



Out of the Dark

Hot Topic in Neurology: Approach to Concussion

Claus Reinsberger, M.D., Ph.D.

Chief, Division of Sports Neurology and Neurosciences, Mass General Brigham

Co-Director, Sport Concussion Program, Mass General Brigham

Professor of Sports Medicine, Paderborn University, Germany

Email: creinsberger@mgb.org

Claus Reinsberger, MD, PhD



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, University of Paderborn
- ... 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)
- Persisting post concussion symptoms may be associated with risk factors (outside of the initial trauma) that need to be addressed



Sports Neurology / Neuroscience

sports and exercise associated (overuse) syndromes

CNS: dystonias, dysautonomia, PNS: trauma

‘cerebral performance’ in sports (and training)

ANS control, cognitive-motor training, neuroathletic training

***clinical neurology
& neurosciences***



***sports medicine
& sports physiology***

sports and exercise to prevent & treat neurological diseases

‘exercise is medicine’

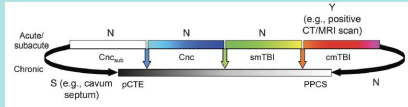
‘sports is pharmacy’



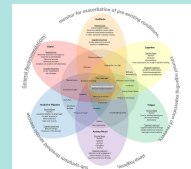


Mass General Brigham

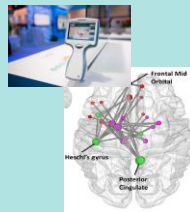
(Sports Associated) Concussion



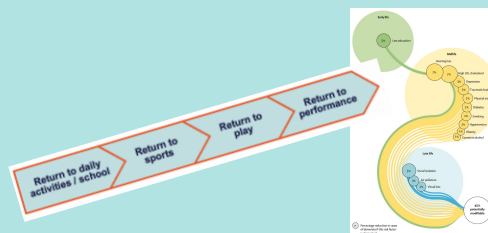
definition and classification



on pitch, in the gym

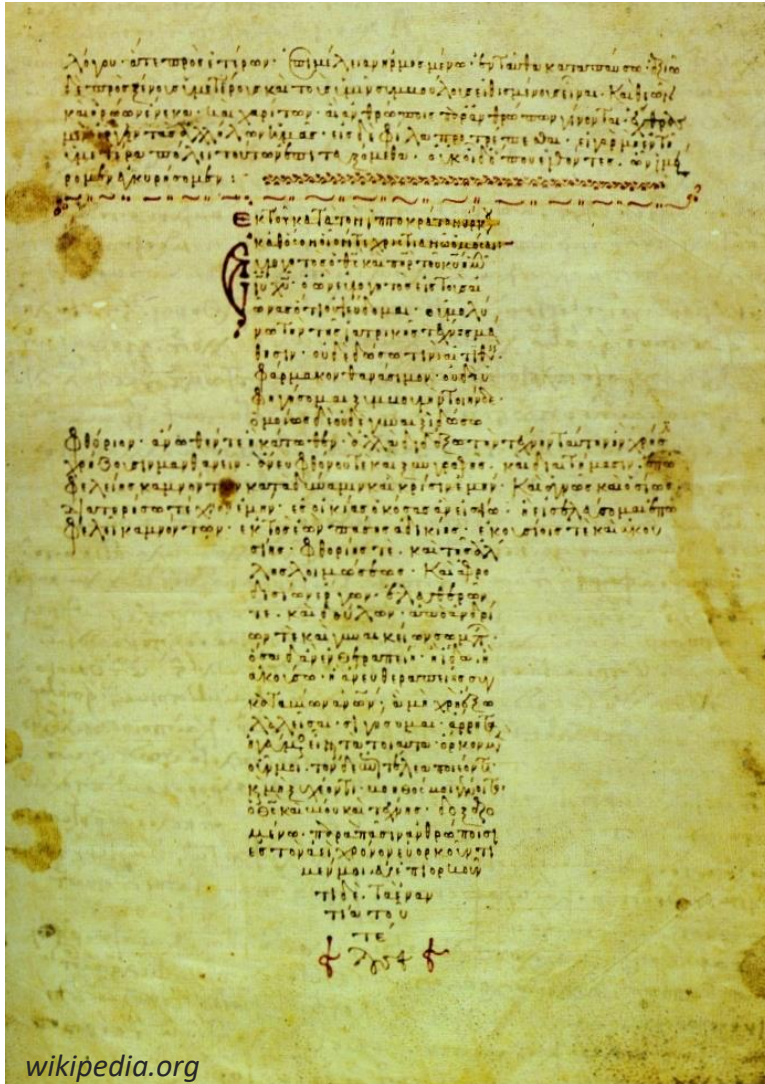


diagnosis: biomarkers, devices etc...



rehabilitation, 'return-to/ & long term health

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

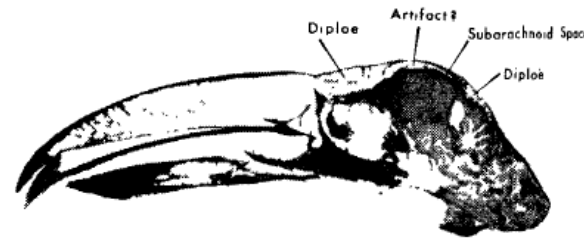
WOODPECKERS AND HEAD INJURY

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.



TOUCAN Sagittal Section



WOODPECKER Sagittal Section

...really?

OPEN ACCESS Freely available online

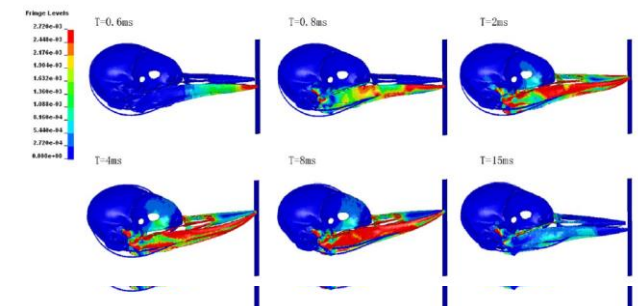
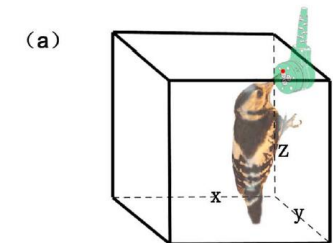
PLOS one

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*}

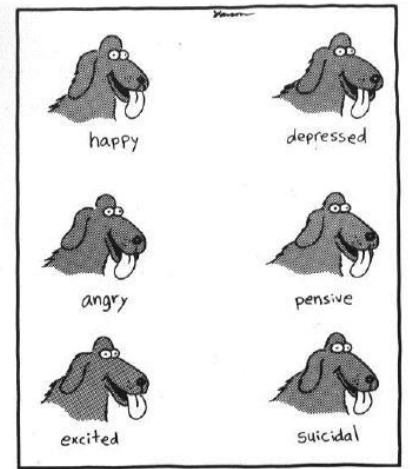
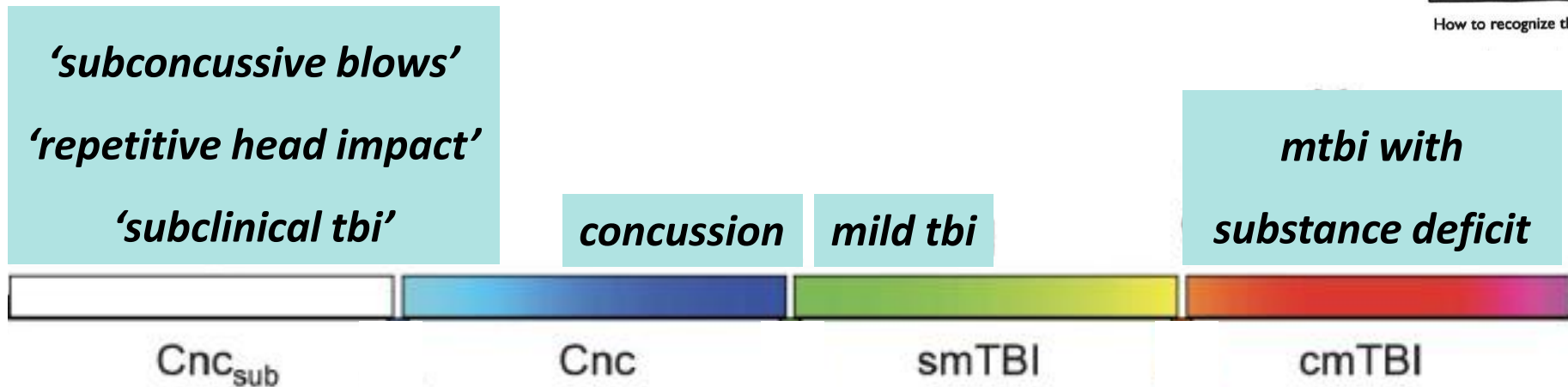
¹Key Laboratory for Biomechanics and Mechanobiology of Ministry of Education, School of Biological Science and Medical Engineering, Beihang University, Beijing, People's Republic of China, ²Department of Health Technology and Informatics, the Hong Kong Polytechnic University, Hong Kong, ³Li Ning Sports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

October 2011 | Volume 6 | Issue 10 | e26490



Sport associated brain damage is not a clinical entity

spectrum of mild traumatic brain injury



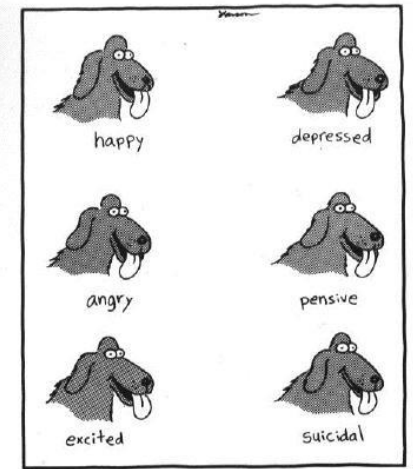
How to recognize the moods of an Irish setter

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

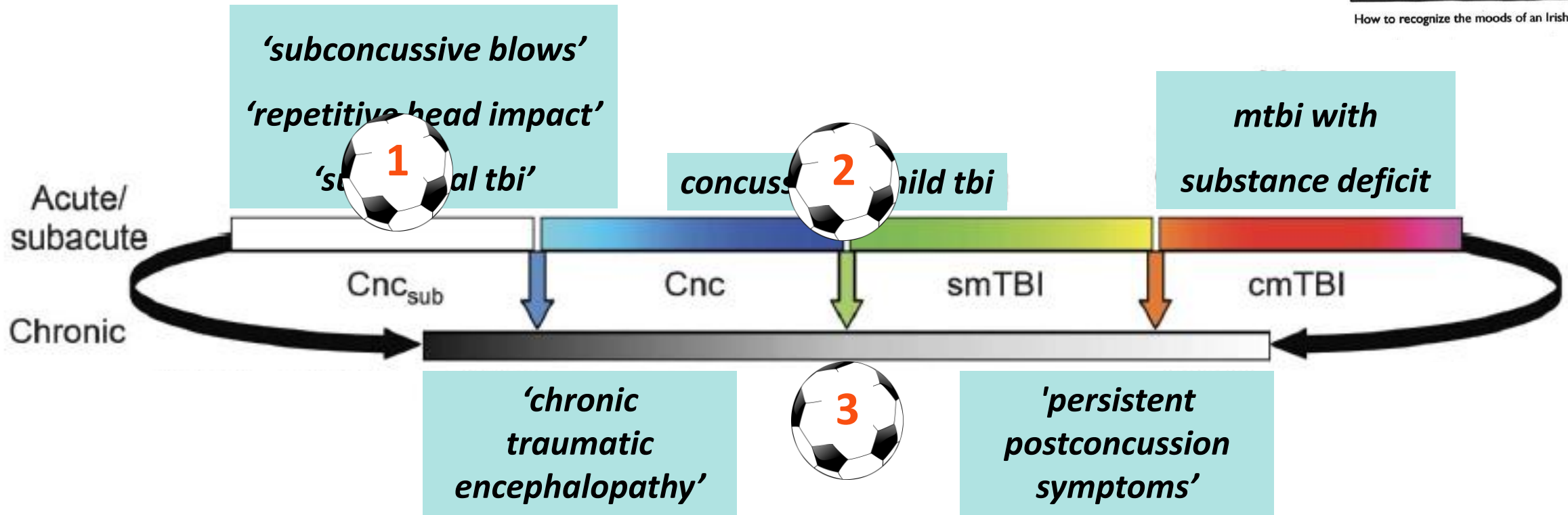


Sport associated brain damage is not a clinical entity

spectrum of mild traumatic brain injury



How to recognize the moods of an Irish setter



Definition of Sport Related Concussion

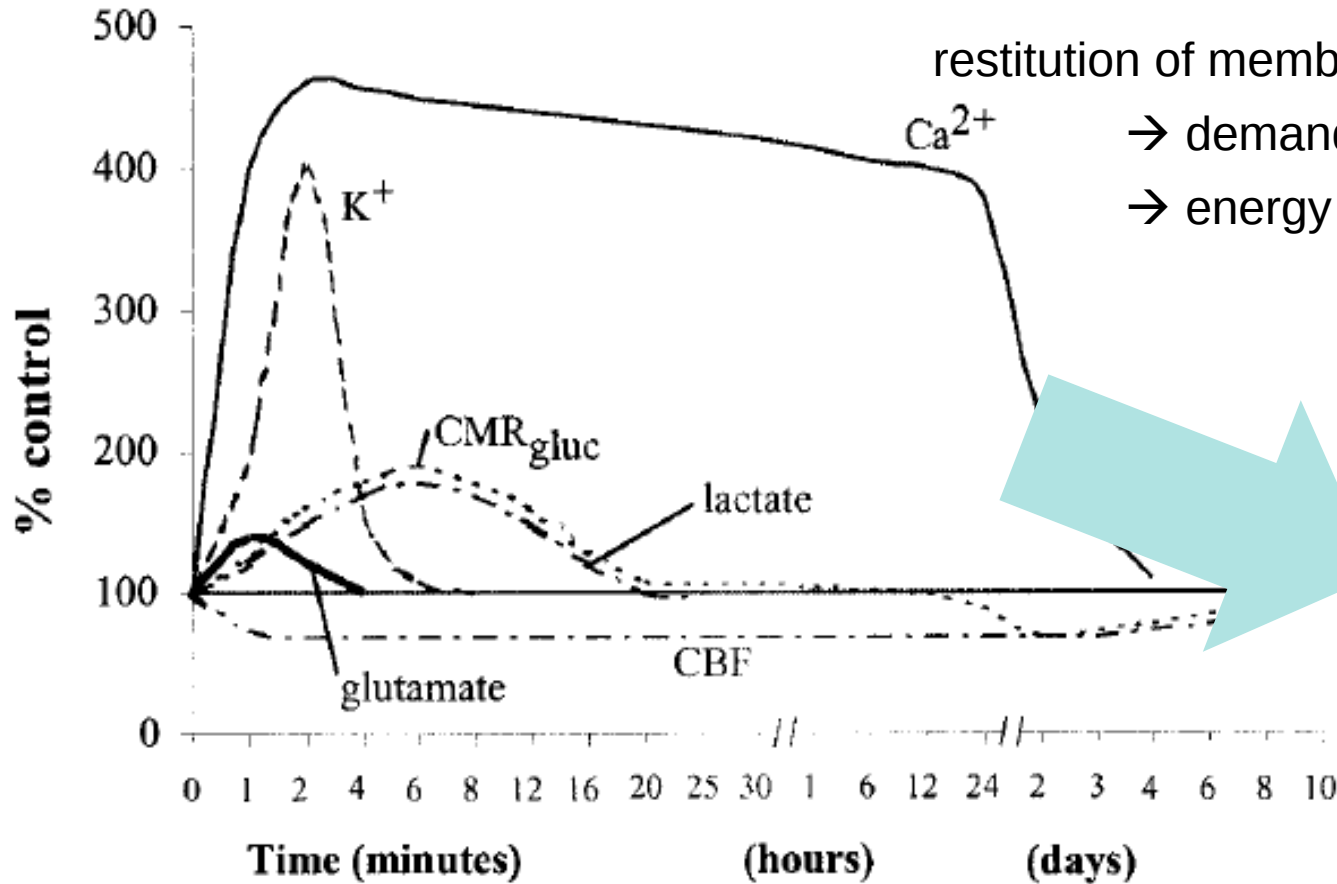
- Concussion in Sport Group -

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

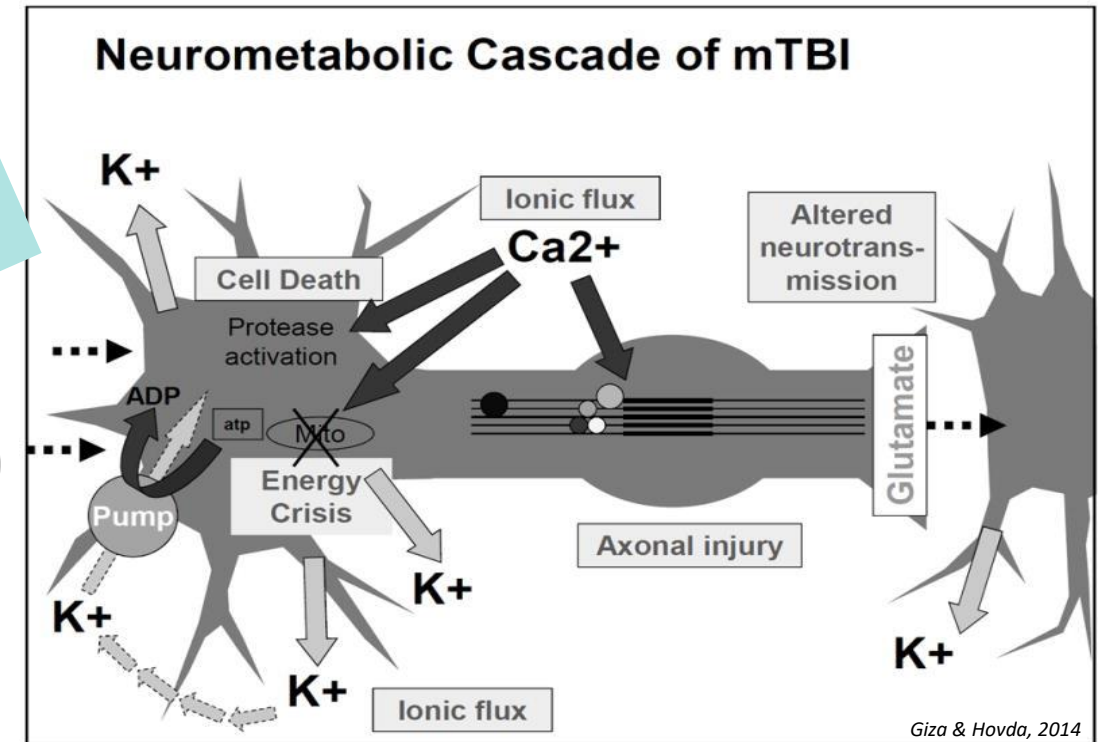
- initiation of a neurotransmitter and metabolic cascade with possible axonal injury, blood flow change and inflammation affecting the brain
- Symptoms and signs may present immediately or evolve over minutes or hours, and commonly resolve within days, but may be prolonged
- no abnormality on standard 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

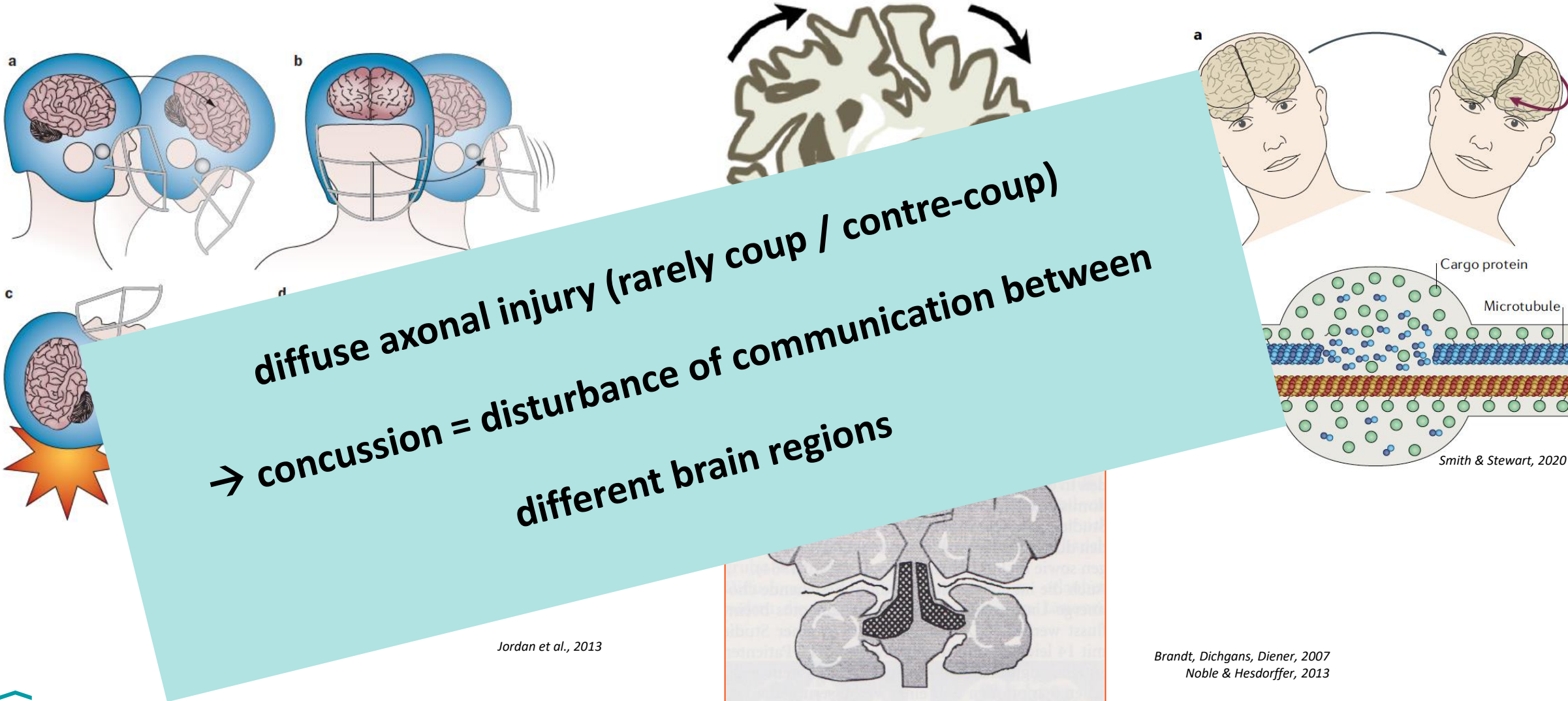


sequestration of excessive calcium in mitochondria

→ decreased oxidative capacity (days/weeks)



What happens during concussion? diffuse axonal injury



Clinical Signs / Symptoms

modifiers:

- sleep
- c-spine

ocular

vestibular

cognition

SCAT6™

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

SCOAT6™

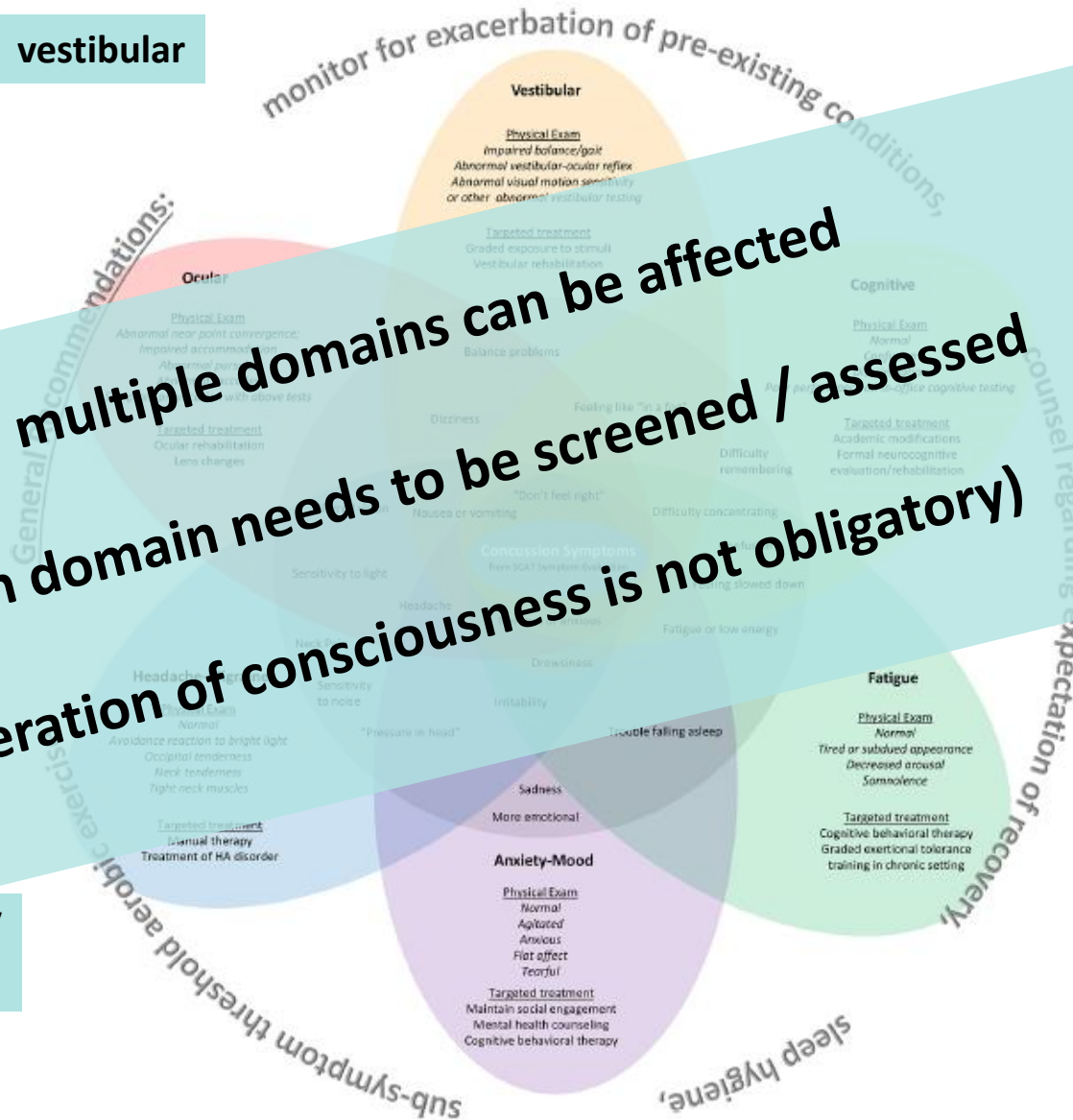
Sport Concussion Office Assessment Tool
For Adults & Adolescents (13 years +)

fatigue

headache /
migraine

anxiety /
mood

→ multiple domains can be affected
→ each domain needs to be screened / assessed
(alteration of consciousness is not obligatory)



Initial Assessment (on pitch, in the gym)



Concussion Recognition Tool 6 - CRT6™

CRT6 Concussion Recognition Tool
To Help Identify Concussion in Children, Adolescents and Adults

1: Visible Clues of Suspected Concussion
Visible clues that suggest concussion include:

- Loss of consciousness or responsiveness
- Lying motionless on the playing surface
- Falling unpredictably to the playing surface
- Disorientation or confusion, staring or limited responsiveness, or an inability to respond appropriately to questions
- Dazed, blank, or vacant look
- Seizure, fits, or convulsions
- Slow to get up after a direct or indirect hit to the head
- Unsteady on feet / balance problems or falling over / poor coordination / wobbly
- Facial injury

2: Symptoms of Suspected Concussion

Physical Symptoms	Changes in Emotions
Headache	More emotional
"Pressure in head"	More irritable
Balance problems	Sadness
Nausea or vomiting	Nervous or anxious
Drowsiness	
Dizziness	
Blurred vision	Difficulty concentrating
More sensitive to light	Difficulty remembering
More sensitive to noise	Feeling slowed down
Fatigue or low energy	Feeling like "in a fog"
"Don't feel right"	
Neck Pain	

3: Awareness
(Modify each question appropriately for each sport and age of athlete)
Failure to answer any of these questions correctly may suggest a concussion:

"Where are we today?"
"What event were you doing?"
"Who scored last in this game?"
"What team did you play last week/game?"
"Did your team win the last game?"

Any athlete with a suspected concussion should be - IMMEDIATELY REMOVED FROM PRACTICE OR PLAY and should NOT RETURN TO ANY ACTIVITY WITH RISK OF HEAD CONTACT, FALL OR COLLISION, including SPORT ACTIVITY until ASSESSED MEDICALLY, even if the symptoms resolve.

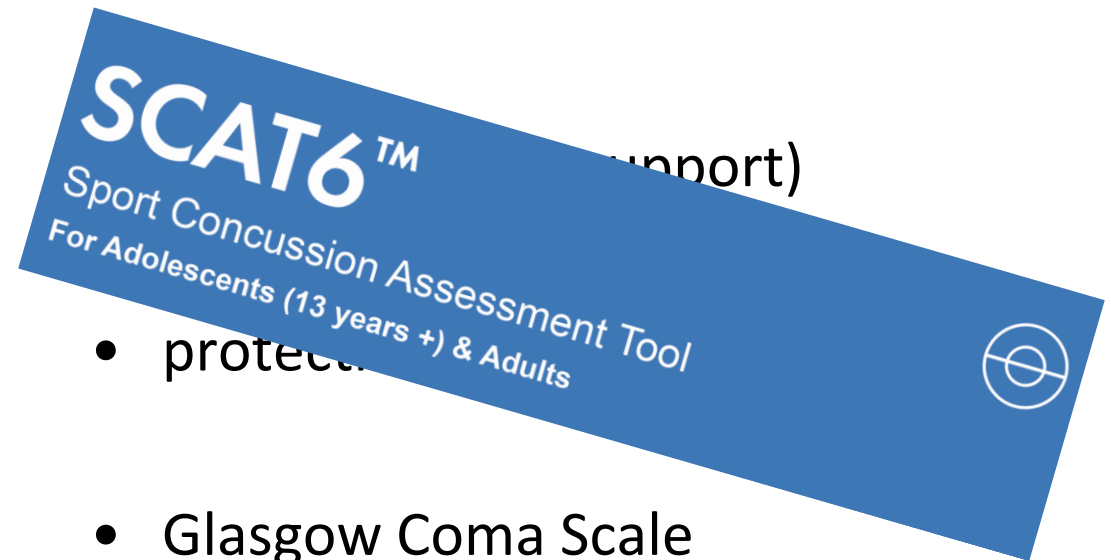
Athletes with suspected concussion should NOT:

- Be left alone initially (at least for the first 3 hours). Worsening of symptoms should lead to immediate medical attention.
- Be sent home by themselves. They need to be with a responsible adult.
- Drink alcohol, use recreational drugs or drugs not prescribed by their HCP
- Drive a motor vehicle until cleared to do so by a healthcare professional

? continue to play

? substitution & outpatient care

? substitution & inpatient care



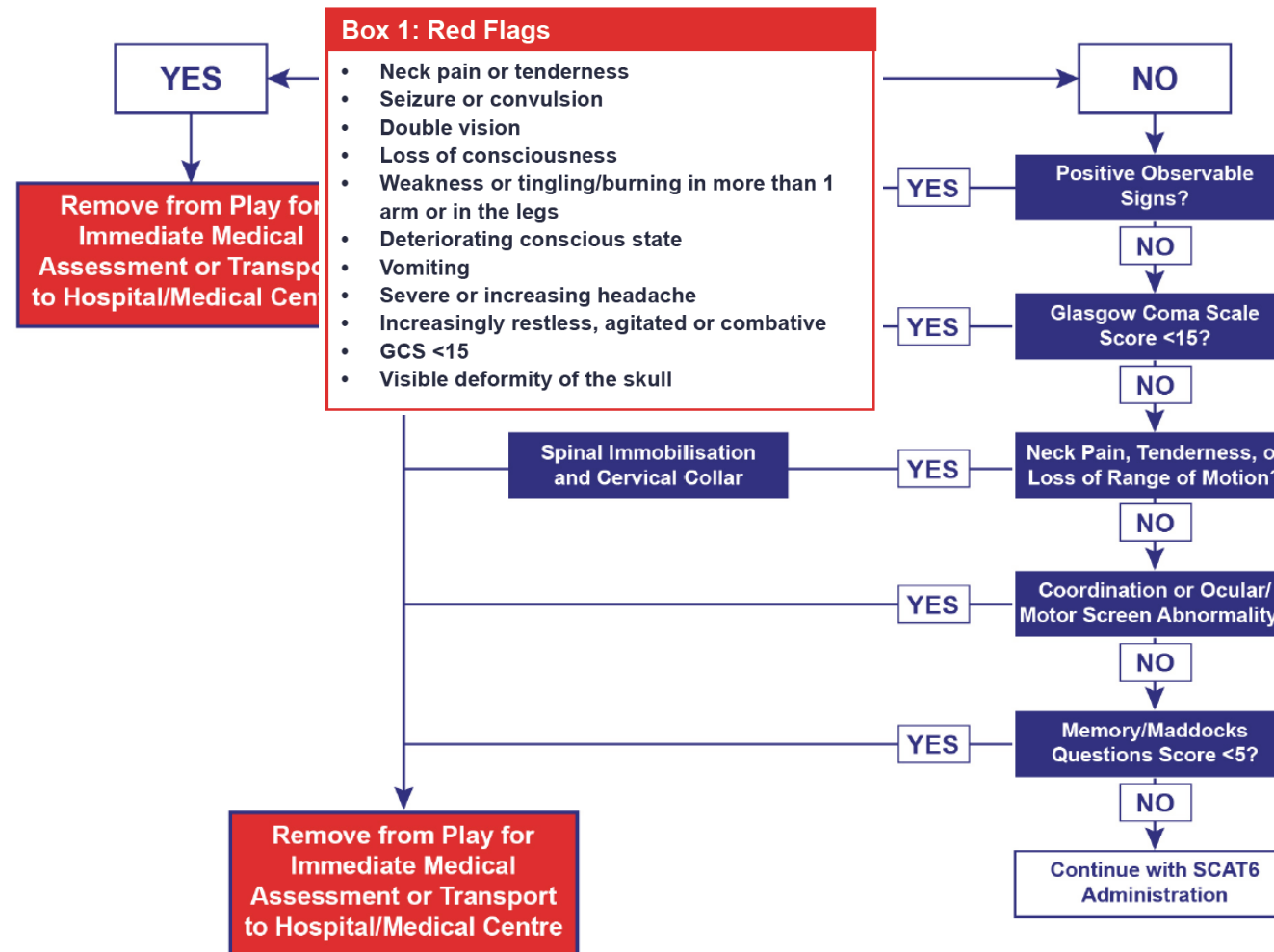
- protect
- Glasgow Coma Scale
- neurological assessment
- ...

! screening ≠ diagnosing !





Immediate Assessment/Neuro Screen



How to Diagnose a Concussion

SCHRITT 2: SYMPTOM BEURTEILUNG

Dem Sportler sollte der Symptombogen gegeben werden mit der Aufforderung, diesen Instruktionssatz laut vorzulesen und danach die Symptomskala zu beurteilen. Bei einer Basisuntersuchung sollte der Sportler seine Symptome danach bewerten, wie er sich psychisch fühlt. Bei einer Untersuchung nach einer Verletzung sollte der Sportler seine Symptome zu diesem Zeitpunkt bewerten.

Bitte ankreuzen: ☐ Basistestung ☐ nach Verletzung

Bitte geben Sie das Formular dem Sportler

	kein	leicht	mäßig	stark			
Kopfschmerzen	0	1	2	3	4	5	6
„Druck 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
Verschwommenes Sehen	0	1	2	3	4	5	6
Gleichgewichtsprobleme	0	1	2	3	4	5	6
Lichtempfindlichkeit	0	1	2	3	4	5	6
Geräuschempfindlichkeit	0	1	2	3	4	5	6
Gefühl „verlangert“ / langsam zu sein	0	1	2	3	4	5	6
Gefühl „wie in Wolken“ / „zuckelt“ zu sein	0	1	2	3	4	5	6
„Zinsen strecken nicht mehr“	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
Ermüdung, Müdigkeit oder wenig Energie	0	1	2	3	4	5	6
Verwirrtheit	0	1	2	3	4	5	6
Schläfrigkeit	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 einzuschlafen (wenn zutreffend)	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**

All 3 trials must be administered. Months in Reverse Order:

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		3-2-7-9	4-9-6-8	3-4-8-1	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, the patient should not proceed to the next step.

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.

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





SCOA6™

Sport Concussion Office Assessment Tool

For Adults & Adolescents (13 years +)



SCAT6™

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



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							
Symptoms¹	Midline Tenderne	Normal	Modified Vestibular/Ocular-Motor Screening (mVOMS) for Concussion						
- Dizziness or light-he - Fainting - Blurred or fading vis - Nausea - Fatigue - Lack of concentratio	Paravertebral Ter	Notes:	For detailed instructions please see the Supplement.						
Results	Flexion (50-70°)	Other Neurological	mVOMS	Not Tested	Headache	Dizziness	Nausea	Fogginess	Comments
	Extension (60-85°)	Limb Tone:	Baseline symptoms	N/A					
	Right Lateral Flex	Strength:	Smooth pursuits (2 horizontal and 2 vertical, 2 seconds to go full distance right-left and back; up-down and back)						
	Left Lateral Flexi	Deep Tendon Reflexes:	Saccades – Horizontal (10 times each direction)						
	Right Rotation (60°)	Sensation:	VOR – Horizontal (10 repetitions) (metronome set at 180 beats per minute – change direction at each beep, wait 10 secs to ask symptoms)						
	Left Rotation (60°)	Cerebellar Function:	VMS (x 5, 80° rotation side to side) (at 50 bpm, change direction each beep, wait 10 secs to ask symptoms)						
		Comments:							



SCOAT6™

Sport Concussion Office Assessment Tool

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SCAT6™

Sport Concussion Assessment Tool

For Adolescents (13 years +) & Adults



Completion Guide

Blue: Complete only at first assessment

Green: Recommended part of assessment

Orange: Optional part of assessment



Anxiety Screen

Not Done ☐

Assign score
days,” and “

Depression Screen

Over the
bother

1. Feeling r

2. Not being

3. Worrying

4. Trouble r

5. Being so

6. Becomin

7. Feeling a

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

Not Done ☐

Sleep Screen

Over the la
bothered

1. Little intere

2. Feeling dov

Not Done ☐

Computerised Cognitive Test Results (if used)

5 to 6 hour

6 to 7 hour

7 to 8 hour

8 to 9 hour

More than 9

Not Done ☐

Test Battery Used:

Recent Baseline - if per

Post-Injury Result (Res

Post-Injury Result (Pos

1. Little intere

2. Feeling dov

Depression Sc

Anxiety Screen Score:

Graded Aerobic Exercise Test

1. Little intere

2. Feeling dov

Depression Sc

Anxiety Screen Score:

Not Done ☐

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

Protocol Used:

1. Little intere

2. Feeling dov

Depression Sc

Anxiety Screen Score:

Not Done ☐

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

Protocol Used:

1. Little intere

2. Feeling dov

Depression Sc

Anxiety Screen Score:

Not Done ☐

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

Protocol Used:

Very dissatisfied	
Somewhat dissatisfied	
Somewhat satisfied	
Satisfied	
Very satisfied	

2. How satisfied/diss

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



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



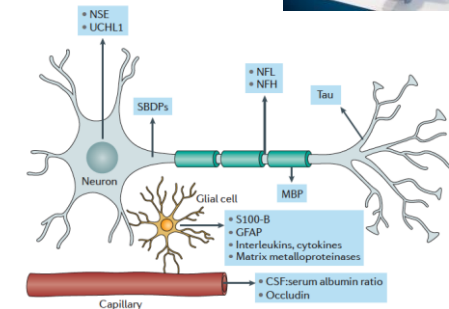
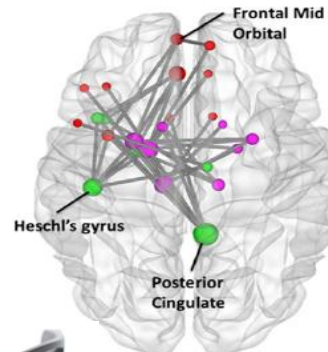
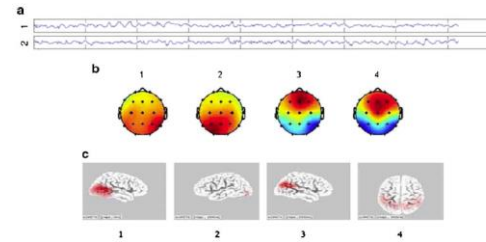
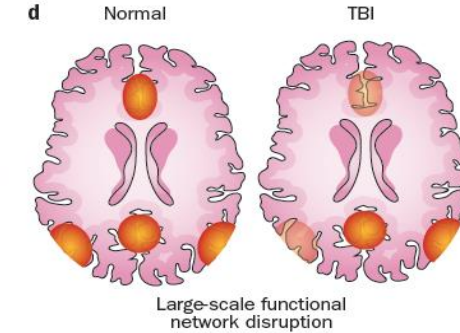
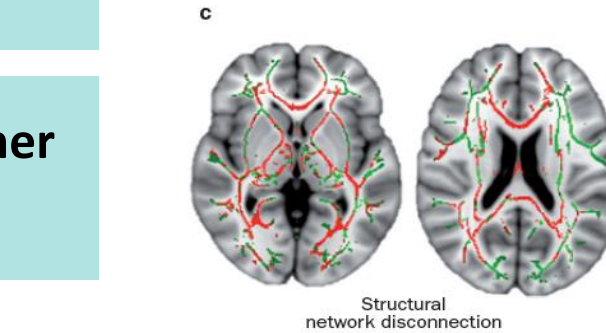
The Quest for Biomarkers

→ concussion is a clinical diagnosis

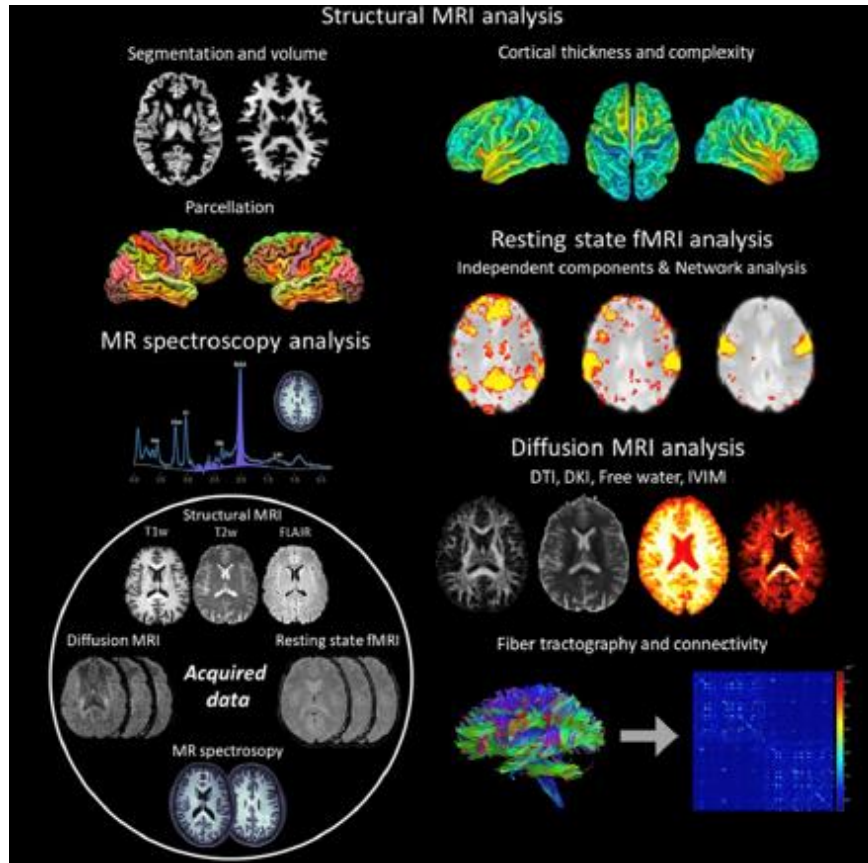
→ workup may be needed to assess for higher degree tbi or other pathology



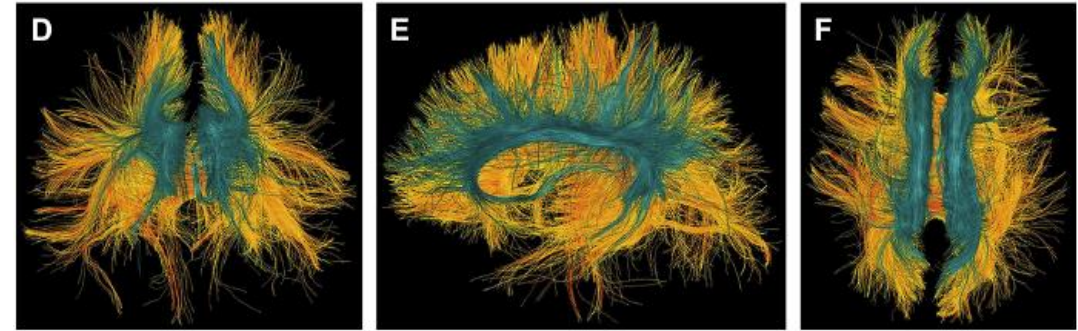
"He's clear, coach!"



Neuroimaging



Koerte et al., 2021



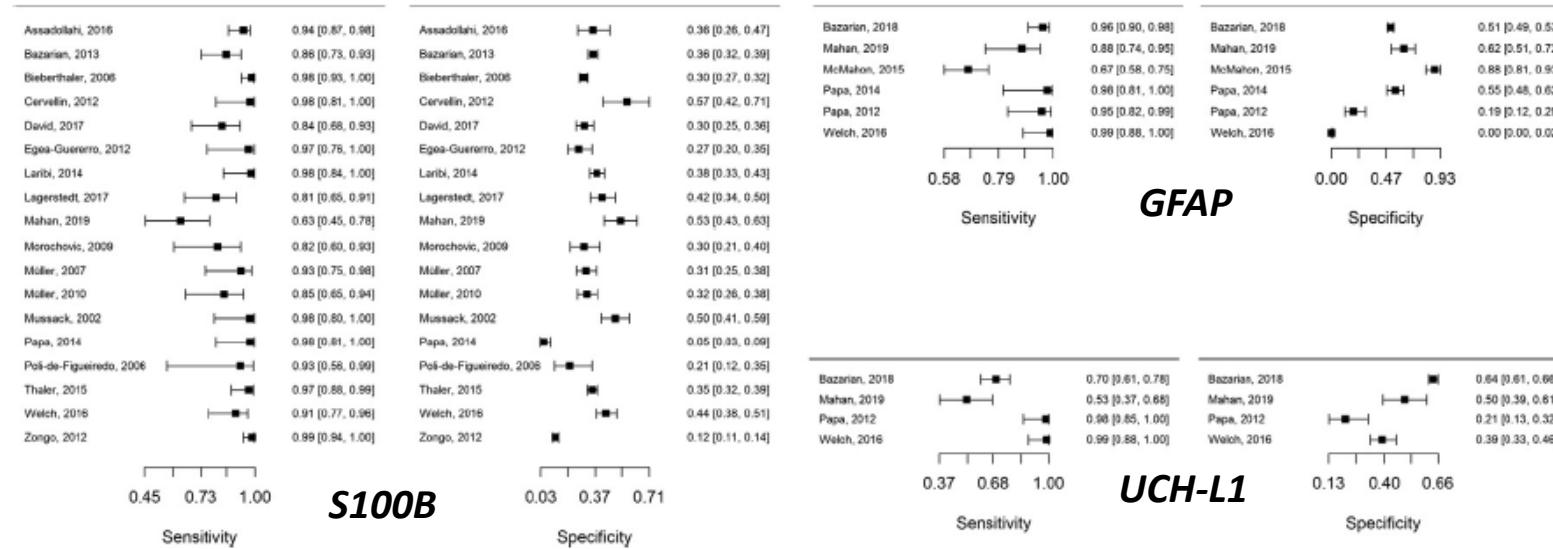
Guenette et al., 2017

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

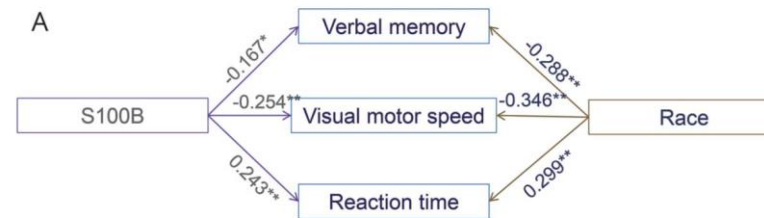
→ ***not (yet) ready for clinical use to dx concussion !***

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

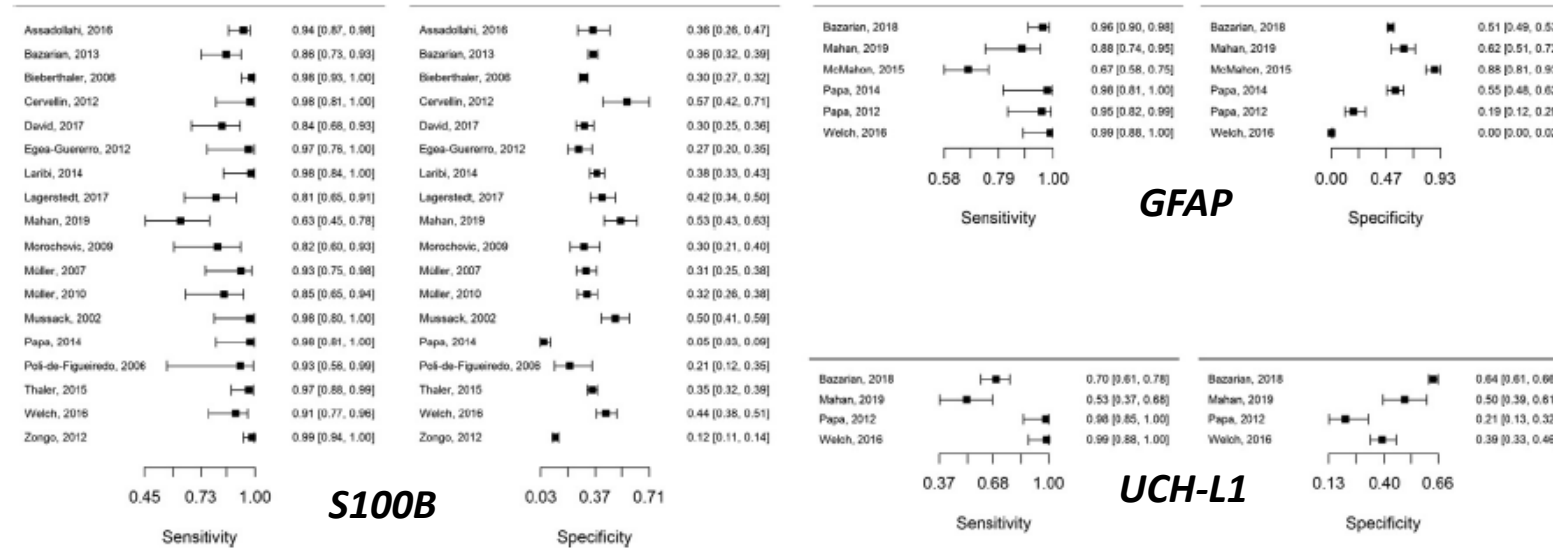
Serological Biomarkers



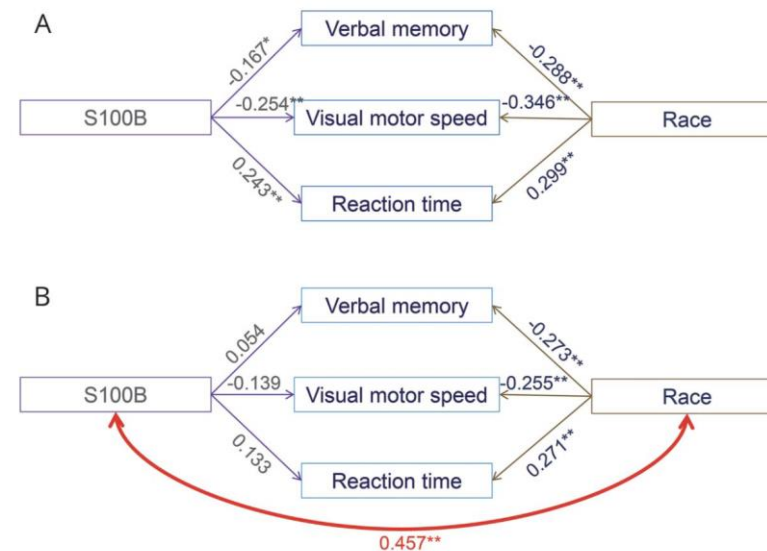
Rogan et al., 2022



Serological Biomarkers



Rogan et al., 2022



Asken et al., 2018



Guidelines

1.) concussion diagnosed / suspected:

→ no return to play/practice
on the same day

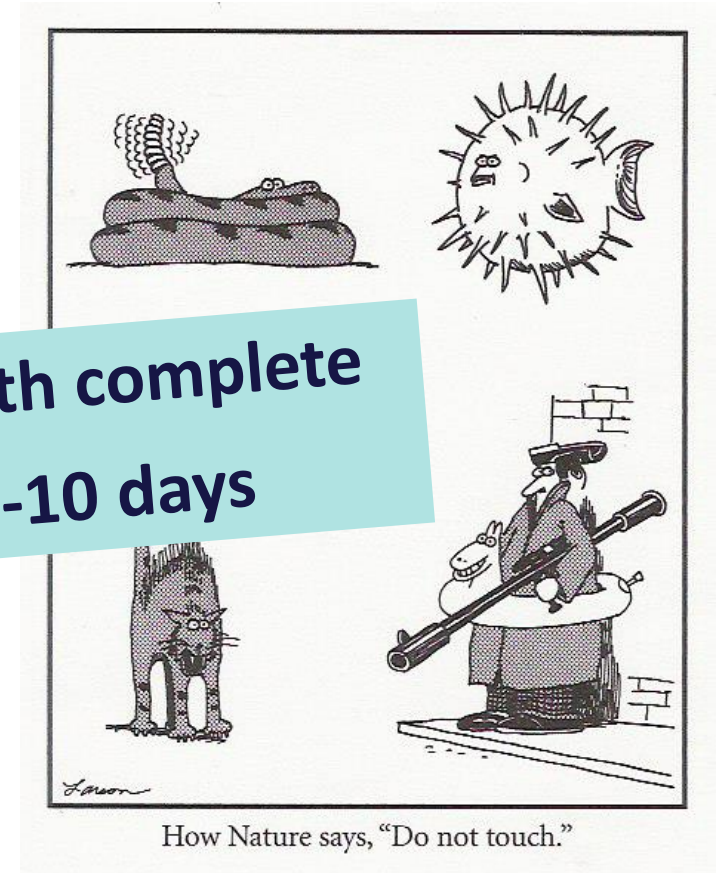
2.) after

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

stepwise return to play / practice

SPORTS CONCUSSION

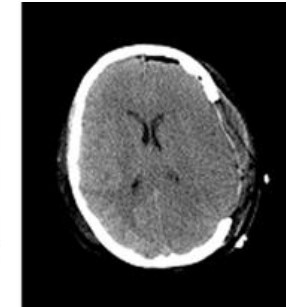
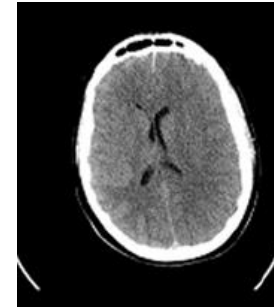
When in Doubt—Sit it Out!



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) if no more than mild symptoms.	Return to aerobic exercise
3	Individual sport-specific exercises Note: If sport-specific exercises are not tolerated, return to step 2.	Individual sport-specific exercises (eg, passing drills, multiplayer training) away from the team environment. No activities at risk of head impact.	Add movement, change of direction and/or individual skills
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!

Table 1 Return-to-learn (RTL) strategy

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 5–15 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 in 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



Treatment / Rehabilitation

BRAIN INJURY
2020, VOL. 34, NO. 9, 1139–1149
<https://doi.org/10.1080/02699052.2020.1797168>



**Treatment outcomes in m
randomized controlled t**

M Arbabi^{a,b}, RJG Sheldon^{c,d,e,f}

JAMA
Network | **Open**

Original Investigation | Neurology

**Nonpharmacological Treatment of Persistent Post-
Traumatic Stress Disorder: A Systematic Review and Meta-analysis and**

Hana Malá Rytter, PhD; Heidi J. Graff, PhD; Henriette K
Erhard Trillingsgaard Næss, PhD; Bente

Aerobic Exercise for Sport A Systematic Review

PIERRE

BRAIN INJURY
2020, VOL. 34, NO. 2, 149–159
<https://doi.org/10.1080/02699052.2019.1683892>



**Cognitive and neural effects of exercise following traumatic brain injury: A
systematic review of randomized and controlled clinical trials**

Bhanu Sharma^a, David Allison^a, Patricia Tucker^b, Donald Mabbott^c, and Brian W. Timmons^a



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	7.00			
Micay 2018	8.14	10.93						
Rytter 2019								

Exercise is Medicine for Concussion

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

Favours Control Favours Intervention
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 Toomey,³ 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 Samuels ¹³

Tool Box for Athletes:

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

Therapeutic principles of Concussion

Systematic review

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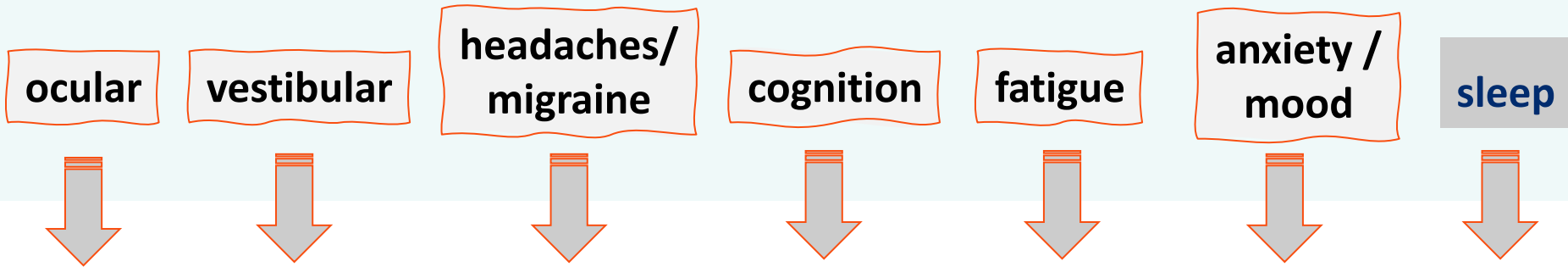
Conclusion Early PA, prescribed aerobic exercise and reduced screen time are beneficial following SRC. Strict physical rest until symptom resolution is not effective, and sleep disturbance impairs recovery after SRC.

- 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

Assessment of affected clinical domains

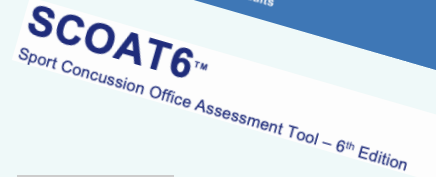


need for further diagnostic work-up?

Concussion Therapy is Teamwork!

symptom-specific pharmacological and/or non-pharmacological therapy

Individualize return-to protocol according to affected clinical domain



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 with traumatic etiology	Signs and symptoms of persistent postconcussion syndrome
Trauma	History of head trauma	History of head injury		
Loss of consciousness (LOC)	"Usually"			
Assessment		Psychologic testing	Neurologic exam	"Impairment of neurologic functioning"
Maximum symptom duration for a diagnosis of trauma		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

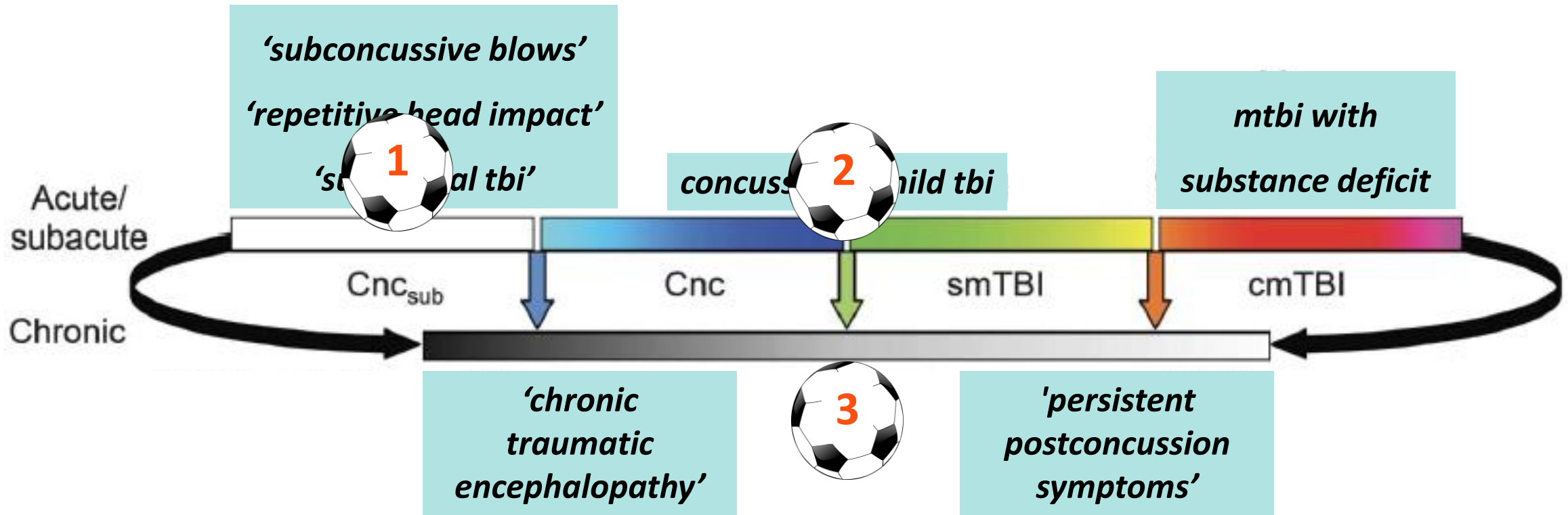
⇒ Continuing to play and delayed access to healthcare providers (HCPs) after SRC are associated with longer recovery after SRC.

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

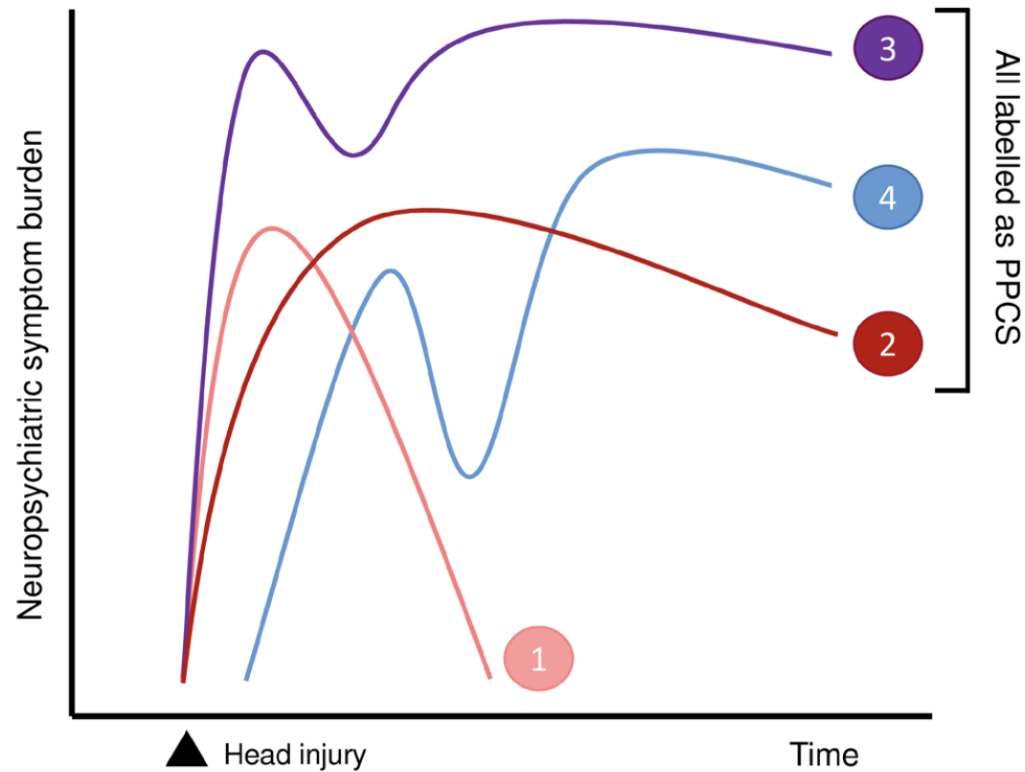
Dwyer and Katz, 2018

Sport associated brain damage is not a clinical entity

spectrum of mild traumatic brain injury



Persistent Postconcussion Symptoms



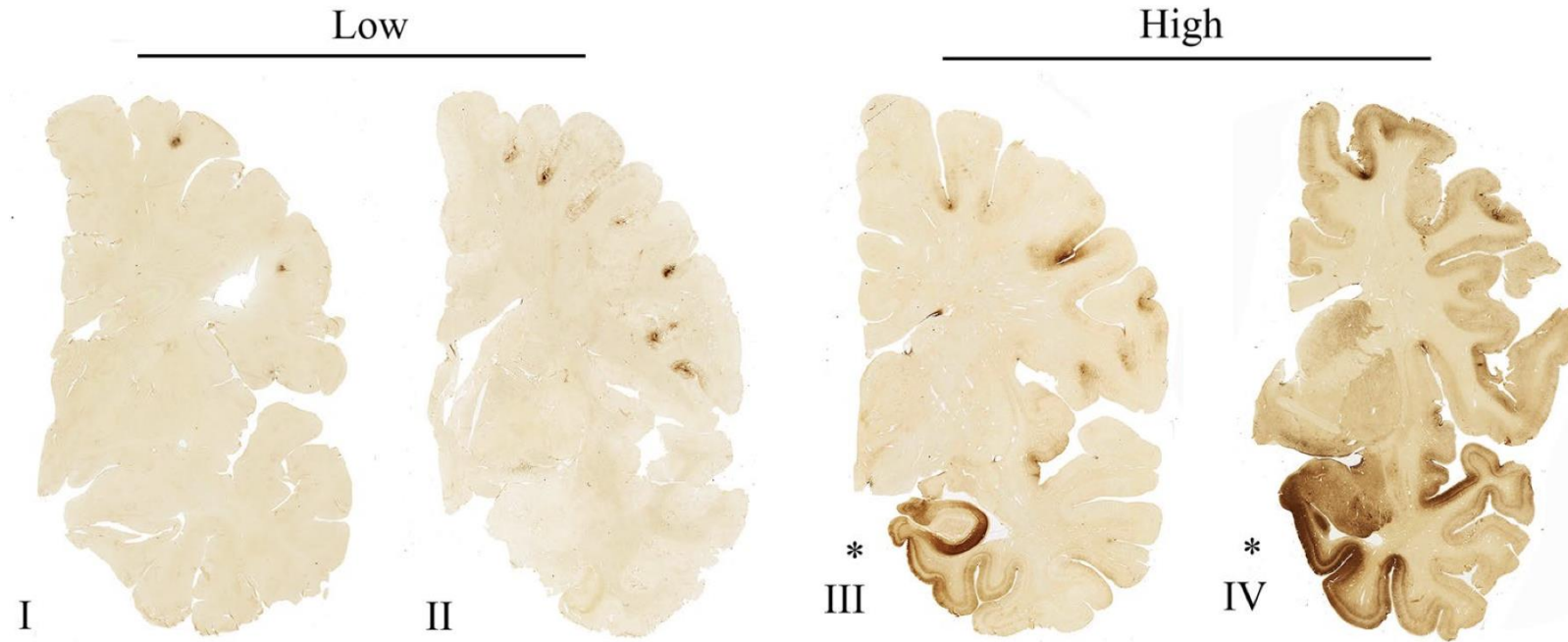
Clinical factors favoring FND (rightward shift on spectrum):

- 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

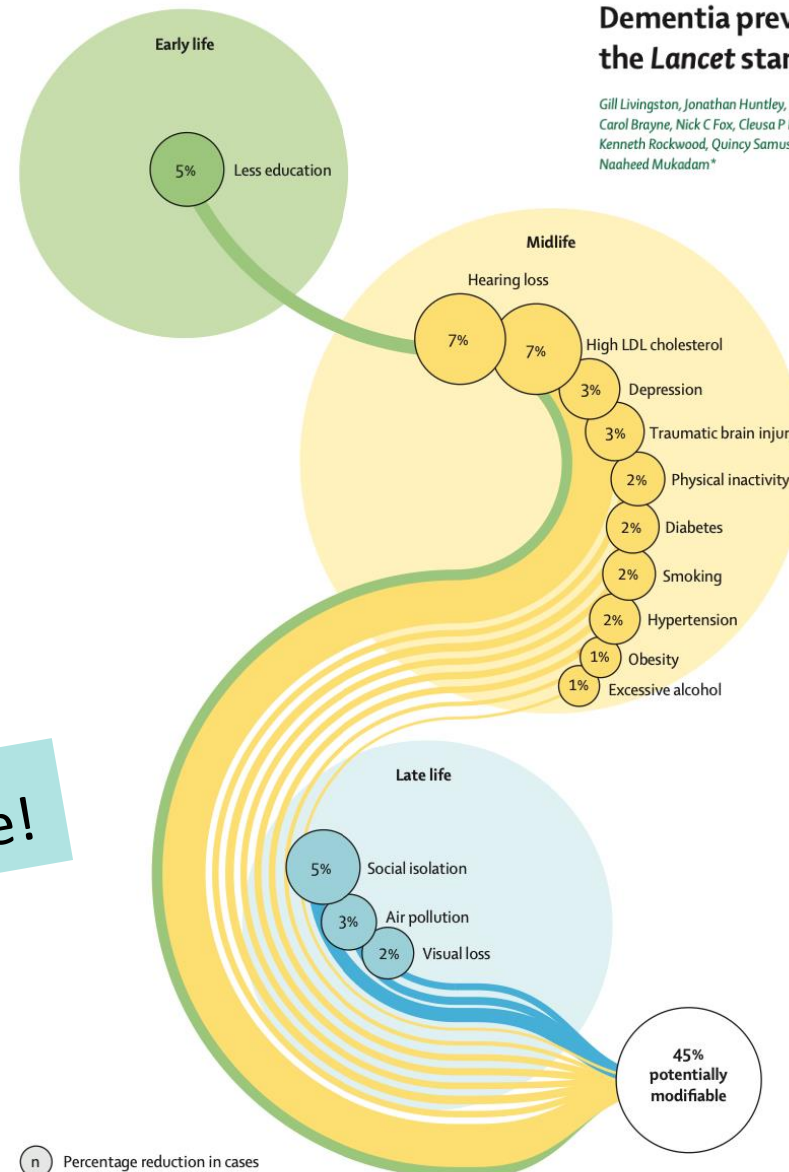
Dementia prevention, intervention, and care: 2024 report of the *Lancet* standing Commission

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 Kivimäki, Eric B Larson, Noeline Nakasujja, Kenneth Rockwood, Quincy Samus, Kokoro Shirai, Archana Singh-Manoux, Lon S Schneider, Sebastian Walsh, Yao Yao, Andrew Sommerlad*, Naaheed Mukadam*

Lancet 2024; 404: 572-628

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

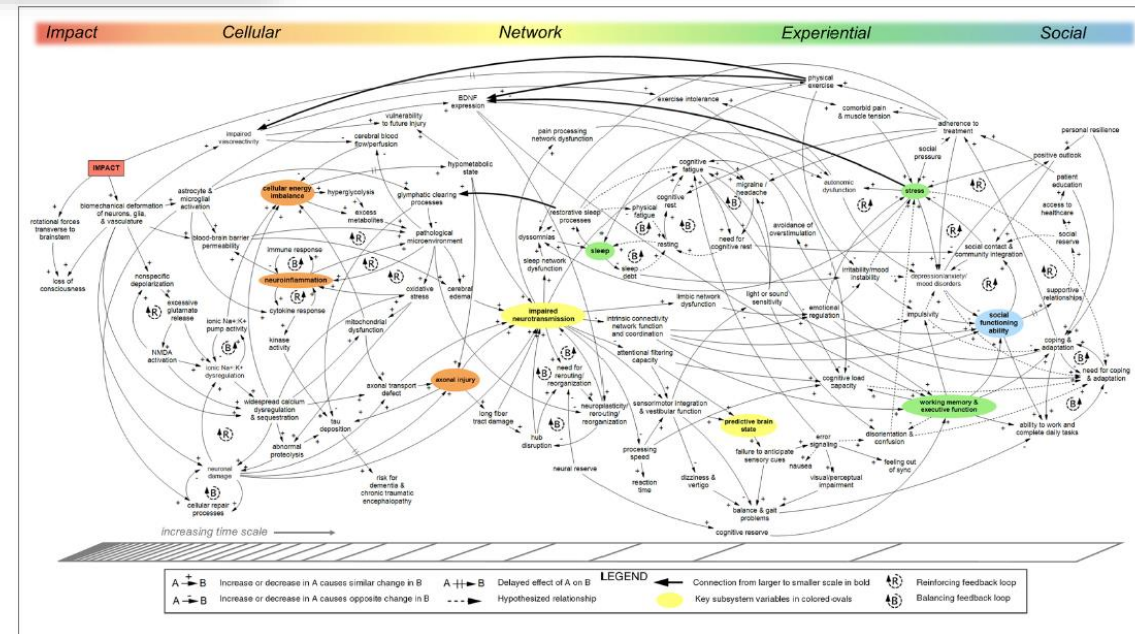
early specialized care improves outcome!



n Percentage reduction in cases of dementia if this risk factor is eliminated



MGB Sport Concussion - Multidisciplinary Clinics





Mass General Brigham

Mass General Brigham

Sports Neurology & Neurosciences

concussion care and beyond

Claus Reinsberger, M.D., Ph.D.

Chief, Division of Sports Neurology and Neurosciences, Mass General Brigham

Co-Director, Mass General Brigham Sport Concussion Program

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.

