



Out of the Dark

Hot Topic in Neurology: Approach to Concussion

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Professor of Sports Medicine, Paderborn University, Germany*

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Ruhr University Bochum (GER), NUI Galway (IRE), UTMB Galveston

PhD in Sports Medicine @ Paderborn University (GER)

Neurology Residency @ University Hospital Wuerzburg (GER)

Epilepsy & Clinical Neurophysiology Fellowship @BWH

Chief, Sports Medicine, Paderborn University (GER)

Chief, Sports Neurology & Neurosciences @ MGB

Co-Director, Sports Concussion Program@ MGB

- clinical focus: Sports Neurology, focus on health & performance
- research focus: multimodal imaging & ANS in sports & exercise



Disclosures

**I have no actual or potential conflict of interest
in relation to this presentation, but...**

... see patients / athletes with concussion and neurological disorders in my sports neurology clinic

... use various technologies to assess patients with concussion

... receive scientific funding by the Federal Institute of Sports Sciences (Germany), District of
Paderborn & Paderborn County, Westfalian Foundation, Paderborn University

... am a member of the medical committee of the German Football association (DFB) and
counsel the Union of European Football Associations (UEFA)



Learning Objectives

- understand and apply current concepts of (sport associated) concussion
- be familiar with the diagnosis and management of (sport associated) concussion (incl. therapy and 'return-to' concepts)



MOC REFLECTIVE STATEMENT

- Concussion is a treatable injury, incremental subsymptomatic activities should be applied soon after a brief resting period, even when symptoms are still present
- Early specialized care improves the time and quality of recovery (as opposed to watchful waiting)
- Persistent post concussion symptoms may be associated with risk factors (outside of the initial trauma) that need to be addressed





NEUROLOGY / NEUROSCIENCE

- Clinical neurology
- Brain structure and function
- Neural plasticity
- Neural networks
- Neuroimaging, electrophysiology

SPORTS MEDICINE / PHYSIOLOGY

- Exercise physiology
- Training and adaptation
- Injury prevention and management
- Biomechanics
- Performance optimization



SPORTS NEUROSCIENCE

Integrating brain health, injury,
and performance in sport



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Integrating brain health, injury, and performance in sport

KEY AREAS

TREATMENT OF NEUROLOGICAL DISEASES



Dementia, Multiple Sclerosis, Parkinson's Disease, Epilepsy, Brain Tumors, Stroke, etc.

CONCUSSION / TRAUMATIC BRAIN INJURIES



Diagnosis, acute management, rehabilitation, return-to-sport strategies, etc.

SPORT ASSOCIATED OVERUSE CONDITIONS



Overtraining, sport associated dystonia, peripheral nervous compression syndromes, etc.

EFFECTS OF BRAIN PERFORMANCE IN SPORTS



Cerebral performance diagnostics, cognitive-motor training, autonomic control, regeneration, etc.



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CLINICAL CARE

ADDRESSED AT THREE LEVELS

Direct patient care across the full spectrum: assessment, diagnosis, treatment, rehabilitation, and return-to-play / return-to-performance



CLINICAL RESEARCH

Translation and evidence generation to improve outcomes: clinical trials, outcome studies, biomarkers, intervention research



BASIC SCIENCE

Understanding mechanisms and building knowledge: molecular, cellular, systems and animal studies



ULTIMATE GOAL:

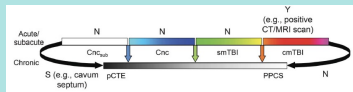
Optimize brain health, treat neurological diseases, prevent injury and disease, enhance recovery, and improve performance in athletes and active individuals.





Mass General Brigham

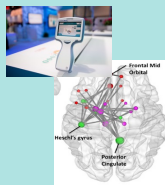
(Sports Associated) Concussion



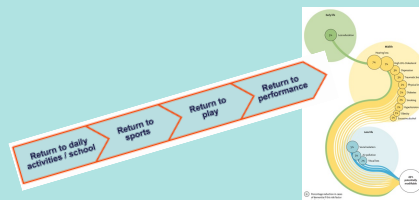
definition and classification



on pitch, in the gym



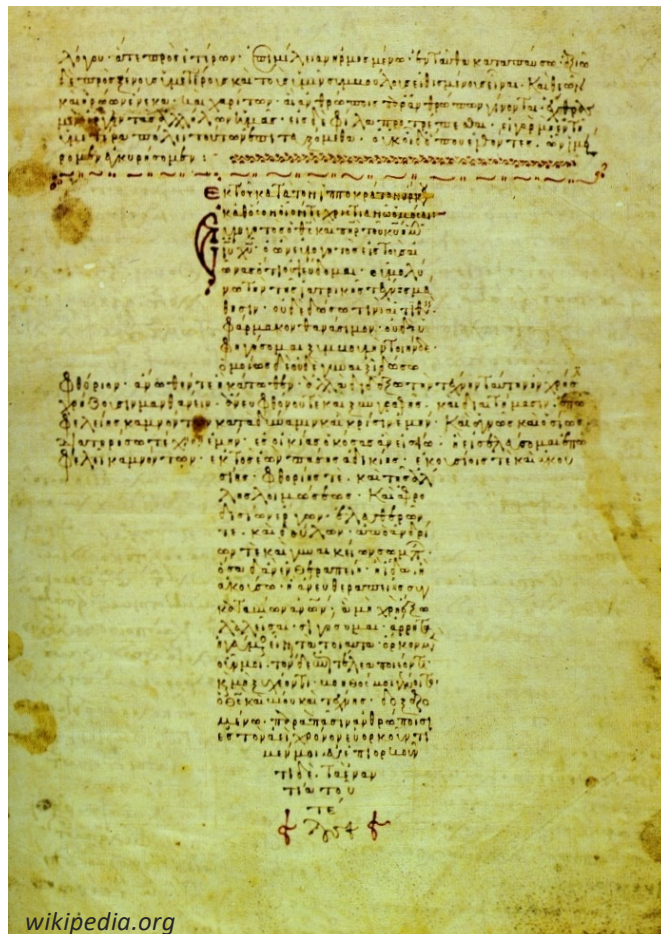
diagnosis: biomarkers, devices etc...



rehabilitation, 'return-to/ & long term health

Confidential—do not copy or distribute

The Hippocratic Corpus



loss of speech, hearing and sight
that can result from
"commotion of the brain"

There is no good animal model for concussion...

454

THE LANCET, FEBRUARY 28, 1976

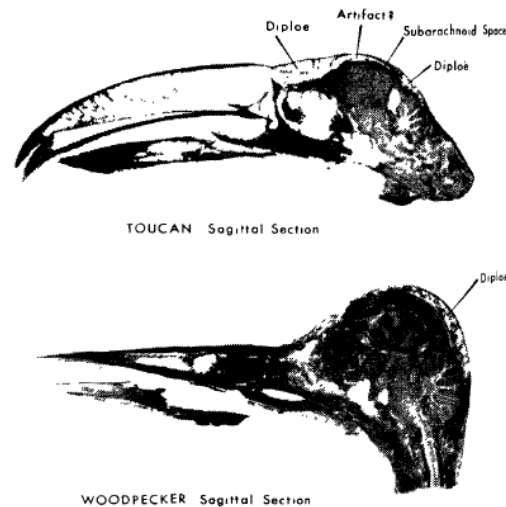
WOODPECKERS AND HEAD INJURY

PHILIP R. A. MAY
PAUL NEWMAN

JOAQUIN M. FUSTER
ADA HIRSCHMAN

Brentwood Veterans Administration Hospital, Los Angeles, California 90073, and Neuropsychiatric Institute, University of California at Los Angeles, Los Angeles, California 90024, U.S.A.

Summary The woodpecker is an experiment in Nature, a model for the investigation of mechanisms of basic importance for head injury and its prevention. A preliminary anatomical study of the woodpecker's head suggests that it may be fruitful to explore impact protective systems which are radically different from those in common use.



...really?

OPEN ACCESS Freely available online

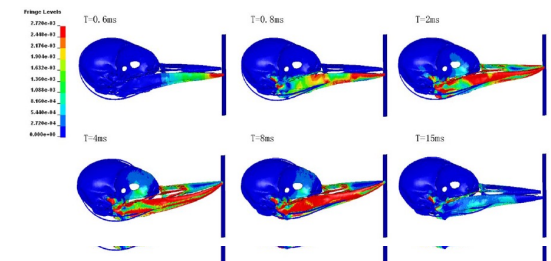
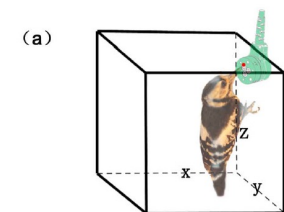
PLoS one

Why Do Woodpeckers Resist Head Impact Injury: A Biomechanical Investigation

Lizhen Wang^{1,2}, Jason Tak-Man Cheung³, Fang Pu¹, Deyu Li¹, Ming Zhang^{2*}, Yubo Fan^{1*}

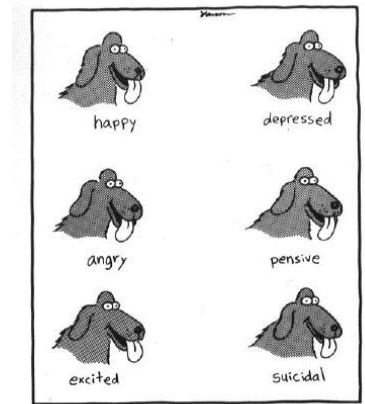
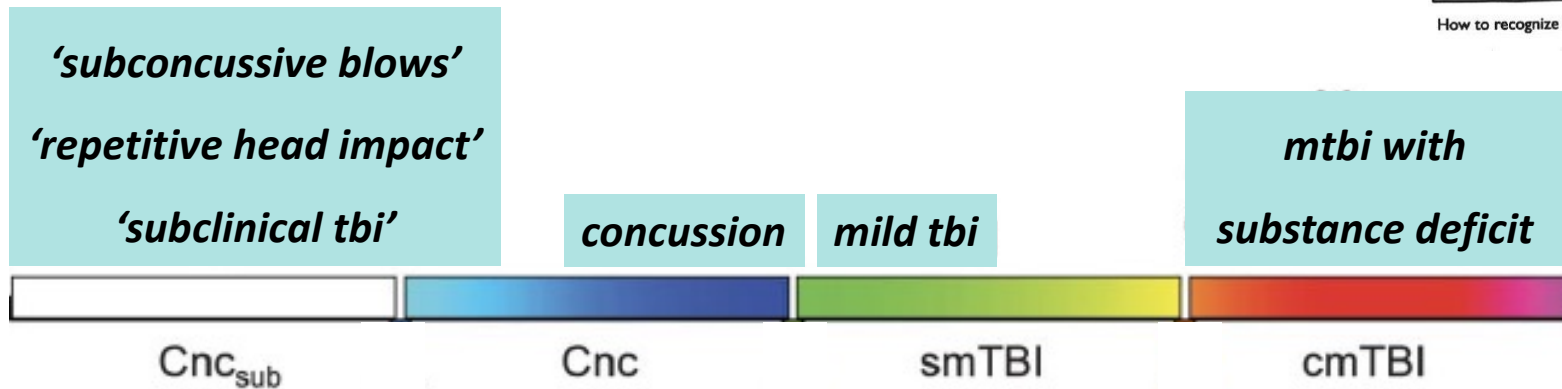
¹Key Laboratory for Biomechanics and Mechanobiology of Ministry of Education, School of Biological Science and Medical Engineering, Beihang University, Beijing, People's Republic of China, ²Department of Health Technology and Informatics, the Hong Kong Polytechnic University, Hong Kong, ³Li Ning Sports Science Research Center, Beijing, People's Republic of China

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Sport associated brain damage is not a clinical entity

spectrum of mild traumatic brain injury



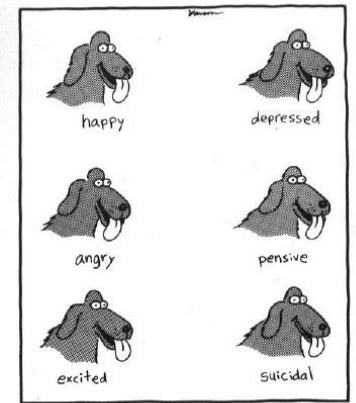
How to recognize the moods of an Irish setter

concussion $\neq$ commotio $\neq$ mild TBI

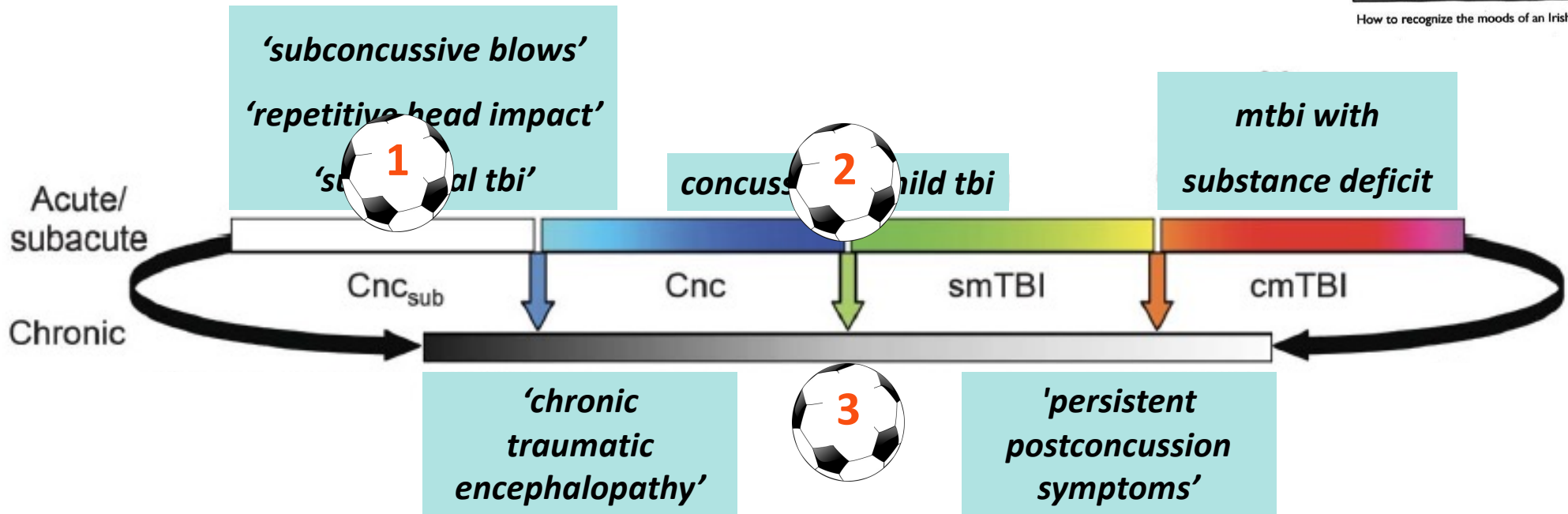


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How to recognize the moods of an Irish setter



Definition of Sport Related Concussion

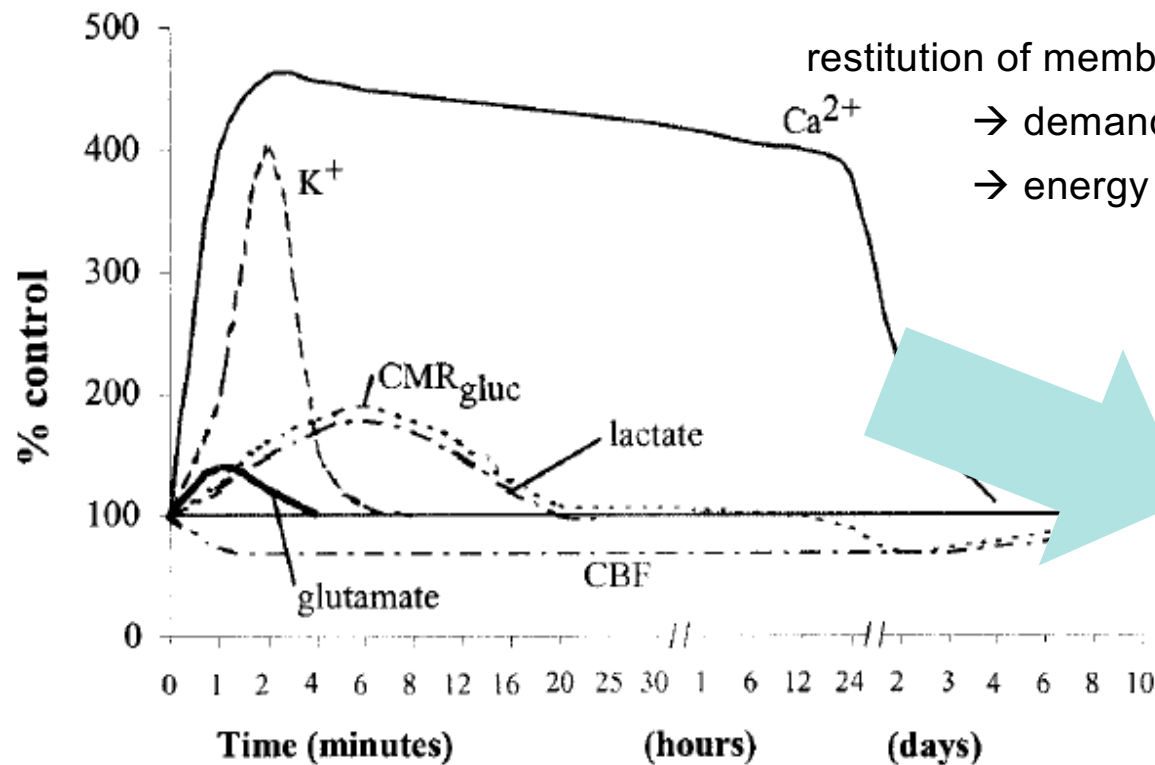
- Concussion in Sport Group -

sport related concussion is a traumatic brain injury caused by a direct blow to the head, neck or body resulting in an impulsive force being transmitted to the brain that occurs in sports and exercise-related activities

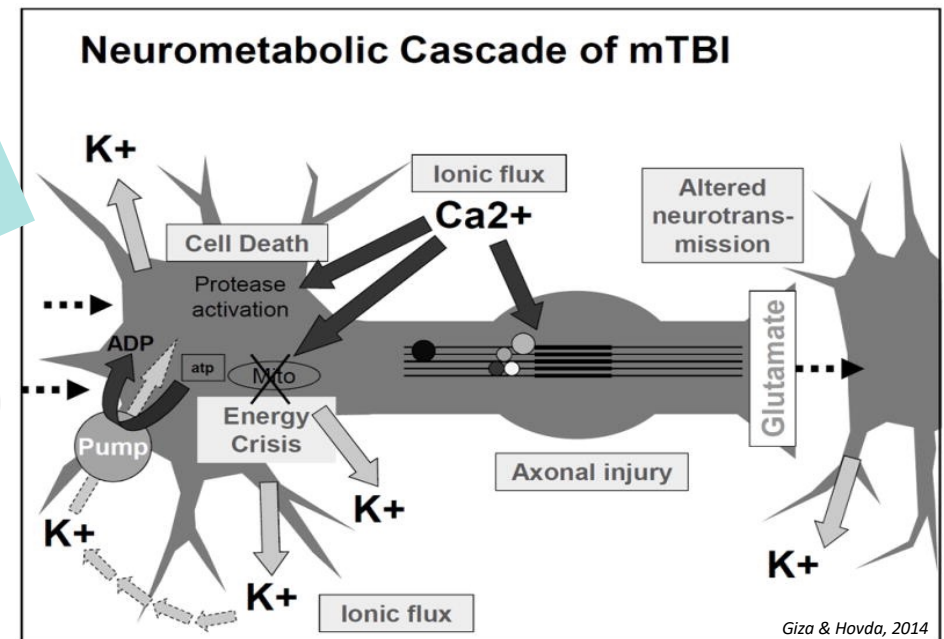
- initiation of a neurotransmitter and metabolic cascade with possible axonal injury, blood flow change and inflammation affecting the brain
- Symptoms and signs may present immediately or evolve over minutes or hours, and commonly resolve within days, but may be prolonged
- no abnormality on standard structural neuroimaging (but in research protocols)
- range of clinical signs and symptoms, loss of consciousness may or may not be involved
- clinical signs and symptoms cannot be explained by drug, alcohol, or medication use, other injuries (such as cervical injuries, peripheral vestibular dysfunction, etc) or other comorbidities (eg, psychological factors or coexisting medical conditions)



Concussion → energy crises of the neuron

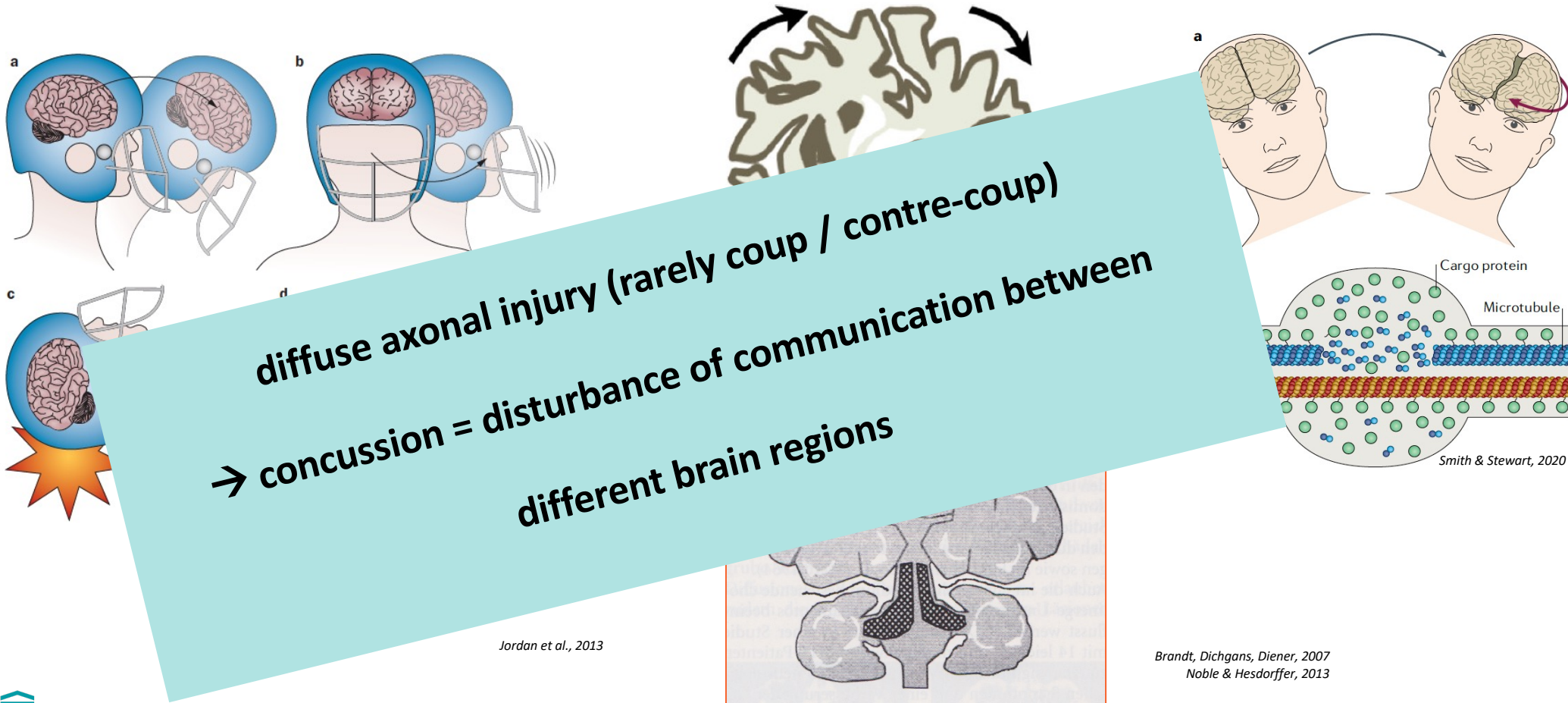


Cantu & Cantu, 2000

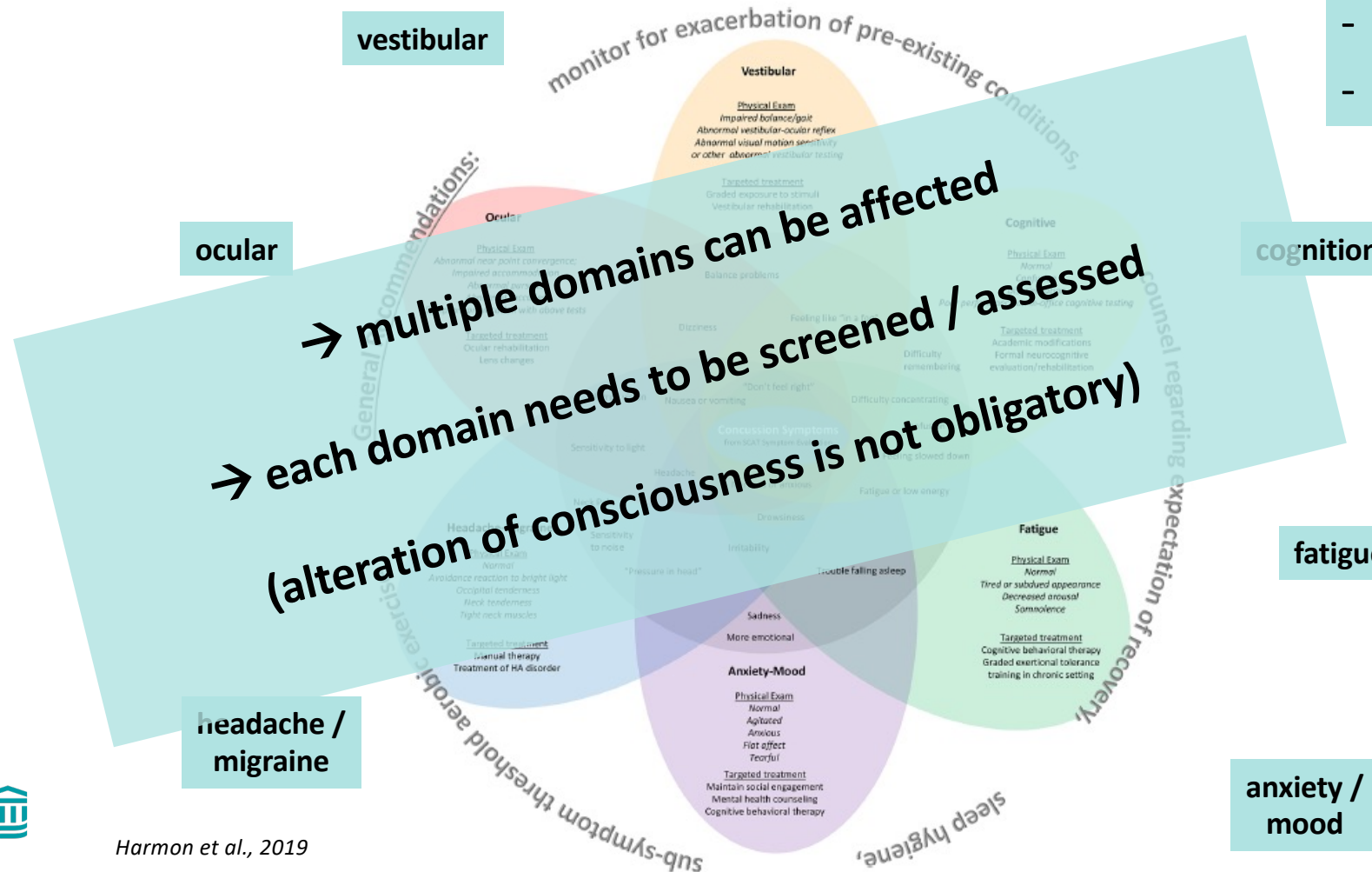


sequestration of excessive calcium in mitochondria
 → decreased oxidative capacity (days/weeks)

What happens during concussion? diffuse axonal injury



Clinical Signs / Symptoms



modifiers:

- sleep
- c-spine

SCAT6™

Sport Concussion Assessment Tool
For Adolescents (13 years +) & Adults

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Sport Concussion Office Assessment Tool
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Harmon et al., 2019

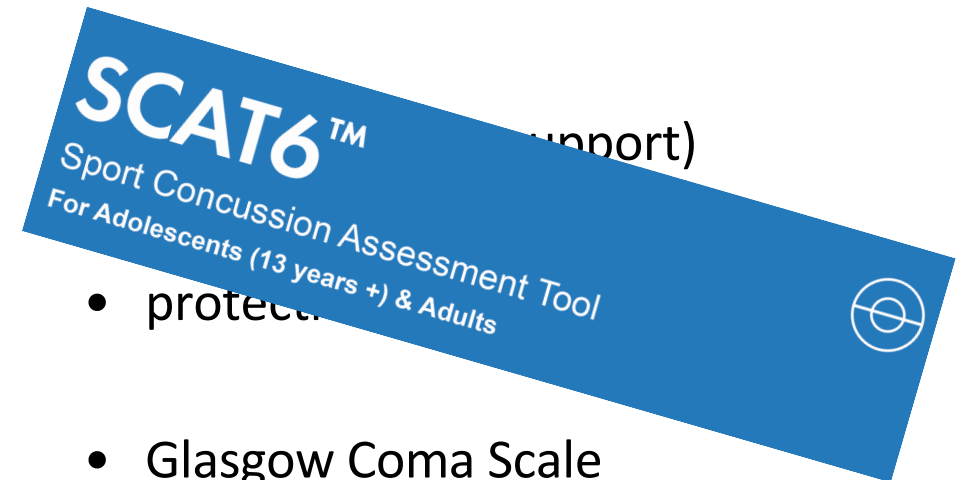
Initial Assessment (on pitch, in the gym)



? continue to play

? substitution & outpatient care

? substitution & inpatient care



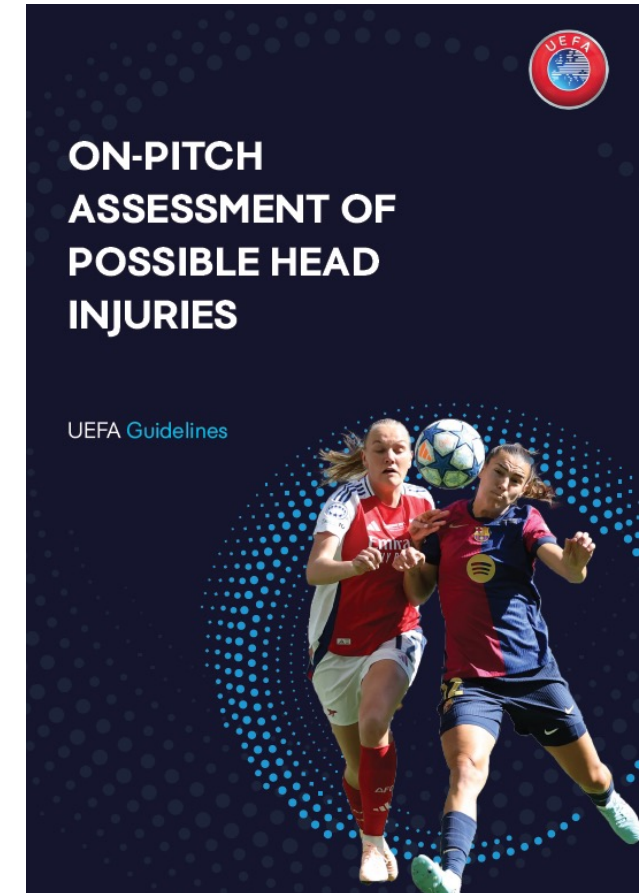
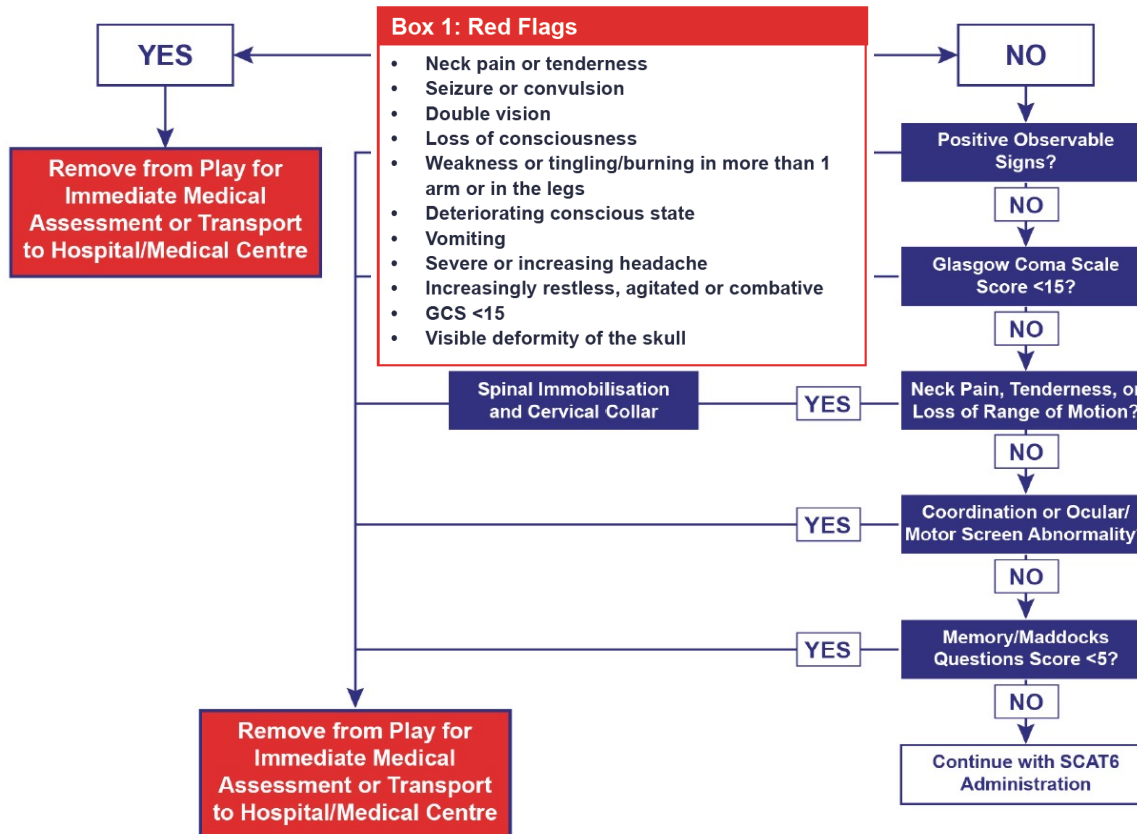
- protect
- Glasgow Coma Scale
- neurological assessment
- ...

! screening ≠ diagnosing !

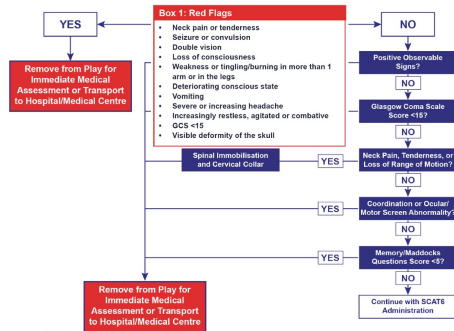




Immediate Assessment/Neuro Screen



Immediate Assessment/Neuro Screen



Step-by-Step Procedure (1/2)



Step 1: Review of 'red flags' and observable signs of TBI.

While approaching the player, assess the **red flags** and **observable signs**, in communication with the bench if possible, as different team members may have different angles and can review video footage immediately after the impact. **(mandatory if a medical video review system (MVRS) is available).**

Step 2: Assessment of consciousness and responsiveness

Consciousness and responsiveness to verbal and painful stimuli should be assessed using the **AVPU system** (Alert, Verbal, Pain, Unresponsive). Anything less than **Alert** requires the player to be removed for the rest of the match, even if they become fully alert again later.

Step 3: Cervical spine assessment

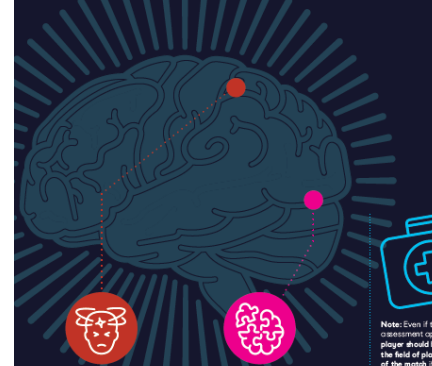
Proper cervical spine assessment includes an assessment of neck pain at rest, tenderness on palpation, full range of active pain-free movement and normal limb strength and sensation. The player should be removed for the rest of the match if there is posterior midline cervical spine tenderness, inability to achieve 45-degrees lateral neck rotation in both directions, concern over the mechanism of injury or distracting injuries.

ON-PITCH ASSESSMENT OF POSSIBLE HEAD INJURIES

UEFA Guidelines



Step-by-Step Procedure (2/2)



Step 4: Coordination & oculomotor screening

Includes finger-to-nose tests (both hands separately, eyes open and closed) as well as looking side-to-side and up-and-down. **Specific attention should be paid** to the presence of nystagmus or double vision and any **smelliedation** or induction of symptoms. These tests may be performed **on the pitch or on the sideline**. While performing oculomotor tests, check for subjective dizziness, lightheadedness or discomfort.

Step 5: Memory & cognitive assessment

Performed by using the **Maddocks questions** and **engaging the player** in conversation. Assessment of recall (for example five to ten words) is encouraged. As the player stands, check for any sign of **instability** and ask them about symptoms of dizziness and lightheadedness.

Note: Even if the on-field assessment appears normal, a player should be removed from the field of play for the remainder of the match if a healthcare professional has any suspicion that they might have sustained a TBI based on their assessment or knowledge of the player's baseline condition or history of previous concussions or if the video review suggests a mechanism of injury consistent with a potential TBI.

A more conservative approach should be taken with players who are under 18 or have a history of concussion, especially within the last year. Any player who is allowed to continue to play after screening for possible TBI should be observed closely for the rest of the match and removed if in any doubt about their condition arises.

How to Diagnose a Concussion

SCHRITT 2: SYMPTOM BEURTEILUNG

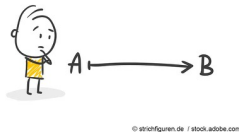
Dem Spieler sollte die Symptomliste gegeben werden mit der Aufforderung: „Bitte kreuzen Sie die Symptome an, die Sie nach der Verletzung bemerkt haben.“ Bei einer Besondereinschätzung sollte der Spieler seine Symptome durch Ankreuzen der entsprechenden Zeile. Bei einer Untersuchung nach einer Verletzung sollte der Spieler seine Symptome zu diesem Zeitpunkt bewerten.

Bitte ankreuzen: ☐ Basistestung ☐ nach Verletzung

Bitte geben Sie das Formular dem Spieler

	keine	leicht	mäßig	stark			
Kopfschmerzen	0	1	2	3	4	5	6
„Zick im Kopf“	0	1	2	3	4	5	6
Nackenschmerzen	0	1	2	3	4	5	6
Übelkeit oder Erbrechen	0	1	2	3	4	5	6
Schwindelgefühl / Benommenheit	0	1	2	3	4	5	6
Verschmommenheit / Beten	0	1	2	3	4	5	6
Gleichgewichtsstörungen	0	1	2	3	4	5	6
Lichtempfindlichkeit	0	1	2	3	4	5	6
Gedruckschmerzhaftigkeit	0	1	2	3	4	5	6
Wahrnehmung / hören zu sein	0	1	2	3	4	5	6
Wahrnehmung / sehen zu sein	0	1	2	3	4	5	6
„Dinge sehen nicht richtig“	0	1	2	3	4	5	6
Schwierigkeiten, sich zu konzentrieren	0	1	2	3	4	5	6
Schwierigkeiten, sich zu erinnern	0	1	2	3	4	5	6
Verwirrung, Irritation oder wenig Energie	0	1	2	3	4	5	6
Vermindert	0	1	2	3	4	5	6
Schlaflosigkeit	0	1	2	3	4	5	6
Emotionaler als gewohnt	0	1	2	3	4	5	6
Reizbarkeit	0	1	2	3	4	5	6
Trägheit	0	1	2	3	4	5	6
Nervös oder ängstlich	0	1	2	3	4	5	6
Schwierigkeiten auszuweichen (nicht schrittweise)	0	1	2	3	4	5	6
Gesamtzahl der Symptome							von 22

→ history



→ ‘physical’ exam



→ additional exams / workup





Off-Field Assessment

Step 1: Athlete Background

Step 2: Symptom Evaluation

Step 3: Cognitive Screening (Based on Standardized Assessment of Concussion; SAC)²

Orientation

Immediate Memory

Concentration

Step 4: Coordination and Balance Examination

Modified Balance Error Scoring System (mBESS)³ testing

(see detailed administration instructions)

Foot Tested: Left ☐ Right ☐ (i.e. test the non-dominant foot)

Testing Surface (hard floor, field, etc.):

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

OPTIONAL (depending on clinical presentation and setting resources): For further assessment, the same 3 stances can be performed on a surface of medium density foam (e.g., approximately 50cm x 40cm x 6cm) with the same instructions and scoring.

April March February January

Balance problems	Arrow	3-8-1-4	1-7-9-5	6-8-3-1	Y	N	
Sensitivity to light						N	0 1
Sensitivity to noise					Y	N	



Off-Field Assessment

Step 4: Coordination and Balance Examination (Continued)

Modified BESS (20 seconds each)

Double Leg Stance: of 10

Tandem Stance: of 10

Single Leg Stance: of 10

Total Errors: of 30

Note: If the mBESS yields normal findings then proceed
If the mBESS reveals abnormal findings or clinically significant findings then proceed to the next section.

Timed Tandem Gait

Dual Task Gait (Optional. Timed Tandem Gait must be completed first)

Place a 3-metre-long line on the floor/firm surface with athletic tape. The task should be timed.

Say “Now, while you are walking heel-to-toe, I will ask you to count backwards out loud by 7s. For example, if we started at 100, you would say 100, 93, 86, 79. Let’s practise counting. Starting with 93, count backward by sevens until I say “stop.”” Note that this practice only involves counting backwards.

Dual Task Practice: Circle correct responses; record number of subtraction counting errors.

Task									Errors	Time
Practice	93	86	72	65	58	51	44	37		

Say “Good. Now I will ask you to walk heel-to-toe and count backwards out loud at the same time. Are you ready? The

Step 5: Delayed Recall

The Delayed Recall should be performed after at least 5 minutes have elapsed since the end of the Immediate Memory section:
Score 1 point for each correct response.

number of subtraction counting errors.

Task														Errors	Time (circle fastest)
Trial 1	88	81	74	67	60	53	46	39	32	25	18	11	4		



SCOAT6™



Sport Concussion Office Assessment Tool
For Adults & Adolescents (13 years +)

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Completion Guide

Blue: Complete only at first assessment

Green: Recommended part of assessment

Orange: Optional part of assessment

Orthostatic Vital Signs		Supine		Standing (after 1 minute)																																											
Blood Pressure (mmHg)	Cervical Spine Palpation			Signs and Symptoms																																											
Heart Rate (bpm)	Muscle Spasm	Cranial Nerves																																													
Symptoms ¹	Midline Tenderness	Normal	☐	Modified Vestibular/Ocular-Motor Screening (mVOMS) for Concussion																																											
• Dizziness or light-headedness	Paravertebral Tenderness	For detailed instructions please see the Supplement.																																													
• Fainting		<table border="1"> <thead> <tr> <th>mVOMS</th> <th>Not Tested</th> <th>Headache</th> <th>Dizziness</th> <th>Nausea</th> <th>Fogginess</th> <th>Comments</th> </tr> </thead> <tbody> <tr> <td>Baseline symptoms</td> <td>N/A</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Smooth pursuits (2 horizontal and 2 vertical, 2 seconds to go full distance right-left and back; up-down and back)</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Saccades – Horizontal (10 times each direction)</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>VOR – Horizontal (10 repetitions) (metronome set at 180 beats per minute – change direction at each beep, wait 10 secs to ask symptoms)</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>VMS (x 5, 80° rotation side to side) (at 50 bpm, change direction each beep, wait 10 secs to ask symptoms)</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>				mVOMS	Not Tested	Headache	Dizziness	Nausea	Fogginess	Comments	Baseline symptoms	N/A						Smooth pursuits (2 horizontal and 2 vertical, 2 seconds to go full distance right-left and back; up-down and back)							Saccades – Horizontal (10 times each direction)							VOR – Horizontal (10 repetitions) (metronome set at 180 beats per minute – change direction at each beep, wait 10 secs to ask symptoms)							VMS (x 5, 80° rotation side to side) (at 50 bpm, change direction each beep, wait 10 secs to ask symptoms)						
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• Nausea		Other Neurological																																													
• Fatigue		Limb Tone:																																													
• Lack of concentration		Strength:																																													
Results	Flexion (50-70°)	Deep Tendon Reflexes:																																													
	Extension (60-85°)	Sensation:																																													
	Right Lateral Flexion	Cerebellar Function:																																													
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Anxiety Screen

Not Done ☐

Assign score
days," and "

Depression Screen

Not Done ☐

The purpose is
the [PHQ-9](#) to d

Over the la
bothered

1. Little intere
2. Feeling dov

Depression Sc

Anxiety Screen Score:

Sleep Screen

Not Done ☐

Over the la
bothered

1. Little intere
2. Feeling dov

Depression Sc

Post-Injury Result (Pos

2. How satisfied/diss

Very dissatisfied

Somewhat dissatisfied

Somewhat satisfied

Satisfied

Very satisfied

3. During the recent past, how long has it usually taken you to fall asleep each night?

Computerised Cognitive Test Results (if used)

Not Done ☐

Test Battery Used:

Recent Baseline - if per

Post-Injury Result (Res

Post-Injury Result (Pos

2. How satisfied/diss

Graded Aerobic Exercise Test

Not Done ☐

Exclude contra-indications: cardiac condition, respiratory disease, significant vestibular symptoms, motor dysfunction, lower limb injuries, cervical spine injury.

Protocol Used:



Quality Improvement / Measurement



Table 2020 Concussion Quality Measurement Set

Title	Numerator	Denominator	Exclusions
Concussion symptoms evaluation	Patients who had a symptom evaluation completed at initial visit	Patients ≥ 5 years of age diagnosed with concussion	• Patient/caregiver unable to report symptoms • Patient/caregiver refusal
Appropriate neurologic examination	Patients who had a neurologic examination that included all components: (1) Cervical assessment (2) Cognitive function (3) Vestibular function (4) Extraocular movements (5) Gait (6) Balance (7) Coordination	Patients ≥ 5 years of age diagnosed with concussion seen for initial visit	• Patient/caregiver refusal • Patient unable to participate in neurologic examination
Documentation of return-to-play strategy or protocol	Patients who had documentation of a return-to-play strategy or protocol	Patients ≥ 5 years of age diagnosed with concussion who were cleared for full participation in sports	• Patient/caregiver refuse return-to-play strategy • Patients who are currently participating in sports without symptoms

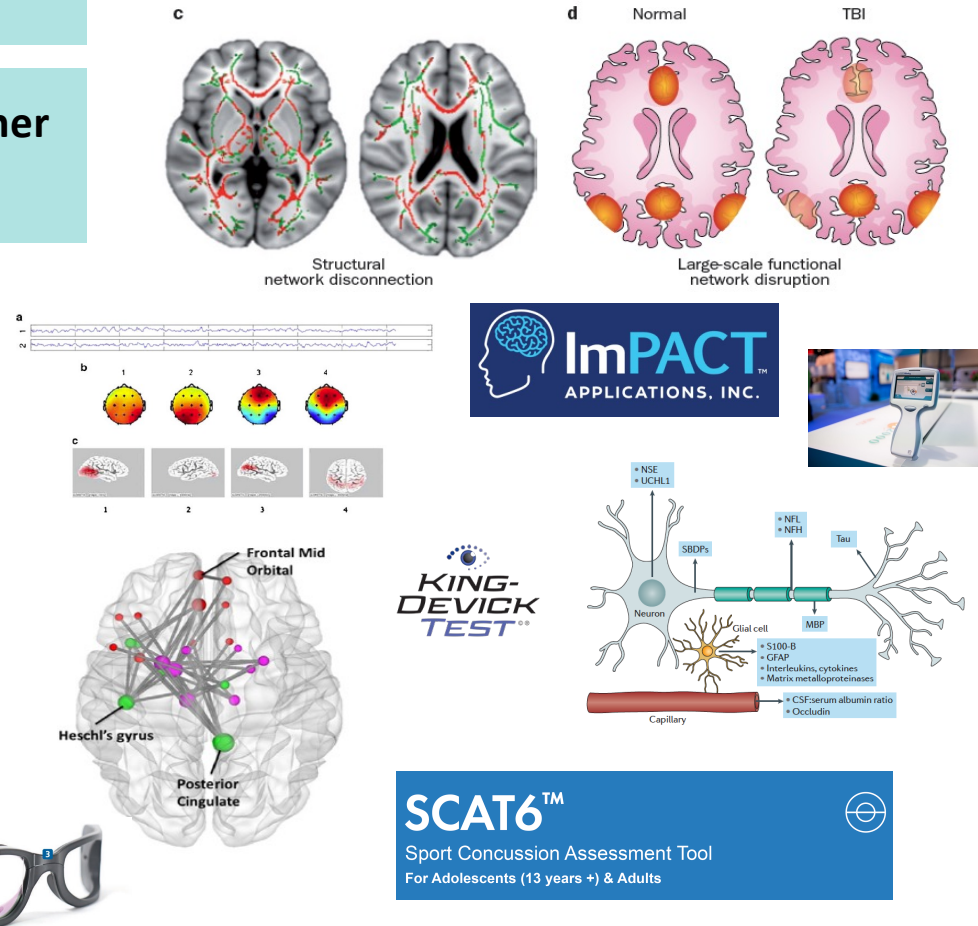
Rose et al., 2021



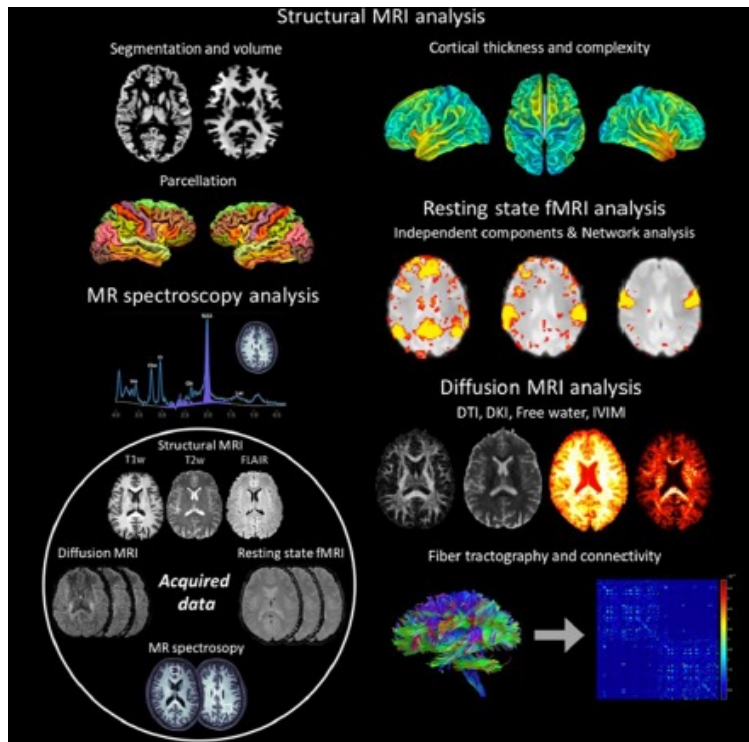
The Quest for Biomarkers

→ **concussion is a clinical diagnosis**

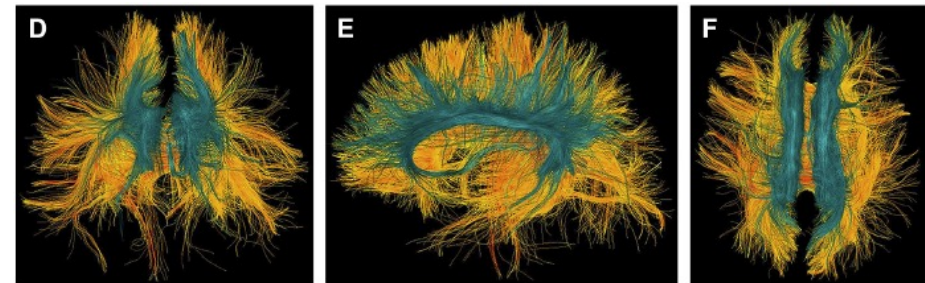
→ workup may be needed to assess for higher degree tbi or other pathology



Neuroimaging



Koerte et al., 2021



Guenette et al., 2017

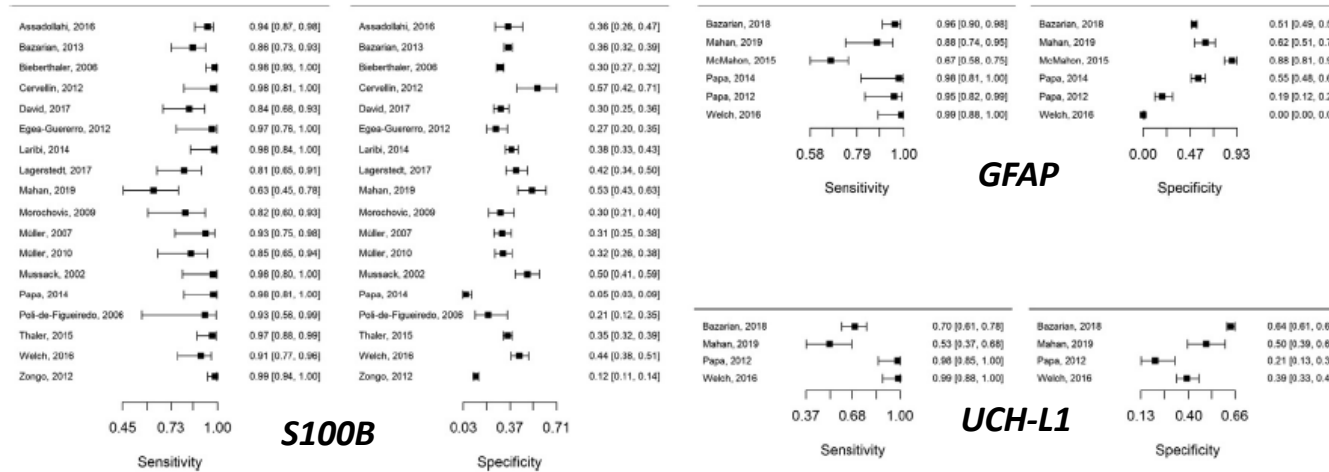
- *group vs. individual level*
- *diagnostic sensitivity*
& specificity not clear

→ ***not (yet) ready for clinical use to dx concussion !***

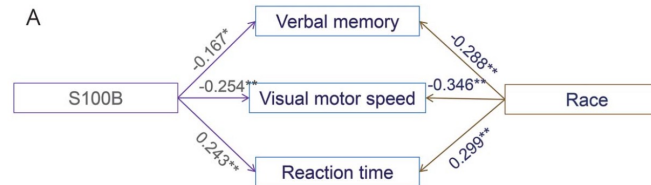
→ ***but important to assess for higher degree tbi!***



Serological Biomarkers



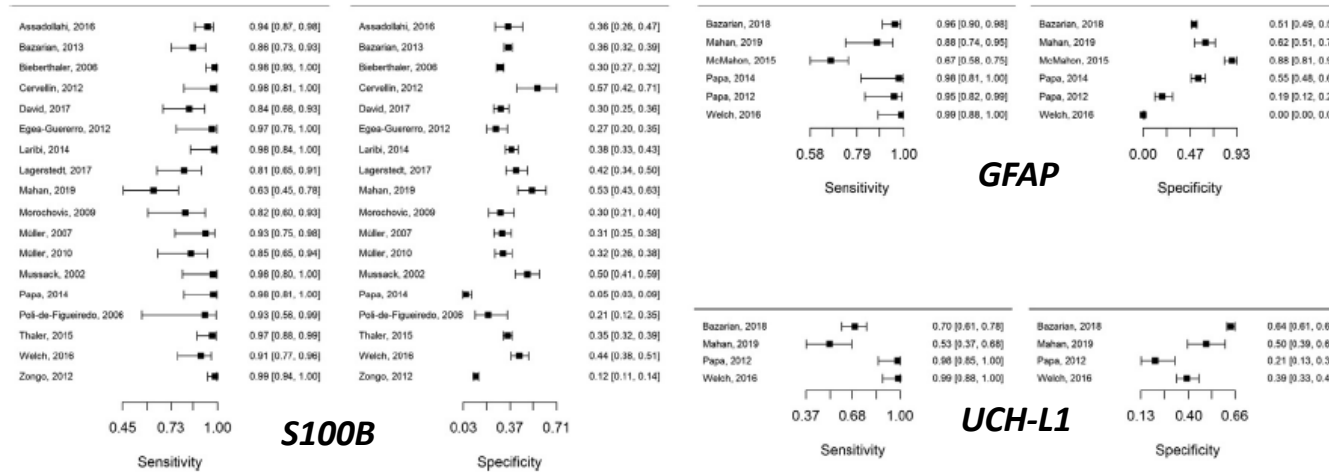
Rogan et al., 2022



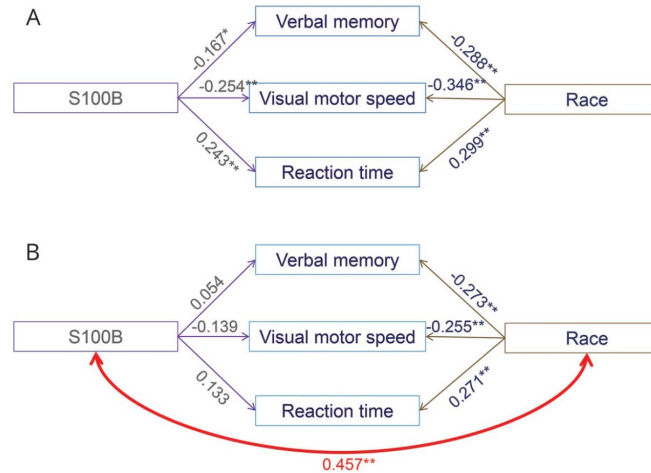
Asken et al., 2018



Serological Biomarkers



Rogan et al., 2022



Asken et al., 2018



Guidelines

1.) concussion diagnosed / suspected:

→ no return to play/practice
on the same day

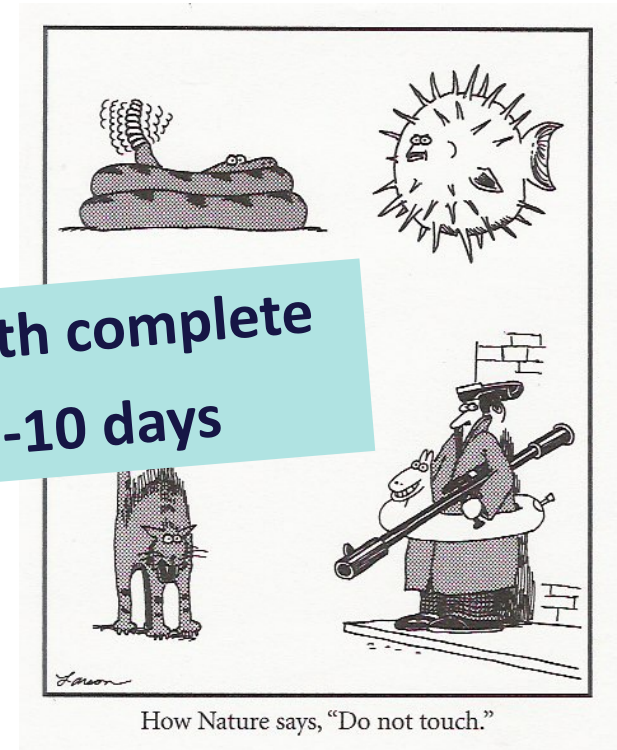
2.) after

→ 80-90%: favorable prognosis with complete
remission of symptoms after 7-10 days

stepwise return to play / practice

SPORTS CONCUSSION

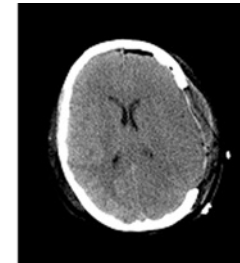
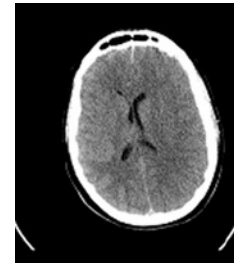
When in Doubt—Sit it Out!



Second Impact Syndrom



Rowan Stringer, 17, R.I.P
Rugby



Jake Snakenberg, 14, R.I.P
American Football



Neurochirurgie
Available online 10 March 2020
In Press, Corrected Proof ?



Original article

Second Impact Syndrome. Myth or reality?

J. Engelhardt ^a, D. Brauge ^b, H. Loiseau ^c ✉

44 cases

1 : 205.000 athlete seasons

male, <20 years



,Return-to'-strategy

Table 2 Return-to-sport (RTS) strategy—each step typically takes a minimum of 24 hours

Step	Exercise strategy	Activity at each step	Goal
1	Symptom-limited activity	Daily activities that do not exacerbate symptoms (eg, walking).	Gradual reintroduction of movement
2	Aerobic exercise 2A—Light (up to approximately 55% maxHR) then 2B—Moderate (up to approximately 70% maxHR)	Stationary cycling or walking at slow to medium intensity. May start light resistance training (eg, sit-ups) no more than 10 minutes.	Return to aerobic exercise
3	Individual sport-specific exercise Note: If sport-specific exercise is not possible, continue with aerobic exercise.	Non-contact drills that simulate game environment. Add movement, change of direction and/or individual skills (eg, passing drills, shooting drills away from the team environment). No activities at risk of head impact.	Return to sport-specific activities
4	Non-contact training drills	Exercise to high intensity including more challenging training drills (eg, passing drills, multiplayer training) can integrate into a team environment.	Resume usual intensity of exercise, coordination and increased thinking
5	Full contact practice	Participate in normal training activities.	Restore confidence and assess functional skills by coaching staff
6	Return to sport	Normal game play.	

earlier access to specialized care → faster and better recovery!

Step	Mental activity	Activity at each step	Goal
1	Daily activities that do not result in more than a mild exacerbation of symptoms related to the current concussion	Typical activities during the day (eg, reading) while minimizing screen time. Start with 5–10 min at a time and increase gradually.	Gradual return to typical activities
2	School activities	Homework, reading or other cognitive activities outside of the classroom.	Increase tolerance to cognitive work
3	Return to school part time	Gradual introduction of schoolwork. May need to start with a partial school day or with greater access to rest breaks during the day.	Increase academic activities
4	Return to school full time	Gradually progress to school activities until a full day can be tolerated without more than mild symptom exacerbation.	Return to full academic activities and catch up on missed work

Return to daily activities / school

Return to sport

Return to play

Return to performance





Treatment / Rehabilitation

Study or Subgroup	Control			Intervention			Weight	Std. Mean Difference
	Mean	SD	Total	Mean	SD	Total		
Kurowski 2017	15.93	20.18	14	4.17	7.20			
Micay 2018	8.14	10.92						
Rytter 2019								

Exercise is Medicine for Concussion

John J. Leddy, MD, FACS, FACP¹; Mohammad N. Haider, MD¹; Michael Ellis, MD, FRCSC²; and Barry S. Willer, PhD³

Symptomscores

individual multimodal (cervical, vestibular, oculomotor) intervention,

if symptoms persist > 2 weeks

→ significant reduction of symptoms

→ finalization of RTS in 8 weeks 3x more likely



Therapeutic principles of Concussion

Systematic review

Rest and exercise early after sport-related concussion:
a systematic review and meta-analysis

John J Leddy ¹, Joel S Burma ², Clodagh M Toomey³, Alix Hayden,⁴
Gavin A Davis ⁵, Franz E Babl ⁶, Isabelle Gagnon,^{7,8} Christopher C Giza,^{9,10}
Brad G Kurowski,¹¹ Noah D Silverberg ¹², Barry Willer,¹³ Paul E Ronksley,¹⁴
Kathryn J Schneider ¹⁵

To cite: Leddy JJ,
Burma JS, Toomey CM,
et al. Br J Sports Med
2023;**57**:762–770.

Conclusion Early PA, prescribed aerobic exercise and reduced screen time are beneficial following SRC. Strict physical rest until symptom resolution is not effective, and sleep disturbance impairs recovery after SRC.

1.) brief (!) protection from stimuli, reduction of screen time

2.) interventions to enhance the regeneration of the cerebral metabolism



RESTORATION OF CEREBRAL ENERGY METABOLISM

Exercise is Therapy!

- aerobic / cardio exercise
- monitoring: hr, RPE, symptom scores
- no significant worsening of symptoms
- careful with resistance training (initially)
- consider cognitive motor training



(Restoration of Healthy) Sleep is Therapy!

Consensus statement

Sleep and the athlete: narrative review and 2021 expert consensus recommendations

Neil P Walsh ,¹ Shona L Halson,² Charli Sargent,³ Gregory D Roach,³ Mathieu Nédélec,⁴ Luke Gupta,⁵ Jonathan Leeder,⁶ Hugh H Fullagar,⁷ Aaron J Coutts,⁷ Ben J Edwards,¹ Samuel A Pullinger ,^{1,8} Colin M Robertson,⁹ Jatin G Burniston,¹ Michele Lastella,³ Yann Le Meur,⁴ Christophe Hausswirth,¹⁰ Amy M Bender,¹¹ Michael A Grandner,¹² Charles H Samuels¹³

Tool Box for Athletes:

- Sleep Education for athletes
- Screen for sleep problems
- Encourage power naps
- Bank sleep

Therapeutic principles of Concussion

Systematic review

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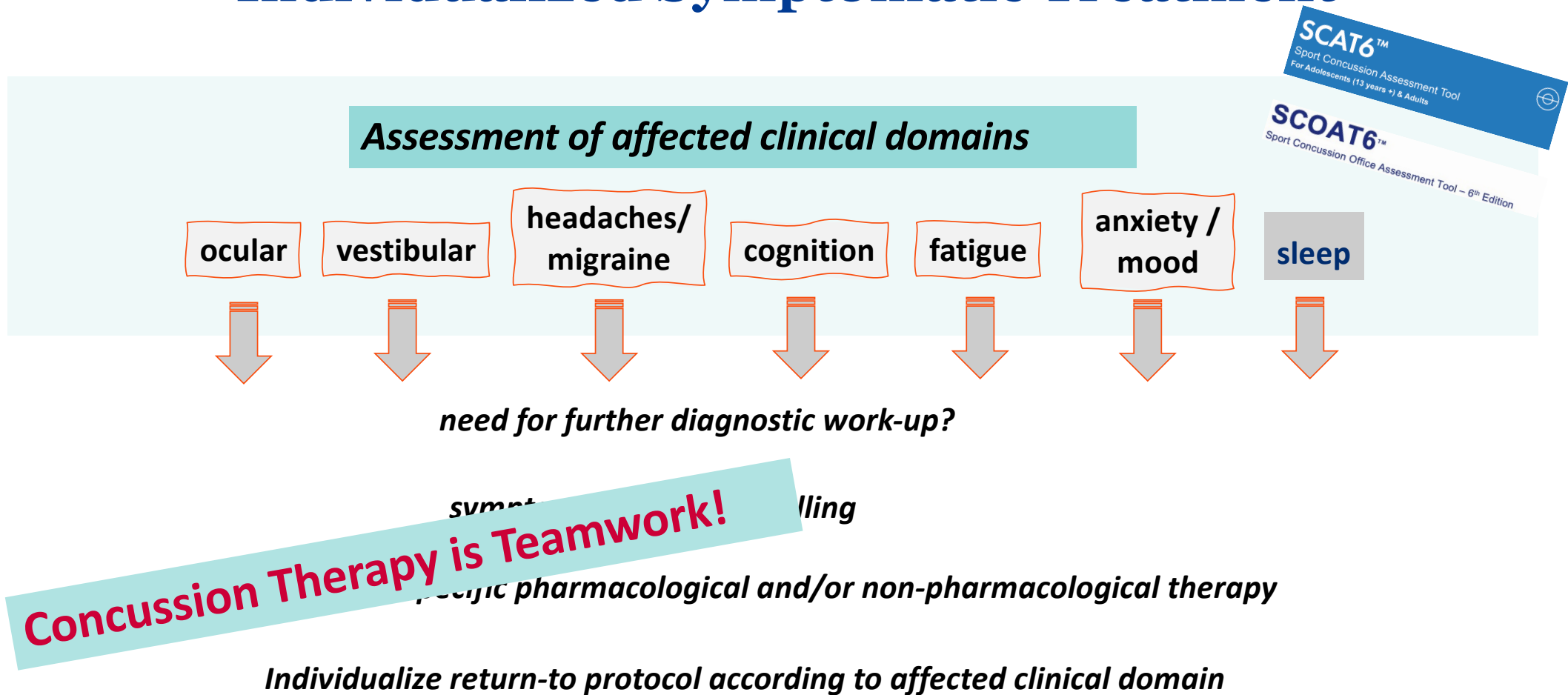
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2023;**57**:762–770.

Conclusion Early PA, prescribed aerobic exercise and reduced screen time are beneficial following SRC. Strict physical rest until symptom resolution is not effective, and sleep disturbance impairs recovery after SRC.

- 1.) brief (!) protection from stimuli, reduction of screen time
- 2.) interventions to enhance the regeneration of the cerebral metabolism
- 3.) interventions to improve symptoms



Individualized Symptomatic Treatment



Persistent Postconcussion Symptoms

Definitions for postconcussion syndrome and related disorders

	ICD-10	DSM-IV	DSM-V	5th International Consensus Conference on Concussion in Sport
Terminology	Postconcussion syndrome	Postconcussional disorder	Major or mild neurocognitive disorder	Concussion
Trauma	History of head trauma	History of head injury	Major or mild traumatic brain injury	Signs of brain injury
Loss of consciousness (LOC)	"Usually"			
Assessment			Neurologic exam	"Impairment of neurologic functioning"
Maximum symptom duration for a diagnosis of postconcussion syndrome		N/A	Immediate or when conscious	Minutes to hours
Minimum duration	N/A	3 months	"Past the acute injury phase"	Adults: 10–14 days Children: 4 weeks
Objective evidence	Not required	Required	Not required	Not required

DSM-IV, *Diagnostic and Statistical Manual of Mental Disorders*, fourth edition; DSM-V, *Diagnostic and Statistical Manual of Mental Disorders*, fifth edition; ICD-10, *International Statistical Classification of Diseases and Related Health Problems*, 10th revision.

managing risk factors = prevention of PPCS

pre-existing:

- prior tbi
- psychiatric disease
- headache syndrome
- genetic predisposition
- female

mechanism of injury:

- quick onset of symptoms
- outside of sport

after injury:

- adjustment disorders, secondary gain
- bad compliance

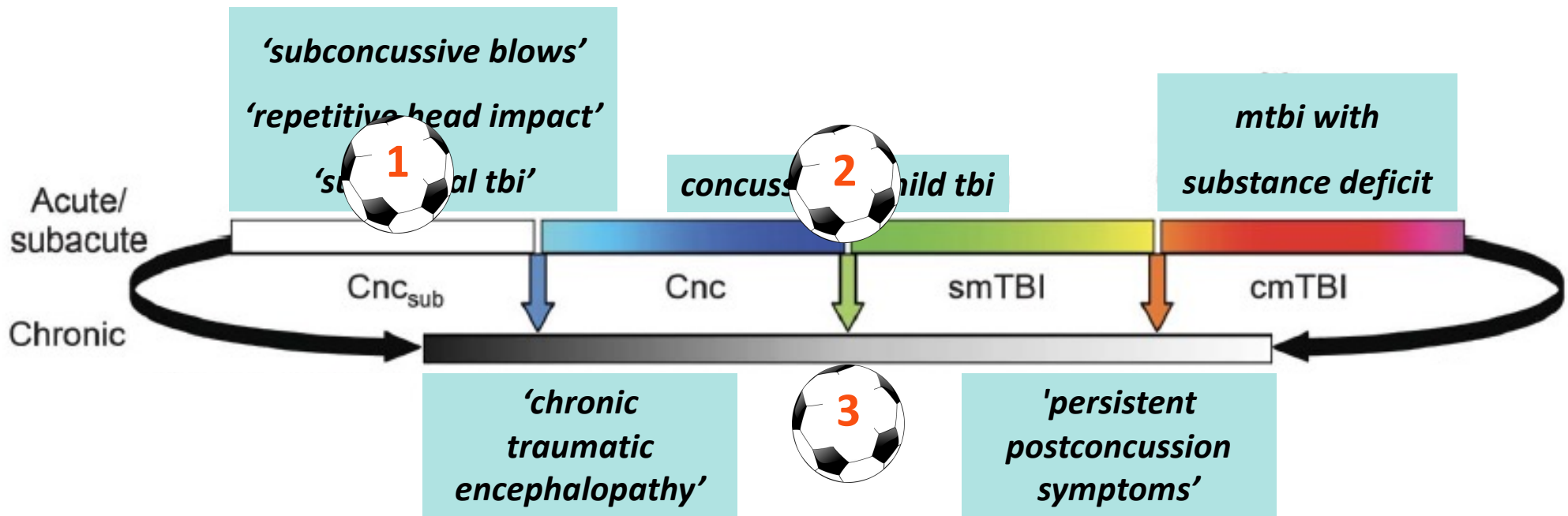
⇒ Continuing to play and delayed access to healthcare providers (HCPs) after SRC are associated with longer recovery after SRC.

To cite: Putukian M, Purcell L, Schneider KJ, et al. *Br J Sports Med* 2023;57:798–809.

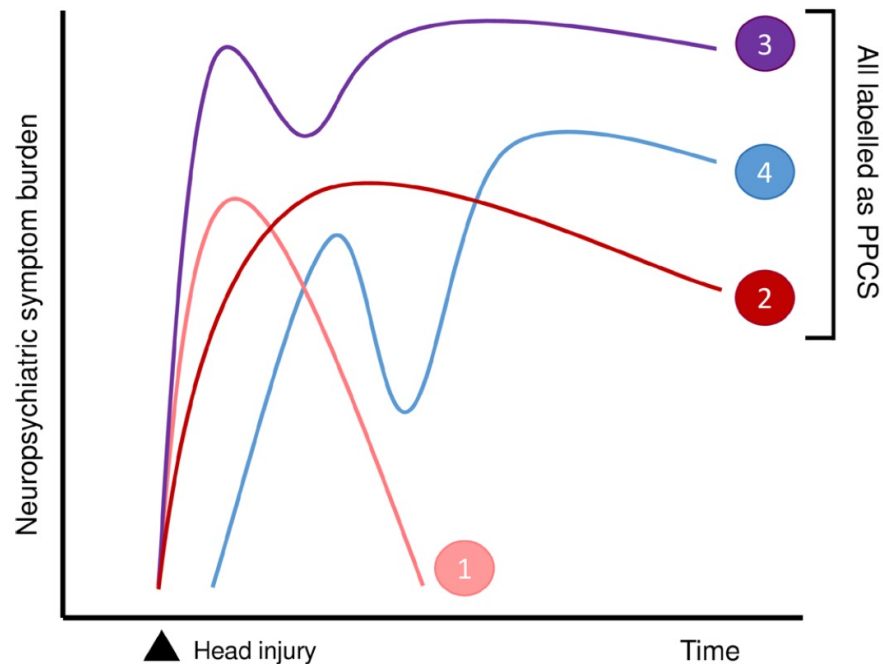
Dwyer and Katz, 2018

Sport associated brain damage is not a clinical entity

spectrum of mild traumatic brain injury



Persistent Postconcussion Symptoms



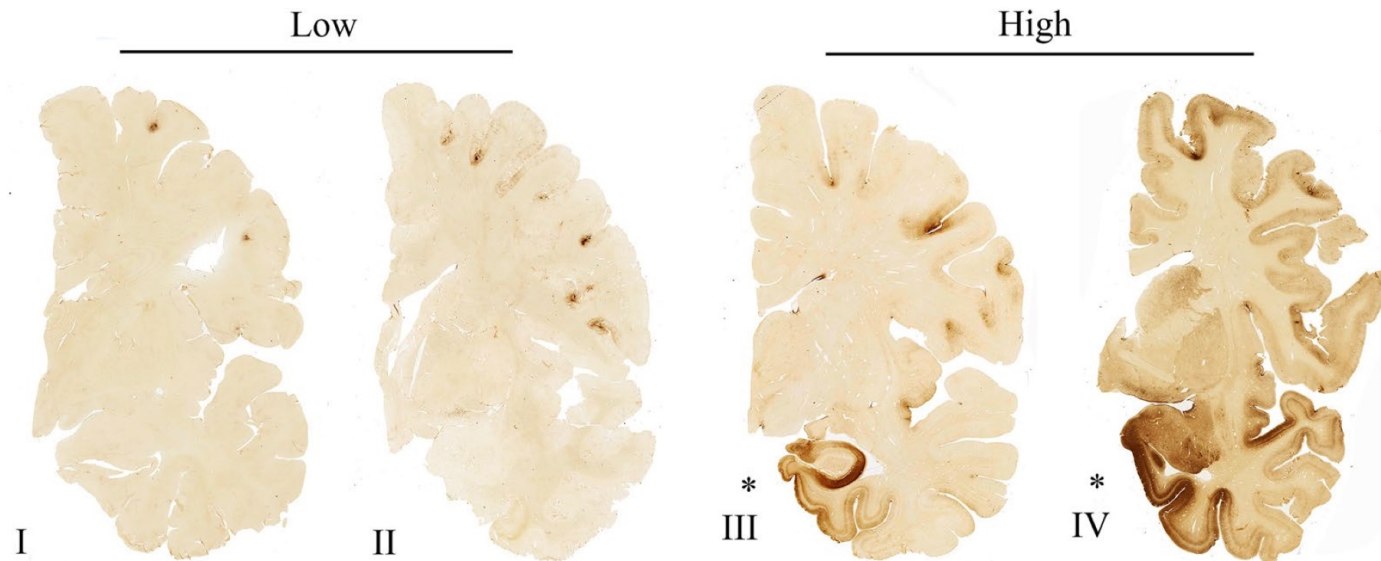
Clinical factors favoring FND (rightward shift on spectrum):

- a) Low likelihood of brain injury (e.g., low-velocity mechanism, no LOC, no post-traumatic amnesia)
- b) Symptom onset delayed (e.g., >48 hours after head injury)
- c) Fluctuating, worsening, or remit/relapse course
- d) Internal inconsistencies* of core symptom(s) (e.g., functional cognitive disorder, PPPD)
- e) Atypical symptoms incongruent with structural neurological disease (e.g., stuttering, abnormal movements, non-epileptic events)
- f) Pre-injury or comorbid functional somatic syndromes (e.g., IBS, fibromyalgia)
- g) Presence of contributory psychological mechanisms (e.g., PTSD, dissociation)



Chronic Traumatic Encephalopathy

can only be diagnosed via autopsy:



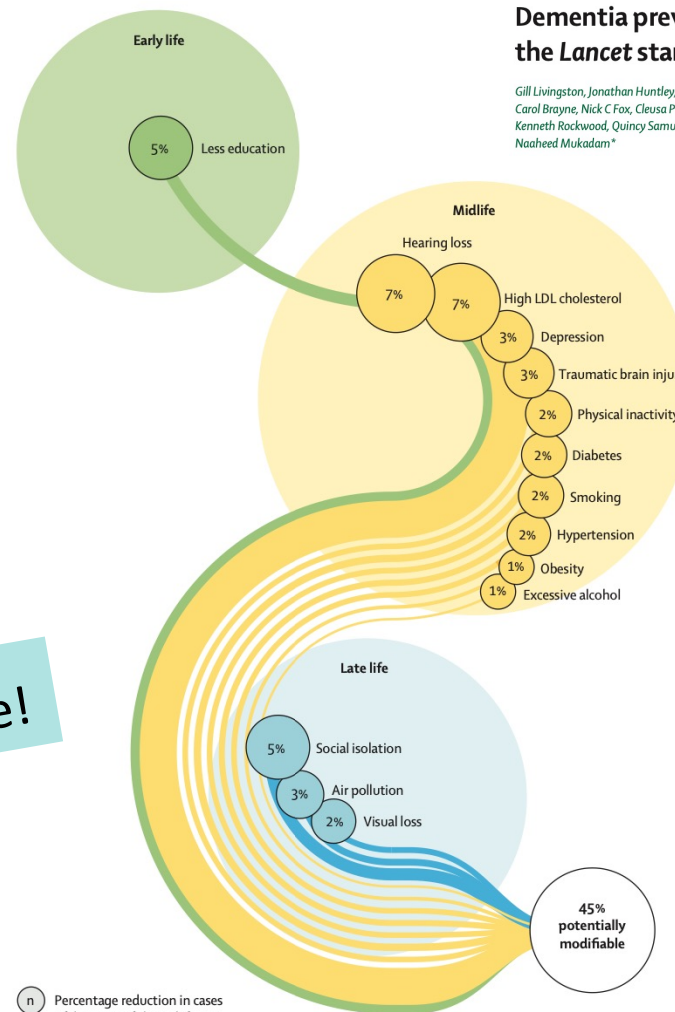
perivascular accumulation of neuronal phosphorylated tau (p-tau)
variably alongside astrocytic aggregates at the depths of the cortical sulci



Long Term Health of Athletes after Concussion

14 potentially modifiable
risk factors
account for ~45%
of worldwide dementias

early specialized care improves outcome!

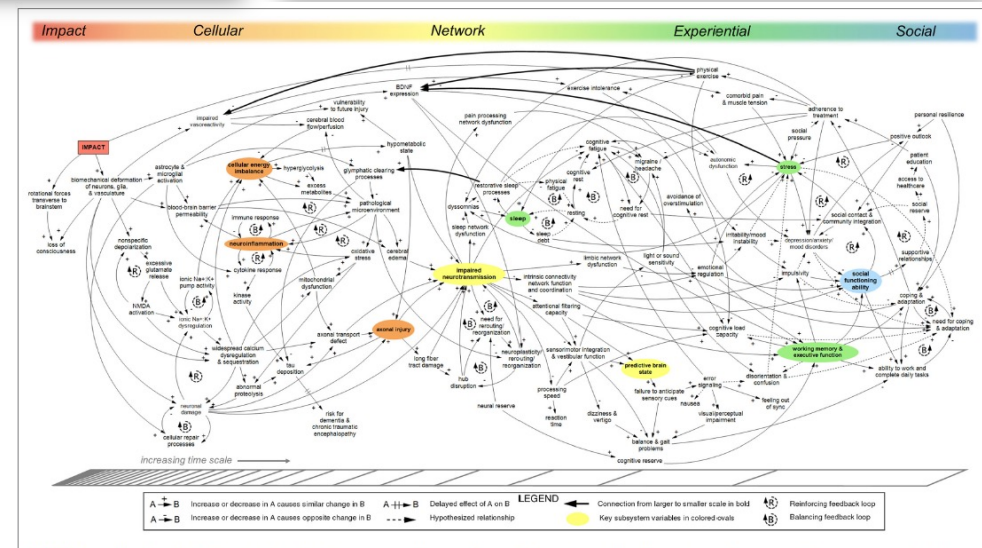


Dementia prevention, intervention, and care: 2024 report of the *Lancet* standing Commission

Gill Livingston, Jonathan Huntley, Kathy Y Liu, Sergi G Costafreda, Geir Selbaek, Suvarna Alladi, David Ames, Sube Banerjee, Alistair Burns, Carol Brayne, Nick C Fox, Cleusa P Ferri, Laura N Gitlin, Robert Howard, Helen C Kales, Mika Kivimaki, Eric B Larson, Noeline Nakasujja, Kenneth Rockwood, Quincy Samus, Kokoro Shirai, Archana Singh-Manoux, Lon S Schneider, Sebastian Walsh, Yao Yao, Andrew Sommerlad*, Naeheed Mukadam*

Lancet 2024; 404: 572-628

MGB Sport Concussion - Multidisciplinary Clinics





Mass General Brigham

Mass General Brigham

Sports Neurology & Neurosciences

concussion care and beyond

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Co-Director, Sport Concussion Program, Mass General Brigham*

*Associate Professor of Neurology, Harvard Medical School
Professor of Sports Medicine, Paderborn University, Germany*

Email: creinsberger@mgb.org

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- Livingston G, Huntley J, Liu KY, et al., Dementia prevention, intervention, and care: 2024 report of the Lancet standing Commission. Lancet. 2024 Aug 10;404(10452):572-628.
- Burke MJ, Silverberg ND, New framework for the continuum of concussion and functional neurological disorder, British Journal of Sports Medicine 2025;**59**:145-147.

