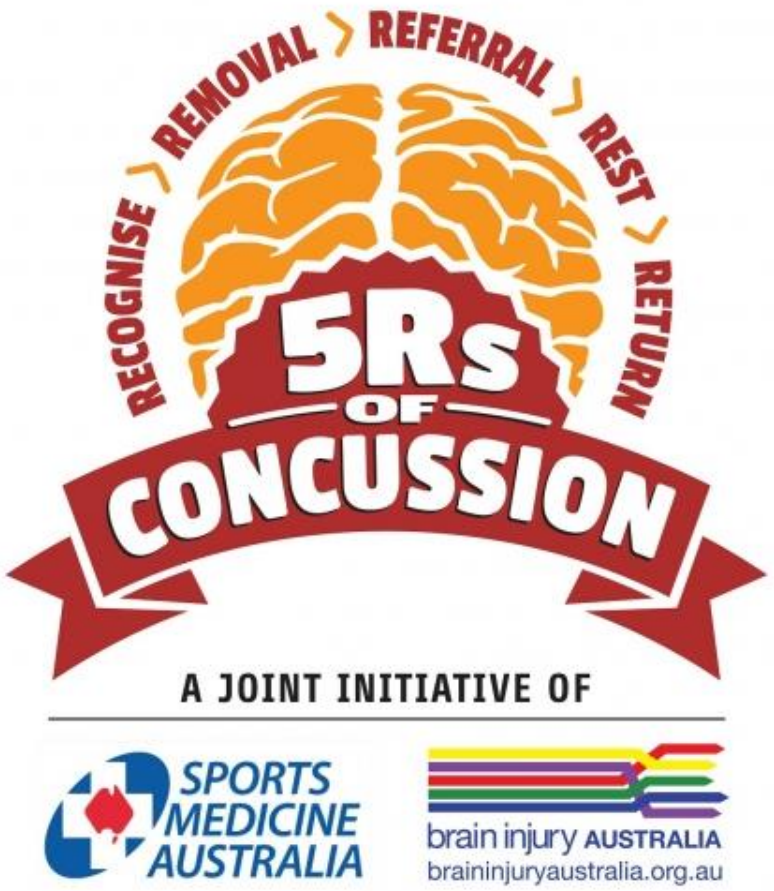
[a]Based on the American Academy of Neurology and the National Institute of Neurological Disorders and Stroke.[5]

Perskind et al, 2013

HOW COMMON IS CONCUSSION?

FROM BRAIN INJURY AUSTRALIA & SPORTS MEDICINE AUSTRALIA

POLICY PAPER 2011-2012



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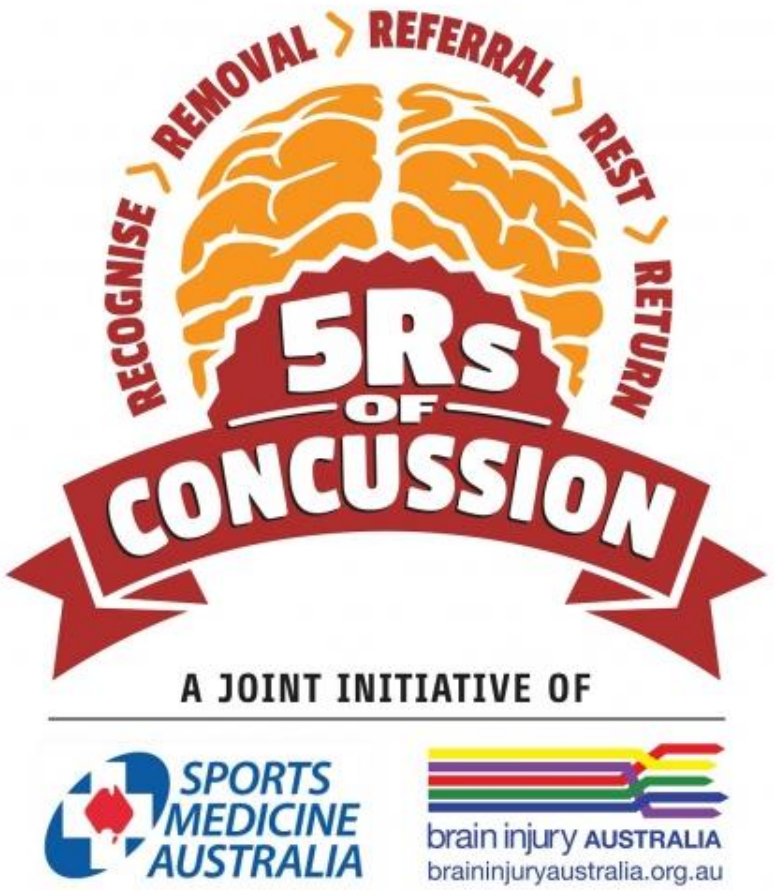
There were around 3,000 hospitalisations for concussion from sport during 2004-2005.

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.

The number of unreported concussions in sport may be as many as 10 times the number disclosed to team doctors annually.



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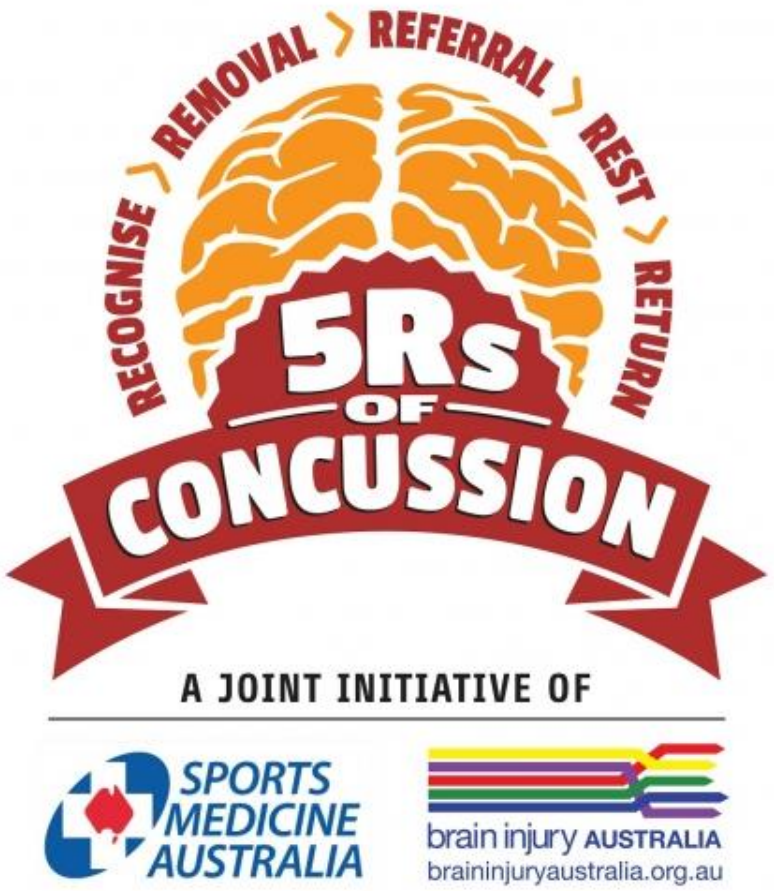
The last national survey of sports and recreation-related injury, conducted during 2002–2003, found 45,452 hospitalisations.

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”



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Concussion and brief loss of consciousness (less than 30 minutes)" comprised the majority of TBI admissions: 60% of "principal diagnosis" cases, and 59% of "additional diagnosis" cases.

Other surveys have estimated that MTBIs, including concussion, comprise 70–90% of all hospital-treated adult TBIs.

CONCUSSION VID #2

THE HISTORY OF CONCUSSION IN ACADEMIA

- November 2001: 1st International Conference on Concussion in Sport (Vienna, Austria)
  - International Ice Hockey Federation (IIHF)
  - Fédération Internationale de Football Association (FIFA)
  - Medical Commission of the IOC

- November 2004: 2nd International Conference on Concussion in Sport (Prague, Czech Republic)
  - + International Rugby Board (IRB)

- October 2008: 3rd International Conference on Concussion in Sport (Zurich, Switzerland)
  - Formal consensus meeting

4TH INTERNATIONAL CONFERENCE ON CONCUSSION IN SPORT (ZURICH, NOVEMBER 2012)

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- Same format as the 3rd International Conference

1. A broad-based non-government, non-advocacy panel was assembled to give balanced, objective and knowledgeable attention to the topic. Panel members excluded anyone with scientific or commercial conflicts of interest.
2. These experts presented data in a public session, followed by inquiry and discussion. The panel then met in an executive session to prepare the consensus statement.
3. A systematic literature review was prepared and circulated in advance for use by the panel in addressing the conference questions.
4. The consensus statement is intended to serve as the scientific record of the conference.
5. The consensus statement will be widely disseminated to achieve maximum impact on both current health care practice and future medical research.

AUTHORS INCLUDE:

- Paul McCrory, MBBS, PhD
  - Associate Professor, The Florey Institute of Neuroscience and Mental Health
- Mark Aubry MD,
  - Chief Medical Officer, International Ice Hockey Federation, Switzerland; Member of the IOC Medical Commission Games Group , Co-Director Ottawa Sport Medicine Centre, Ottawa, Ontario, Canada
- Jirí Dvorák, MD, PhD
  - Professor of Neurology, University of Zurich; Chairman, FMARC (FIFA Medical Assessment and Research Center), Zurich, Switzerland
- Lars Engebretsen, MD, PhD
  - Professor, Department of Orthopaedic Surgery, Oslo University Hospital, and Faculty of Medicine, University of Oslo, Norway; Cochair Oslo Sports Trauma Research Center, Oslo, Norway; Head Scientific Activities, International Olympic Committee, Lausanne, Switzerland
- Martin Raftery, MBBS FACSP
  - Chief Medical Officer, International Rugby Board, Dublin, Ireland

THEY SAID IT…

- Concussion is considered to be among the most complex injuries in sport medicine to diagnose, assess, and manage.
- The majority of concussions in sport occur without loss of consciousness or frank neurologic signs
- At present, there is no perfect diagnostic test or marker

CONCUSSION VID #1

ON-FIELD OR SIDELINE EVALUATION OF ACUTE CONCUSSION WHEN A PLAYER SHOWS ANY FEATURES OF A CONCUSSION

Sideline evaluation of cognitive function is an essential component in the assessment of this injury

Brief neuropsychological test batteries that assess attention and memory function have been shown to be practical and effective

standard orientation questions (eg, time, place, person) have been shown to be unreliable in the sporting situation when compared with memory assessment

--- does not replace neuropsychological testing

--- should not be used as stand-alone tool for the ongoing management of sports concussions

ON-FIELD OR SIDELINE EVALUATION OF ACUTE CONCUSSION WHEN A PLAYER SHOWS ANY FEATURES OF A CONCUSSION

- the appearance of cognitive deficit might be delayed several hours
- should be seen as an evolving injury in the acute stage.

ADDITIONAL CONCUSSION INVESTIGATIONS

- Brain CT (or where available MR brain scan) - suspicion of an intra-cerebral or structural lesion (eg, skull fracture) exists.
  - prolonged disturbance of conscious state,
  - focal neurological deficit, or worsening symptoms
- Clinical balance tests (eg, Balance Error Scoring System [BESS]), have identified acute postural stability deficits lasting approximately 72 hours following sport-related concussion.
  - useful for objectively assessing the motor domain of neurologic functioning

ADDITIONAL CONCUSSION INVESTIGATIONS

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- The application of neuropsychological (NP) testing in concussion has been shown to be of clinical value and contributes significant information in concussion evaluation and return to play.
- in most cases cognitive recovery largely overlaps with the time course of symptom recovery…but not always.
- NP assessment may add important information in the early stages following injury (eg, return to school in a pediatric athlete)
- there is insufficient evidence to recommend the widespread routine use of baseline NP testing

CONCUSSION MANAGEMENT

PRE-PARTICIPATION CONCUSSION EVALUATION

- Athletes may not be aware of history of concussions
- A detailed concussion history can identify athletes at higher risk of concussion and provide education
- STRUCTURED HISTORY TO INCLUDE:
  - When concussed
  - Previous symptoms of concussion
  - Previous length of concussion
  - All previous head, face, or cervical spine injuries
- Recall by teammates or coaches usually unreliable

CORNERSTONE OF CONCUSSION MANAGEMENT

Physical and cognitive rest until the acute symptoms resolve and then a graded program of exertion prior to medical clearance and return to play.

- initial period of rest 24-48 hours following injury **may** be of benefit
- Low-level exercise for those who are slow to recover **may** be of benefit

MANAGEMENT OF CONCUSSION/MTBI

- Advise that full recovery of symptoms is seen in the majority of cases.
- In majority of cases symptoms resolve and pre-injury cognitive functioning return within days or up to 3 months.
- A person who remains symptomatic post mTBI should not drive for at least 24 hours
- **Education** should ideally be delivered at the time of initial assessment or minimally within one week of injury/first assessment.
- Individualized telephone or in-person follow-up with education on symptom management and encouragement to resume everyday activities should be provided over the 12 weeks after injury.

MANAGEMENT OF CONCUSSION/MTBI

Education should be provided in **printed material** combined with verbal review and consist of:

a. Symptoms and expected outcomes.

b. Normalizing symptoms (education that current symptoms are expected and common after injury event).

c. Reassurance about expected positive recovery.

d. Gradual return to activities and life roles.

e. Techniques to manage stress

SAME DAY RETURN TO PLAY?

A unanimous NO

Some studies show that athletes allowed to RTP on the same day may demonstrate

- NP deficits postinjury that may not be evident on the sidelines
- more likely to have delayed onset of symptoms

GRADUATED RETURN TO PLAY PROTOCOL (RTP)

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TABLE 1. Graduated Return to Play Protocol

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

GRADUATED RETURN TO PLAY PROTOCOL (RTP)

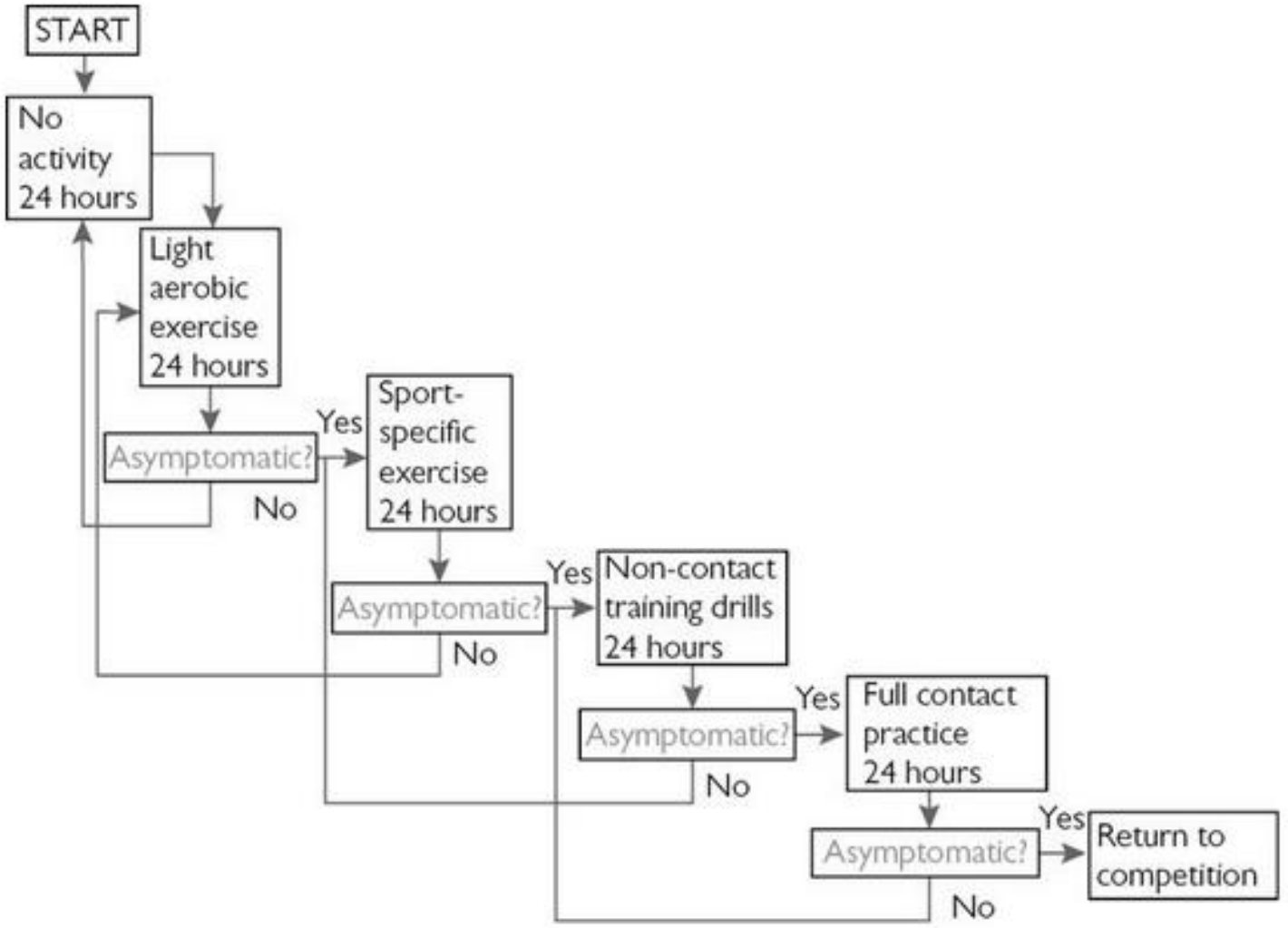

TABLE 2. Concussion Modifiers

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

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THE ‘DIFFICULT’ OR PERSISTENTLY SYMPTOMATIC CONCUSSION PATIENT

- Persistent symptoms (> 10 days) are generally reported in 10%-15% of concussions
- Need to consider what else is going on (other pathologies)
- Multidisciplinary approach

PERSISTENT SYMPTOMS

- Full recovery expected within 3 months after concussion/mTBI….but not all patients experience rapid recovery, with up to 15% experiencing ongoing symptoms
- There is controversy regarding the diagnosis of post-concussion syndrome
- Regardless of formal diagnosis (e.g., post-concussion syndrome versus depression), symptoms following mTBI can cause functional limitations

POST CONCUSSION SYNDROME – ICD-10

A. History of head trauma with loss of consciousness preceding symptom onset by a maximum of 4 weeks.

B. Symptoms in 3 or more of the following symptom categories:

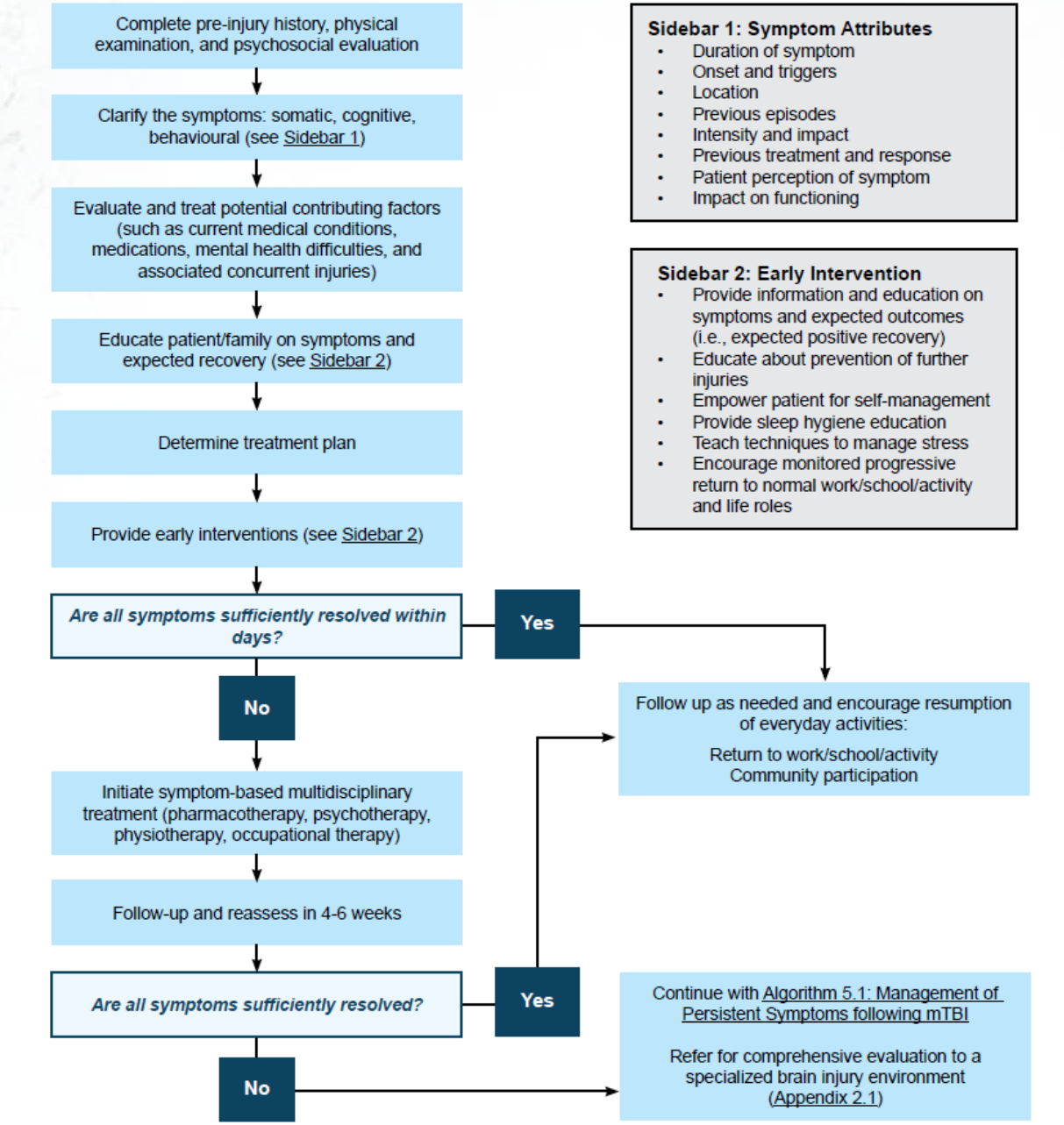
- Headache, dizziness, malaise, fatigue, noise intolerance
- Irritability, depression, anxiety, emotional lability
- Subjective concentration, memory, or intellectual difficulties without neuropsychological evidence of marked impairment
- Insomnia
- Reduced alcohol tolerance
- Preoccupation with above symptoms and fear of brain damage with hypochondriacal concern and adoption of sick role

POST CONCUSSION SYNDROME – ICD-10

A pre-injury depressive or anxiety disorder and acute posttraumatic stress were early markers of PCS.

Females were more likely than males to have PCS.

Initial Management of Symptoms following mTBI*



Sidebar 1: Symptom Attributes

- Duration of symptom
- Onset and triggers
- Location
- Previous episodes
- Intensity and impact
- Previous treatment and response
- Patient perception of symptom
- Impact on functioning

Sidebar 2: Early Intervention

- Provide information and education on symptoms and expected outcomes (i.e., expected positive recovery)
- Educate about prevention of further injuries
- Empower patient for self-management
- Provide sleep hygiene education
- Teach techniques to manage stress
- Encourage monitored progressive return to normal work/school/activity and life roles

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* Adapted from the *VA/DoD Management of Concussion/Mild Traumatic Brain Injury Clinical Practice Guideline (VA/DoD, 2009).*

Activity Suggestions for Recovery Stages After Concussion

Toddler (0-4)

Stage 1 - Rest
- Crafts: colouring, drawing
- Nap in favourite spot
- Parents can read stories
- Watch fish in an aquarium

Stage 2 - Light Activity
- Bird watching
- Crafts: painting
- Play in the Sand
- Play blocks, dolls, cars or small toys
- Supervised walking or crawling

Stage 3 – Sport-specific Activity
- Crawling
- Walking

Stage 4- Non-Contact Practice
- Dance lessons
- Swim lessons

Child (5-10)

Stage 1 - Rest
- Basic board games (i.e. not monopoly)
- Crafts: making bracelets, necklaces
- Light gardening
- Singing
- Stargazing
- Talk on phone
- Talk to friends/family

Stage 2- Light Activity
- Challenging board games
- Helping cook and bake
- Listen to quiet music (no headphones)
- Magazines
- Puzzles
- Billiards
- Bocce ball/ Lawn bowling
- Croquette
- Fishing
- Flying kite
- Freestyle swimming
- Frisbee
- Helping cook and bake
- Light jogging
- Playing Catch
- Walking

Stage 3 – Sport-Specific Activity
- Ipad applications (no gaming)
- Word searches
- Air hockey or foosball
- Biking
- Dribbling, keep-ups and stickhandling
- Golf
- Light badminton
- Ping pong
- Skating
- Sprinklers and splash pads
- Tag
- Tai chi/karate (non-contact)
- Wii or Xbox Kinect games

Stage 4 – Non-contact Practice
- Baseball/cricket
- Basketball
- Dance
- Field hockey
- Figure skating (no jumps)
- Hockey drills
- Soccer without heading
- Slide and swing at playground
- Squash
- Tennis
- Volleyball (no diving)

Teenager (11+)

Stage 1 - Rest
- Cellphone (no texting only calling)
- Crafts: molding clay
- Friends visit (one at a time)
- Knitting and quilting
- Listen to Audiobooks
- Meditation
- Nap
- Photography
- Scrapbooking

Stage 2 –Light Activity
- Cooking and baking
- Crafts: origami, sculpting
- Go to the beach
- Listen to quiet music (no headphones)
- Magazines
- Poetry
- Puzzles
- Re-read familiar books
- Archery
- Billiards
- Camping
- Croquette
- Darts
- Fishing
- Freestyle Swimming
- Lawn bowling
- Light Jogging
- Playing catch
- Stationary cycling
- Walking
- Yoga (no hot yoga)

WARNING: Preform activities ONLY if symptom free. If the symptoms appear during activity, STOP immediately.

Use suggestions in conjunction with CanChild concussion guidelines available at: http://www.canchild.ca/en/ourresearch/mild_traumatic_brain_injury_concussion_education.asp

Stage 3 - Sport-specific Activity
- Crosswords
- Shopping at mall
- Sudoku
- Air hockey or foosball
- Biking
- Calisthenics (stability exercises)
- Curling
- Dribbling, keep-ups and stickhandling
- Golf
- Hiking/orienteering
- Light badminton
- Ping Pong
- Running
- Skating
- Snorkeling
- Tai chi/Karate
- Wii or Xbox Kinect games
- Volleyball (keep ups)
- Windsurfing

Stage 4- Non-contact Practice
- Aerobics and plyometrics
- Baseball/Cricket
- Basketball
- Canoeing/kayaking
- Dance and Cheer (no stunts)
- Figure Skating (no jumping)
- Football Drills
- Hockey Drills
- Light Weight Training
- Mountain/rock climbing
- Non-Contact Soccer (no heading)
- Pilates
- Shadow boxing
- Squash or Tennis
- Track and Field
- Volleyball (no diving)

DIFFERENTIAL DIAGNOSES RELATED TO MTBI

- Major depressive disorder
- Generalized anxiety disorder
- Post-traumatic stress disorder (PTSD)
- Chronic pain syndrome
- Cervical strain/whiplash associated disorder
- Substance abuse or polypharmacy
- Somatoform disorder/factitious disorder
- Malingering
- Post-traumatic headache
- Fibromyalgia syndrome (secondary)
- Primary sleep disorder: e.g., obstructive sleep apnoea

PSYCHOLOGICAL MANAGEMENT AND MENTAL HEALTH ISSUES

Encouraged to evaluate the concussed athlete for affective symptoms such as depression and anxiety, as these symptoms are common in all forms of traumatic brain injury.

THE ROLE OF PHARMACOLOGICAL THERAPY

1. the management of specific and/or prolonged symptoms (eg, sleep disturbance, anxiety, etc)
2. to modify the underlying pathophysiology of the condition with the aim of shortening the duration of the concussion symptoms (only for concussion “experts”).

- **Effects of medication masking /modifying symptoms of concussion**
- **Effects of return to play while on medication (e.g. anxiolytics)**

WHAT IS THE EVIDENCE FOR CHRONIC CONCUSSION-RELATED CHANGES? - BEHAVIOURAL, PATHOLOGICAL, AND CLINICAL OUTCOMES

- chronic traumatic encephalopathy (CTE)
- a distinct tauopathy with an **unknown** incidence in athletic populations
- not related to concussions alone or just exposure to contact sports

WHAT DO THE NEUROPSYCHS THINK?

R.S. MOSER ET AL. / ARCHIVES OF CLINICAL NEUROPSYCHOLOGY 22 (2007)

Baseline and post-injury neuropsychological testing is preferred

- provides unique information that can be invaluable not only in diagnosing the injury but also in tracking recovery over time
- Although there is variability across sports concussion management programs regarding the administration of neuropsychological tests, the *interpretation* of neuropsychological test data should be conducted by a clinical neuropsychologist

Concussions carry some risk for cumulative effects

- Once concussed, an athlete is at a statistically increased risk for a future concussion. The reasons for the increased risk are unclear.
- Guskiewicz et al. (2003) reported that previously concussed athletes are four to six times more likely to experience a second concussion, even if the second blow is relatively mild.

R.S. MOSER ET AL. / ARCHIVES OF CLINICAL NEUROPSYCHOLOGY 22 (2007)

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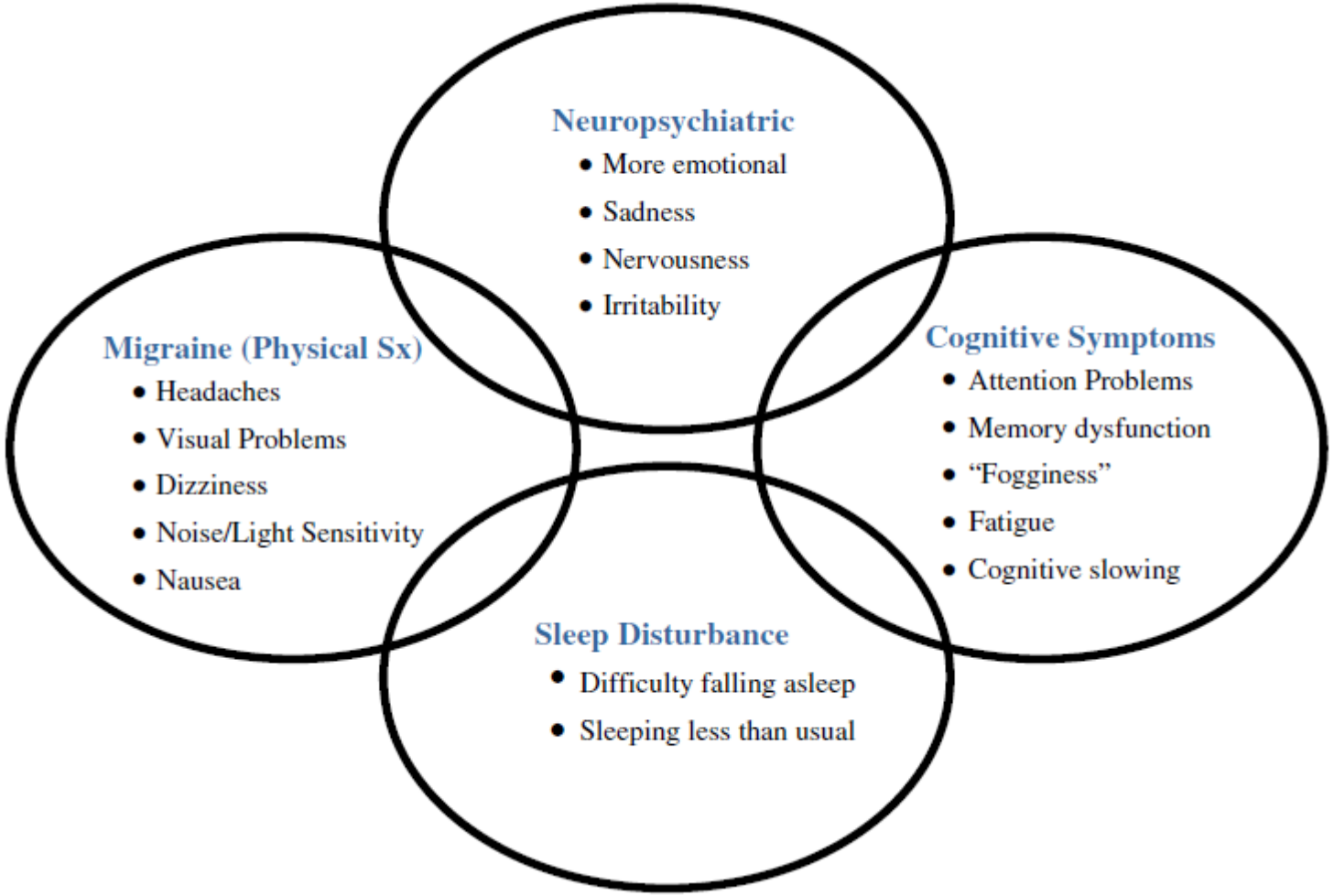
- Guskiewicz et al. (2003) reported that previously concussed athletes are four to six times more likely to experience a second concussion, even if the second blow is relatively mild.
- There is accumulating evidence that a history of *three or more* concussions is associated with changes in neurophysiology (Gaetz et al., 2000), subjective symptoms (Gaetz et al., 2000; Iverson, Gaetz, Lovell, & Collins, 2004a), and neuropsychological test performance (Iverson et al., 2004a) in some athletes.

JOHNSON ET AL. / CLIN SPORTS MED 30 (2011)



Neuropsychological testing is more sensitive to recovery than subjective symptom reporting

CHRONIC TRAUMATIC ENCEPHALOPATHY (CTE)

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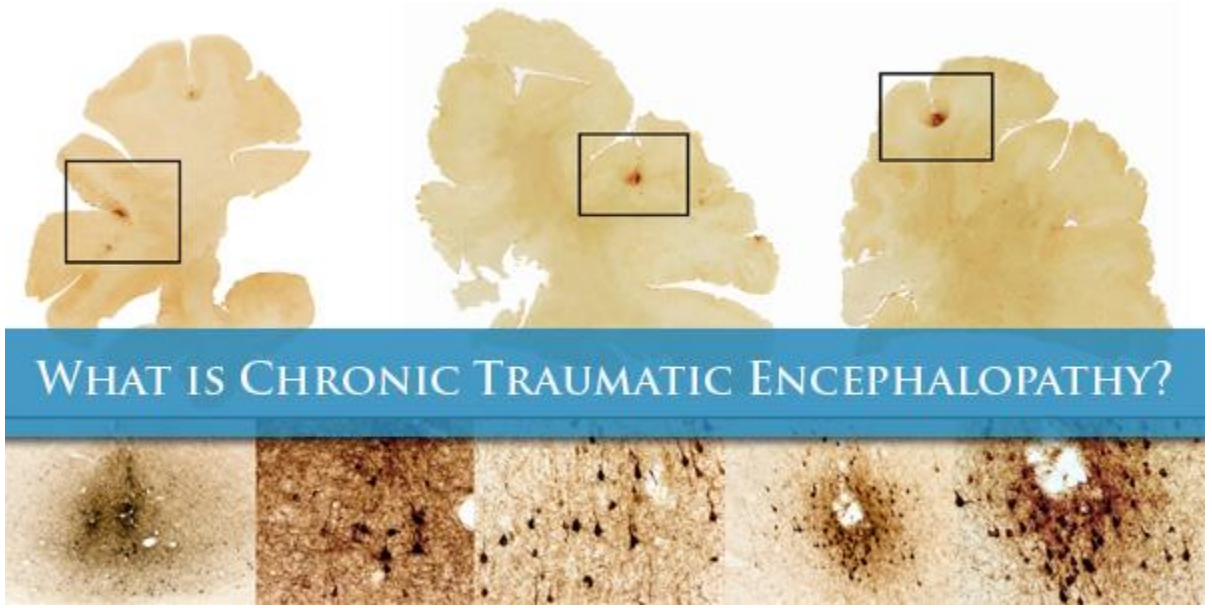


CHRONIC TRAUMATIC ENCEPHALOPATHY (CTE)

- a progressive degenerative disease of the brain found in athletes and others with a history of repetitive brain trauma,
  - including **symptomatic concussions**
  - and **asymptomatic subconcussive** hits to the head

- originally reported in 1928 by a pathologist (Martland)
  - described the clinical aspects of a progressive neurological deterioration ('punch drunk') that occurred after repetitive brain trauma in boxers
  - originally termed dementia pugilistica

CHRONIC TRAUMATIC ENCEPHALOPATHY (CTE)

- CTE has been documented in amateur and professional athletes involved in contact sports, military personnel exposed to explosive blast, and others subjected to repetitive brain trauma (RBT)
- All reported neuropathologically confirmed cases of CTE have had exposure to RBT.
- However, not all individuals with histories of RBT develop CTE
- Additional risk factors, including genetics, likely have a role in the neuropathogenesis of this disease.

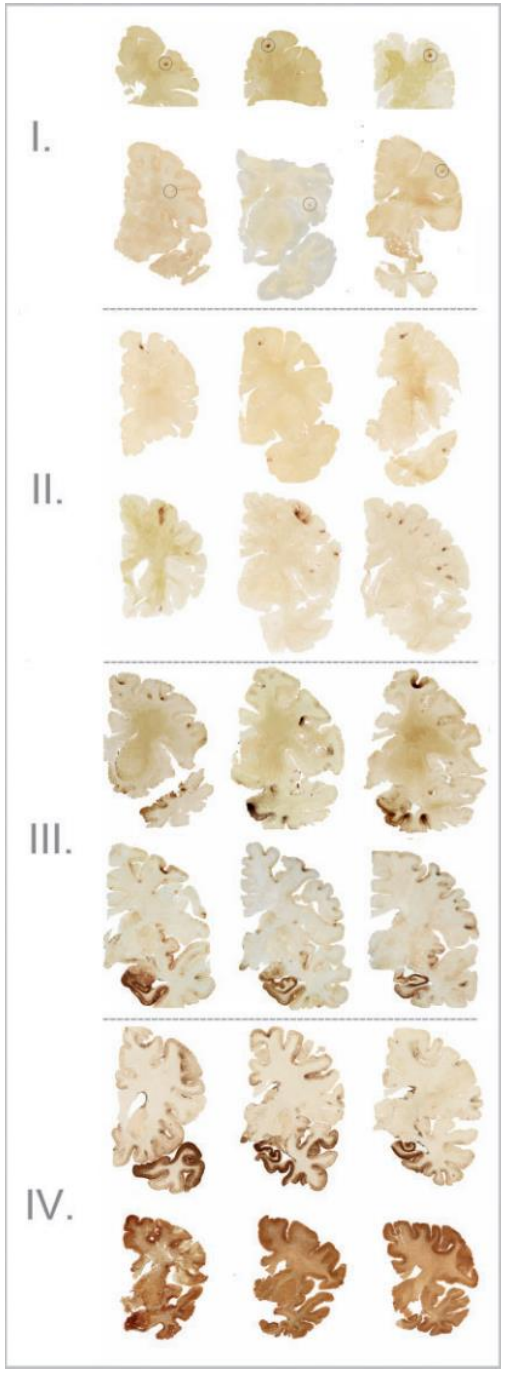
- in cases of repetitive concussion or mild traumatic brain injury - at least 17% of individuals develop chronic traumatic encephalopathy

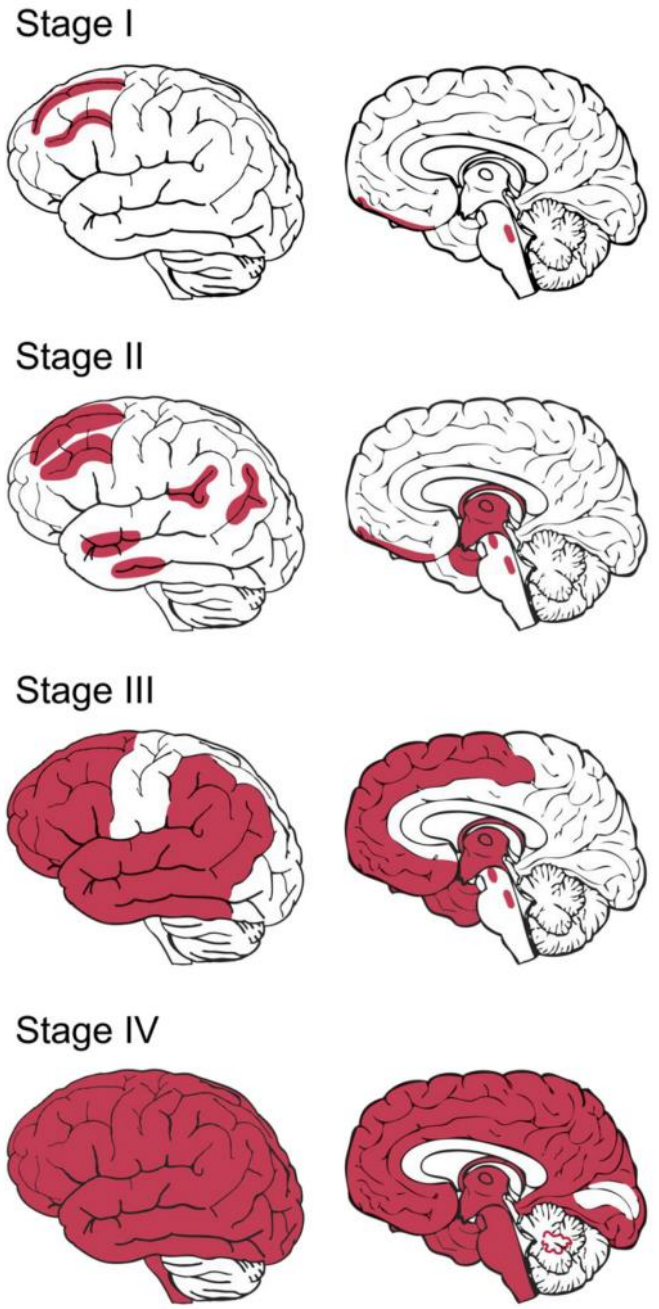
CHRONIC TRAUMATIC ENCEPHALOPATHY (CTE)

- The trauma triggers progressive degeneration of the brain tissue,
- including the build-up of an abnormal protein called **tau**
  - hyperphosphorylated tau (p-tau)
- These changes in the brain can begin months, years, or even decades after the last brain trauma or end of active athletic involvement.
- The brain degeneration is associated with memory loss, confusion, impaired judgment, impulse control problems, aggression, depression, and, eventually, progressive dementia.
- The neuropathological changes of CTE are distinctive and easily distinguished

CHRONIC TRAUMATIC ENCEPHALOPATHY (CTE)

- In late stages, CTE may be clinically mistaken for Alzheimer's disease or frontotemporal dementia
- A subset of cases with CTE is associated with motor neuron disease


I.
II.
III.
IV.


Stage I
Stage II
Stage III
Stage IV

CHRONIC TRAUMATIC ENCEPHALOPATHY (CTE)

- STAGE I: headache and loss of attention and concentration
- STAGE II: depression and mood swings, explosivity, loss of attention and concentration, headache and short-term memory loss
- STAGE III: cognitive impairment with memory loss, executive dysfunction, loss of attention and concentration, depression, explosivity and visuospatial abnormalities
- STAGE IV: uniformly demented with profound short-term memory loss, executive dysfunction, attention and concentration loss, explosivity and aggression. Most also showed paranoia, depression, impulsivity and visuospatial abnormalities

CHRONIC TRAUMATIC ENCEPHALOPATHY (CTE)

CONCUSSION AUSTRALIA

- Of the 68 cases with CTE, 37% had **co-morbid** neurodegenerative disease, including MND, Parkinson's disease or Lewy body disease, Alzheimer's disease and FTLD
- Most subjects with CTE-MND (63%) presented with symptoms of MND, developing cognitive and behavioural symptoms several years after the onset of motor weakness, atrophy and fasciculations.
- The minority presented with apathy, depression, memory loss, cognitive decline, paranoia, impulsivity or executive dysfunction 1–8 years before the development of motor neuron symptoms

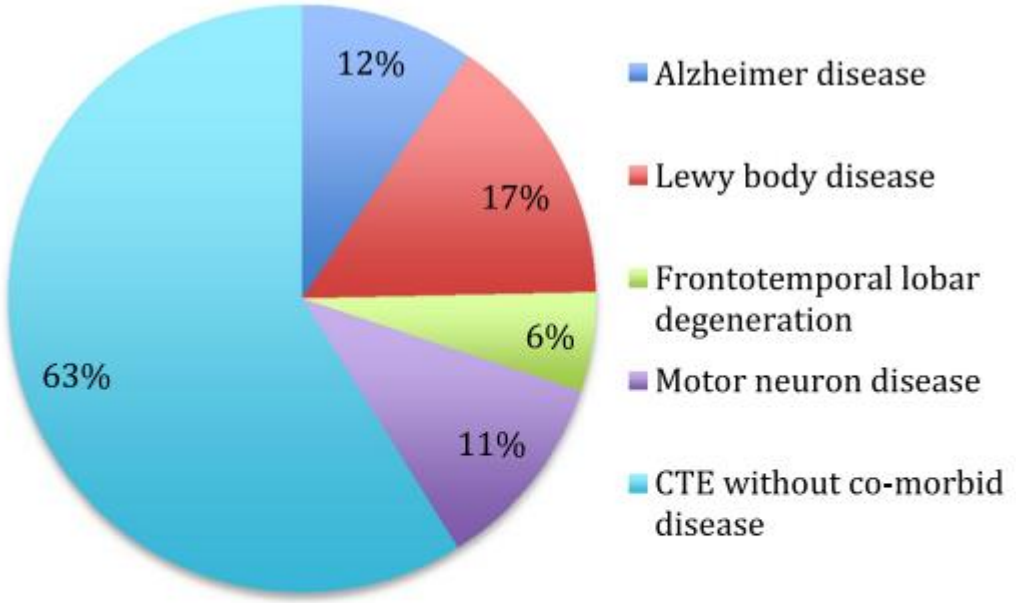


Figure 6 Chronic traumatic encephalopathy with comorbid disease. Percentage of cases with chronic traumatic encephalopathy (CTE) with and without comorbidity. Of those cases with CTE and Alzheimer's disease, 43% had overlapping Lewy body disease; of those with CTE and frontotemporal lobar degeneration, 50% also had Lewy body disease.

NEUROPSYCHOLOGY AND CTE

- Limited studies…
- A meta-analysis of 8 studies of healthy former athletes showed that compared with a history of only one mTBI, a history of repeated mTBI was associated with **reduced delayed recall and executive function, but not with impairment in attention or language.**
- There is also evidence that subconcussive blows to the head can affect neuropsychological performance.
- High school football players who sustained head injuries that did not result in any reported symptoms still had **lower scores in visual working memory** (as well as decreased activation in the dorsolateral frontal cortex on fMRI) on post-season evaluation compared with pre-season evaluation.
- Another study found that cognitively impaired players had **deficits in naming, word finding, and visual and verbal episodic memory**

BIOMARKER FOR CONCUSSION?

- Blood levels of total-tau — a protein signalling axonal damage in the brain — could be used as a biomarker to gauge severity of concussions in athletes and to assess when it is safe to return to play

- T-tau is usually found only in the cerebral spinal fluid (CSF), but may get into the blood after concussion if the blood-brain barrier is damaged.
- It is a protein secreted by the axons of unmyelinated nerve cells when they are injured, and raised levels are a marker of cortical injury.
- It is increased in the CSF in Alzheimer's disease, but measuring blood levels after head injury is a new concept.

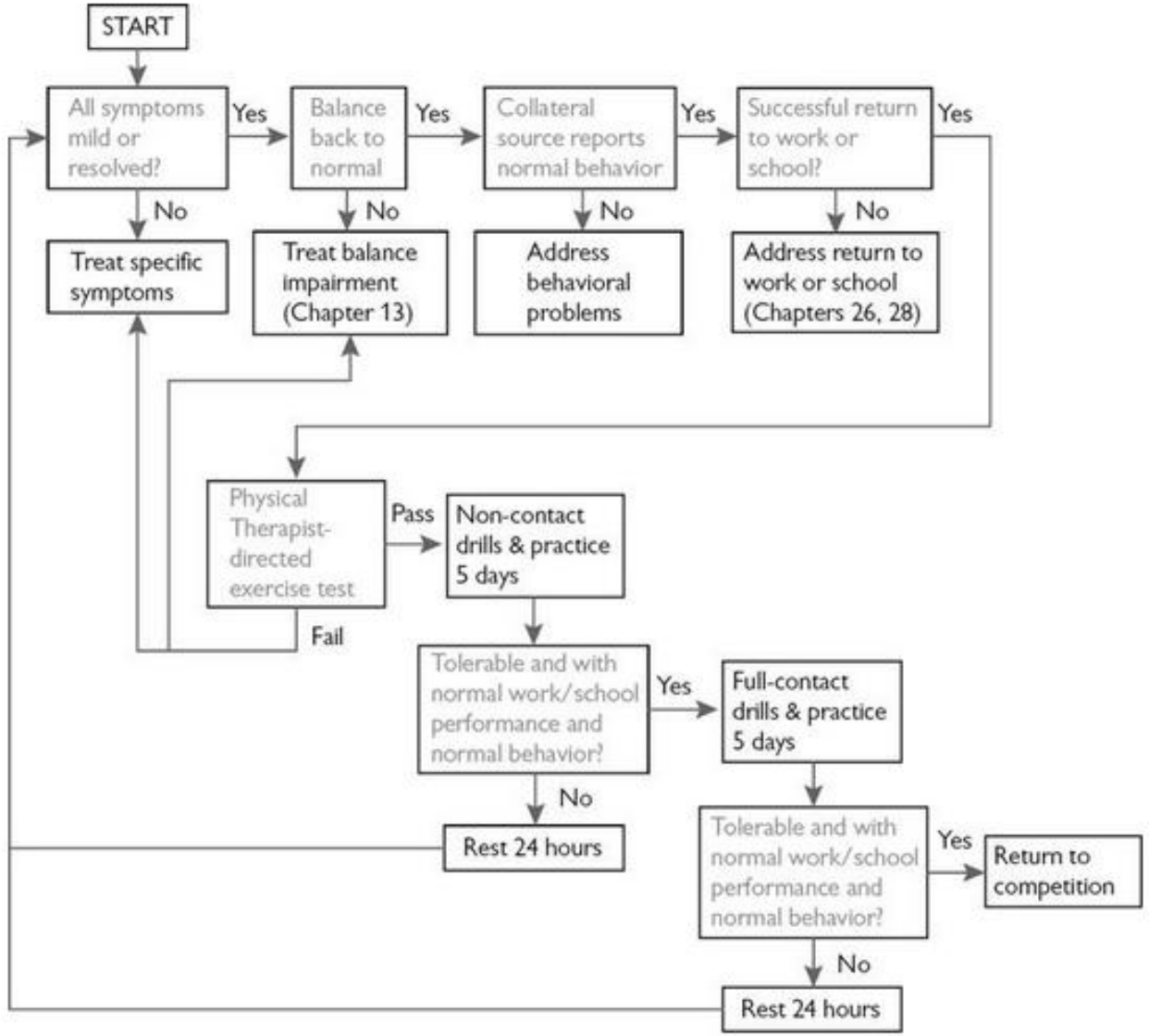
http://archneur.jamanetwork.com/article.aspx?articleid=1846623

T-tau Increased Up to 10-Fold in Concussion

- Plasma levels of T-tau increased in ice hockey players with sports-related concussion.
- The highest concentrations of T-tau were measured immediately after the injury, and the levels declined during the first 12 hours, followed by a second peak between 12 and 36 hours.
- T-tau concentrations at 1 hour after concussion predicted the number of days it took for the concussion symptoms to resolve and the players to return to play safely.

http://archneur.jamanetwork.com/article.aspx?articleid=1846623

MANAGEMENT OF COMPLEX CONCUSSION



Laura Anderson
Clinical Neuropsychologist

Co-founder & President,
Concussion Australia

laura@jurmainehealth.com.au
(03) 9478 1810

CONCUSSION AUSTRALIA

JURMAINE HEALTH

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