Neuropsychological Perspectives on Concussion Management

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Disclosures

- No Disclosures

Objectives

1. Overview of the basics of Sports Related Concussion (SRC)
2. Understand how and when to refer for neuropsychological assessment after Sports Related Concussion (SRC)
3. Review of latest updates from Berlin Consensus Guidelines (2017)
4. Do's and Don'ts for clinical practice
5. Resources for providers and patients on concussion and CTE

"Sports related concussion (SRC): TBI induced by biomechanical forces; several common features

- *May be caused **either by direct blow** to head, face, neck **or elsewhere on body with impulsive force transmitted** to head*
- *Typically results in **rapid onset** of neurological impairment, but **can evolve over minutes to hours***
- *May result in neuropathological changes, but acute signs/symptoms reflect **functional disturbance rather than structural injury** and therefore no abnormal findings on imaging*
- ***May or may not involve LOC**; resolution follows sequential course; in some cases symptoms are prolonged"*

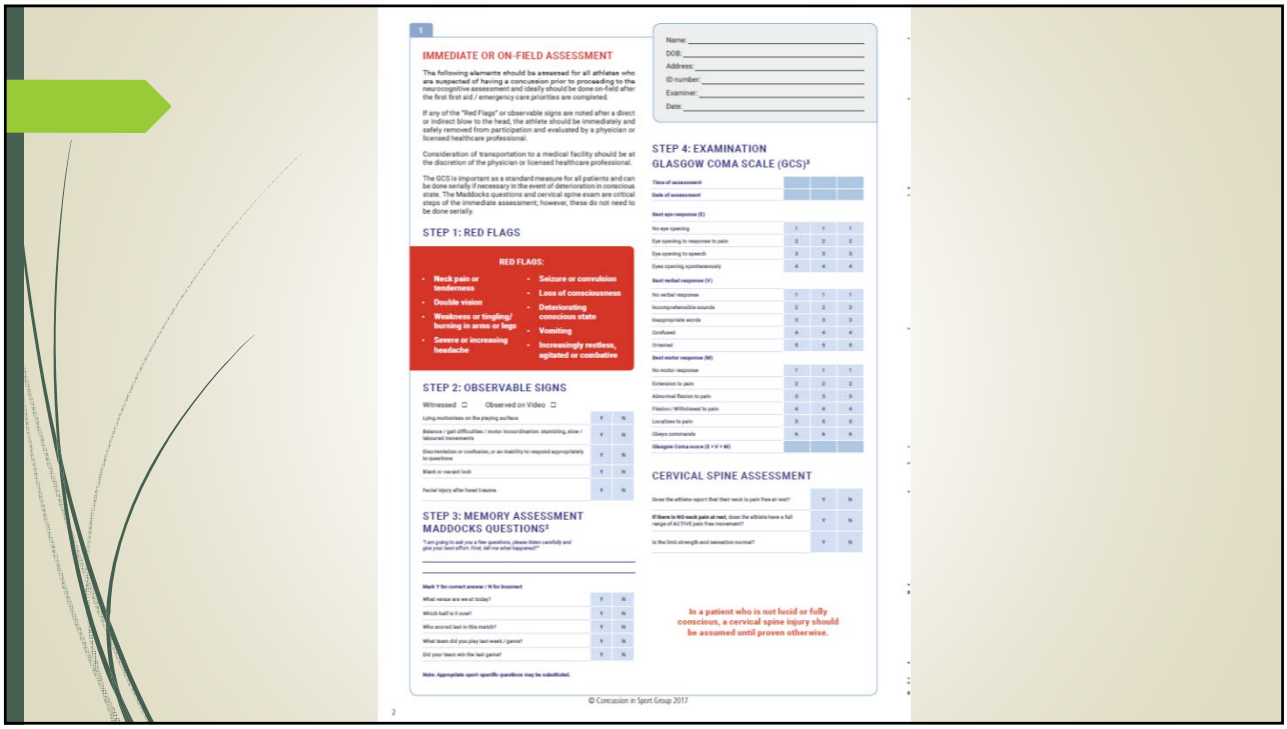
Per: Consensus Statement on Concussion in Sport – 5th Intl. Conference (Berlin, 10/16; pub 4/28/17 in BJSM)

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

- **Symptoms: somatic** (e.g., headache), **cognitive** (e.g., feeling like in a fog) and/or **emotional symptoms** (e.g., lability)
- **Physical signs** (e.g., loss of consciousness, amnesia, neurological deficit)
- **Balance impairment** (e.g., gait unsteadiness)
- **Behavioural changes** (e.g., irritability)
- **Cognitive impairment** (e.g., slowed reaction times)
- **Sleep/wake disturbance** (e.g., somnolence, drowsiness)"

Diagnosis of sports concussion acutely

- *"SCAT5 currently represents the most well-established and rigorously developed instrument available for sideline assessment. There is published support for using the SCAT and Child SCAT in the evaluation of SRC. The SCAT is useful immediately after injury in differentiating concussed from non-concussed athletes, but its utility appears to decrease significantly 3–5 days after injury. The symptom checklist, however, does demonstrate clinical utility in tracking recovery. "*
- *"Baseline testing may be useful, but is not necessary for interpreting post-injury scores. If used, clinicians must strive to replicate baseline testing conditions. Additional domains that may add to the clinical utility of the SCAT tool include clinical reaction time, gait/balance assessment, video-observable signs and oculomotor screening."*



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IMMEDIATE OR ON-FIELD ASSESSMENT

The following elements should be assessed for all athletes who are suspected of having a concussion prior to proceeding to the neurocognitive assessment and ideally should be done on-field after the first first aid / emergency care priorities are completed.

If any of the "Red Flags" or observable signs are noted after a direct or indirect blow to the head, the athlete should be immediately and safely removed from participation and evaluated by a physician or licensed healthcare professional.

Consideration of transportation to a medical facility should be at the discretion of the physician or licensed healthcare professional.

The GCS is important as a standard measure for all patients and can be done serially if necessary in the event of deterioration in conscious state. The Maddocks questions and cervical spine exam are critical steps of the immediate assessment; however, these do not need to be done serially.

STEP 1: RED FLAGS

RED FLAGS:

- Neck pain or tenderness
- Double vision
- Weakness or tingling/ burning in arms or legs
- Severe or increasing headache
- Seizure or convulsion
- Loss of consciousness
- Deteriorating conscious state
- Vomiting
- Increasingly restless, agitated or combative

STEP 2: OBSERVABLE SIGNS

Witnessed ☐ Observed on Video ☐

Lying motionless on the playing surface	Y	N
Balance / gait difficulties / motor incoordination: stumbling, slow / laboured movements	Y	N
Disorientation or confusion, or an inability to respond appropriately to questions	Y	N
Blank or vacant look	Y	N
Facial injury after head trauma	Y	N

STEP 3: MEMORY ASSESSMENT MADDOCKS QUESTIONS²

"I am going to ask you a few questions, please listen carefully and give your best effort. First, tell me what happened?"

_____

_____

Mark Y for correct answer / N for incorrect

What venue are we at today?	Y	N
Which half is it now?	Y	N
Who scored last in this match?	Y	N
What team did you play last week / game?	Y	N
Did your team win the last game?	Y	N

Note: Appropriate sport-specific questions may be substituted.

Name: _____

DOB: _____

Address: _____

ID number: _____

Examiner: _____

Date: _____

STEP 4: EXAMINATION GLASGOW COMA SCALE (GCS)³

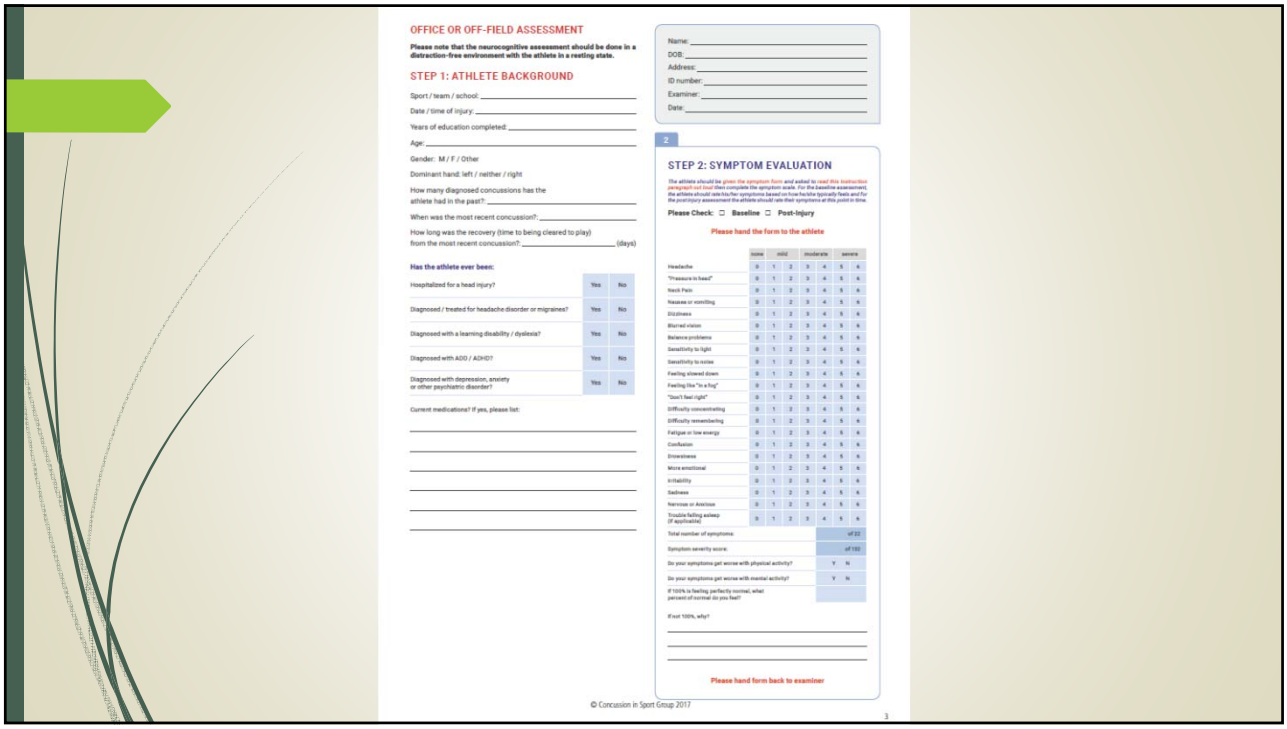
Time of assessment			
Date of assessment			
Best eye response (E)			
No eye opening	1	1	1
Eye opening in response to pain	2	2	2
Eye opening to speech	3	3	3
Eyes opening spontaneously	4	4	4
Best verbal response (V)			
No verbal response	1	1	1
Incomprehensible sounds	2	2	2
Inappropriate words	3	3	3
Confused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

CERVICAL SPINE ASSESSMENT

Does the athlete report that their neck is pain free at rest?	Y	N
If there is NO neck pain at rest, does the athlete have a full range of ACTIVE pain free movement?	Y	N
Is the limb strength and sensation normal?	Y	N

In a patient who is not lucid or fully conscious, a cervical spine injury should be assumed until proven otherwise.

2



OFFICE OR OFF-FIELD ASSESSMENT

Please note that the neurocognitive assessment should be done in a distraction-free environment with the athlete in a resting state.

STEP 1: ATHLETE BACKGROUND

Sport / team / school: _____

Date / time of injury: _____

Years of education completed: _____

Age: _____

Gender: M / F / Other

Dominant hand: left / neither / right

How many diagnosed concussions has the athlete had in the past?: _____

When was the most recent concussion?: _____

How long was the recovery (time to being cleared to play) from the most recent concussion?: _____ (days)

Has the athlete ever been:

Hospitalized for a head injury?	Yes	No
Diagnosed / treated for headache disorder or migraines?	Yes	No
Diagnosed with a learning disability / dyslexia?	Yes	No
Diagnosed with ADD / ADHD?	Yes	No
Diagnosed with depression, anxiety or other psychiatric disorder?	Yes	No

Current medications? If yes, please list:

_____

_____

_____

_____

_____

_____

Name: _____

DOB: _____

Address: _____

ID number: _____

Examiner: _____

Date: _____

2

STEP 2: SYMPTOM EVALUATION

The athlete should be given the symptom form and asked to read this instruction paragraph out loud then complete the symptom scale. For the baseline assessment, the athlete should rate his/her symptoms based on how he/she typically feels and for the post-injury assessment the athlete should rate their symptoms at this point in time.

Please Check: ☐ **Baseline** ☐ **Post-injury**

Please hand the form to the athlete

	none	mild		moderate		severe
Headache	0	1	2	3	4	5	6
"Pressure in head"	0	1	2	3	4	5	6
Neck Pain	0	1	2	3	4	5	6
Nausea or vomiting	0	1	2	3	4	5	6
Dizziness	0	1	2	3	4	5	6
Blurred vision	0	1	2	3	4	5	6
Balance problems	0	1	2	3	4	5	6
Sensitivity to light	0	1	2	3	4	5	6
Sensitivity to noise	0	1	2	3	4	5	6
Feeling slowed down	0	1	2	3	4	5	6
Feeling like "in a fog"	0	1	2	3	4	5	6
"Don't feel right"	0	1	2	3	4	5	6
Difficulty concentrating	0	1	2	3	4	5	6
Difficulty remembering	0	1	2	3	4	5	6
Fatigue or low energy	0	1	2	3	4	5	6
Confusion	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
More emotional	0	1	2	3	4	5	6
Irritability	0	1	2	3	4	5	6
Sadness	0	1	2	3	4	5	6
Nervous or Anxious	0	1	2	3	4	5	6
Trouble falling asleep (if applicable)	0	1	2	3	4	5	6
Total number of symptoms:							of 22
Symptom severity score:							of 132
Do your symptoms get worse with physical activity?						Y	N
Do your symptoms get worse with mental activity?						Y	N
If 100% is feeling perfectly normal, what percent of normal do you feel?							

If not 100%, why?

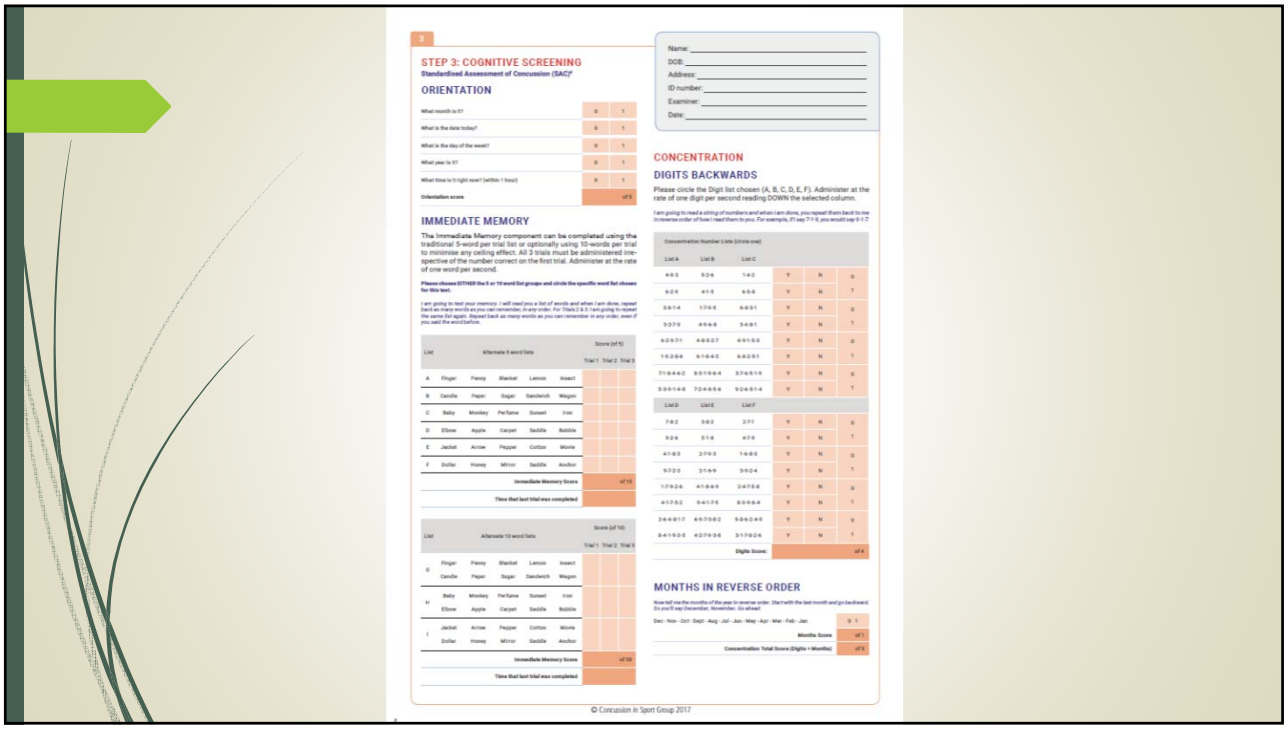
_____

_____

_____

Please hand form back to examiner

3



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STEP 3: COGNITIVE SCREENING

Standardised Assessment of Concussion (SAC)*

ORIENTATION

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

IMMEDIATE MEMORY

The Immediate Memory component can be completed using the traditional 5-word per trial list or optionally using 10-words per trial to minimise any ceiling effect. All 3 trials must be administered irrespective of the number correct on the first trial. Administer at the rate of one word per second.

Please choose SIX5WORD the 5 or 10 word list groups and circle the specific word list chosen for this test.

I am going to test your memory. I will read you a list of words and when I am done, repeat back as many words as you can remember, in any order. For Trials 2 & 3 I am going to repeat the same list again. Repeat back as many words as you can remember in any order, even if you said the word before.

List	Alternate 5 word lists					Score (of 5) Trial 1	Trial 2	Trial 3
A	Finger	Penny	Blanket	Lemon	Insect			
B	Candle	Paper	Sugar	Sandwich	Wagon			
C	Baby	Monkey	Perfume	Sunset	Iron			
D	Elbow	Apple	Carpet	Saddle	Bubble			
E	Jacket	Arrow	Pepper	Cotton	Movie			
F	Dollar	Honey	Mirror	Saddle	Anchor			
					Immediate Memory Score			of 15
					Time that last trial was completed			

List	Alternate 10 word lists					Score (of 10) Trial 1	Trial 2	Trial 3
G	Finger	Penny	Blanket	Lemon	Insect			
	Candle	Paper	Sugar	Sandwich	Wagon			
H	Baby	Monkey	Perfume	Sunset	Iron			
	Elbow	Apple	Carpet	Saddle	Bubble			
I	Jacket	Arrow	Pepper	Cotton	Movie			
	Dollar	Honey	Mirror	Saddle	Anchor			
					Immediate Memory Score			of 30
					Time that last trial was completed			

Name: _____
DOB: _____
Address: _____
ID number: _____
Examiner: _____
Date: _____

CONCENTRATION

DIGITS BACKWARDS

Please circle the Digit list chosen (A, B, C, D, E, F). Administer at the rate of one digit per second reading DOWN the selected column.

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

Concentration Number Lists (circle one)

List A	List B	List C			
4-9-3	5-2-6	1-4-2	Y	N	0
6-2-5	4-1-5	6-5-8	Y	N	1
3-8-1-4	1-7-9-5	6-8-3-1	Y	N	0
3-2-7-9	4-9-6-8	3-4-8-1	Y	N	1
6-2-9-7-1	4-8-5-2-7	4-9-1-5-3	Y	N	0
1-5-2-8-6	6-1-8-4-3	6-8-2-5-1	Y	N	1
7-1-8-4-4-2	8-3-1-9-6-4	3-7-4-9-1-6	Y	N	0
5-3-9-1-4-8	7-2-4-8-5-6	9-2-6-5-1-4	Y	N	1
List D	**List E**	**List F**			
7-8-2	3-8-2	2-7-1	Y	N	0
9-2-6	5-1-8	4-7-9	Y	N	1
4-1-6-3	2-7-9-3	1-6-8-3	Y	N	0
9-7-2-3	2-1-4-9	3-9-2-4	Y	N	1
1-7-9-2-6	4-1-8-4-9	2-4-7-8-6	Y	N	0
4-1-7-8-2	9-4-1-7-6	8-3-9-6-4	Y	N	1
2-6-4-8-1-7	6-9-7-3-8-2	5-8-4-2-4-9	Y	N	0
8-4-1-9-3-5	4-2-7-9-3-8	3-1-7-8-2-6	Y	N	1
		Digits Score:			of 4

MONTHS IN REVERSE ORDER

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

Dec - Nov - Oct - Sept - Aug - Jul - Jun - May - Apr - Mar - Feb - Jan	0 1
Months Score	of 1
Concentration Total Score (Digits + Months)	of 5

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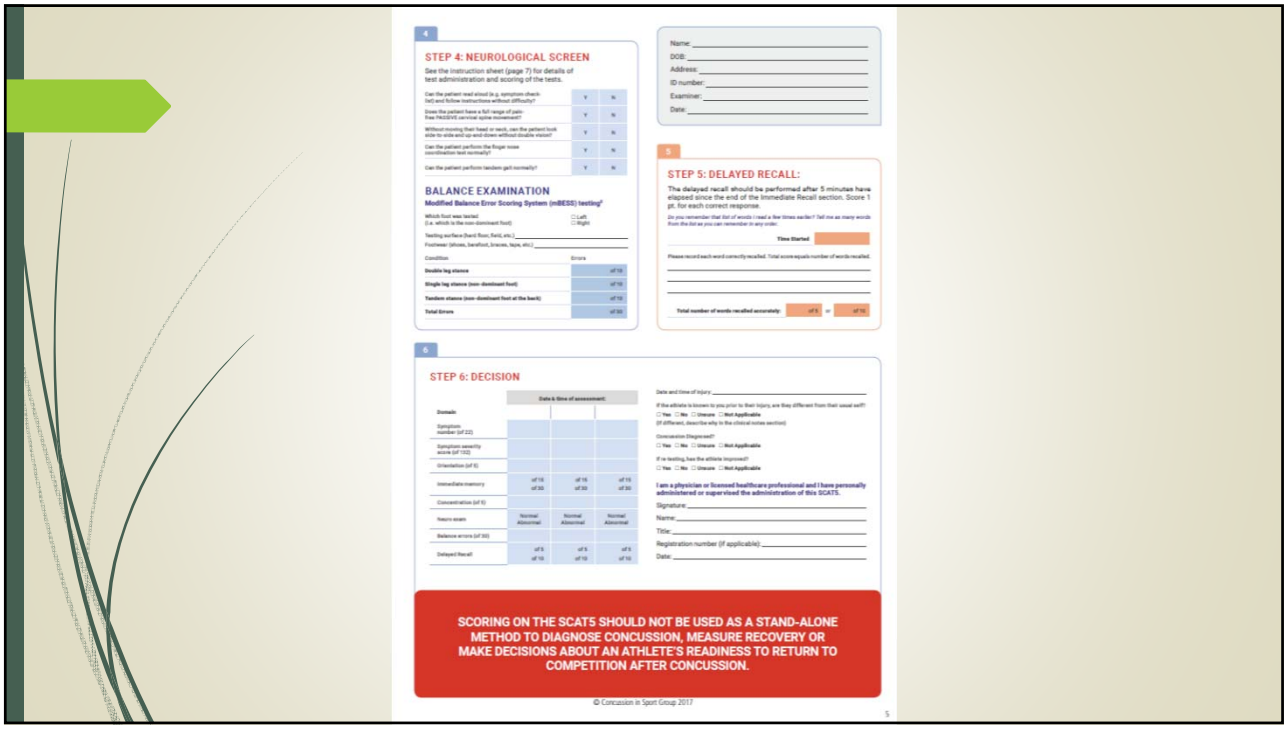

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STEP 4: NEUROLOGICAL SCREEN

See the instruction sheet (page 7) for details of test administration and scoring of the tests.

Can the patient read aloud (e.g. symptom check list) and follow instructions without difficulty?	Y	N
Does the patient have a full range of pain free PASSIVE cervical spine movement?	Y	N
Without moving their head or neck, can the patient look side to side and up and down without double vision?	Y	N
Can the patient perform the finger nose coordination test normally?	Y	N
Can the patient perform tandem gait normally?	Y	N

BALANCE EXAMINATION

Modified Balance Error Scoring System (mBESS) testing*

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

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

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

Condition	Errors	
Double leg stance		of 10
Single leg stance (non-dominant foot)		of 10
Tandem stance (non-dominant foot at the back)		of 10
Total Errors		of 30

Name: _____
DOB: _____
Address: _____
ID number: _____
Examiner: _____
Date: _____

5

STEP 5: DELAYED RECALL:

The delayed recall should be performed after 5 minutes have elapsed since the end of the Immediate Recall section. Score 1 pt. for each correct response.

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

Time Started _____

Please record each word correctly recalled. Total score equals number of words recalled.

_____

_____

_____

Total number of words recalled accurately: _____ of 5 = _____ of 10

6

STEP 6: DECISION

Domain	Date & time of assessment:		
Symptom number (of 22)			
Symptom severity score (of 132)			
Orientation (of 5)			
Immediate memory	of 15 of 30	of 15 of 30	of 15 of 30
Concentration (of 5)			
Neuro exam	Normal Abnormal	Normal Abnormal	Normal Abnormal
Balance errors (of 30)			
Delayed Recall	of 5 of 10	of 5 of 10	of 5 of 10

Date and time of injury: _____

If the athlete is known to you prior to their injury, are they different from their usual self? ☐ Yes ☐ No ☐ Unsure ☐ Not Applicable (If different, describe why in the clinical notes section)

Concussion Diagnosed? ☐ Yes ☐ No ☐ Unsure ☐ Not Applicable

If re-testing, has the athlete improved? ☐ Yes ☐ No ☐ Unsure ☐ Not Applicable

I am a physician or licensed healthcare professional and I have personally administered or supervised the administration of this SCAT5.

Signature: _____

Name: _____

Title: _____

Registration number (if applicable): _____

Date: _____

SCORING ON THE SCAT5 SHOULD NOT BE USED AS A STAND-ALONE METHOD TO DIAGNOSE CONCUSSION, MEASURE RECOVERY OR MAKE DECISIONS ABOUT AN ATHLETE'S READINESS TO RETURN TO COMPETITION AFTER CONCUSSION.

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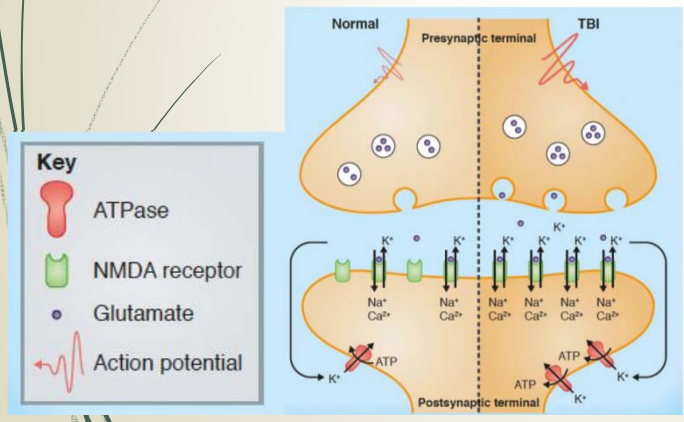
Concussion is a Metabolic Disruption

- **Immediate increases in cerebral metabolic rates of glucose are followed by prolonged glucose metabolic depression.**
- Glucose uptake studies have shown prolonged decrease in glucose uptake following all types of injuries, severities and age groups.
- **The metabolic depression is a hallmark characteristic of TBI of all severities.**
- **Metabolic cascade is mostly resolved within 7-10 days (*BUT per Berlin statement: recent studies using DTI, fMRI, MRS, CBF, etc. suggest physiological recovery may outlast current clinical measures of recovery*)**
  - *"Multiple studies suggest that physiological dysfunction may outlast current clinical measures of recovery, supporting a 'buffer zone' of gradually increasing activity before full contact risk. Future studies need to use generalisable populations, longitudinal designs following to physiological and clinical recovery, and careful correlation of neurobiological modalities with clinical measures. At this stage, these modalities, while useful as research tools, are not ready for clinical management."*

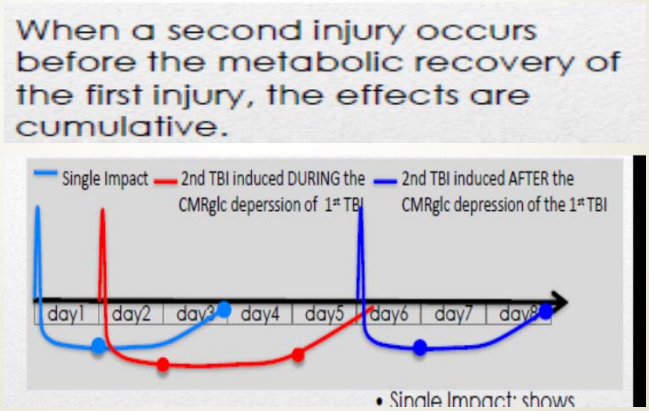
Immediately after IMPACT • indiscriminate presynaptic release of neurotransmitters (glutamate) that activate postsynaptic NMDA receptors. • efflux of potassium (K+) and influx of sodium (Na+) and calcium (Ca2+). • the Na+/K+ ATPase pumps consume ATP to re-establish ionic balance



These early neurochemical events quickly deplete cellular energy stores

Prins et al., 2013

Why keep concussed athletes/patients out of harm's way? Impact Interval Matters (Prins et al., 2013)



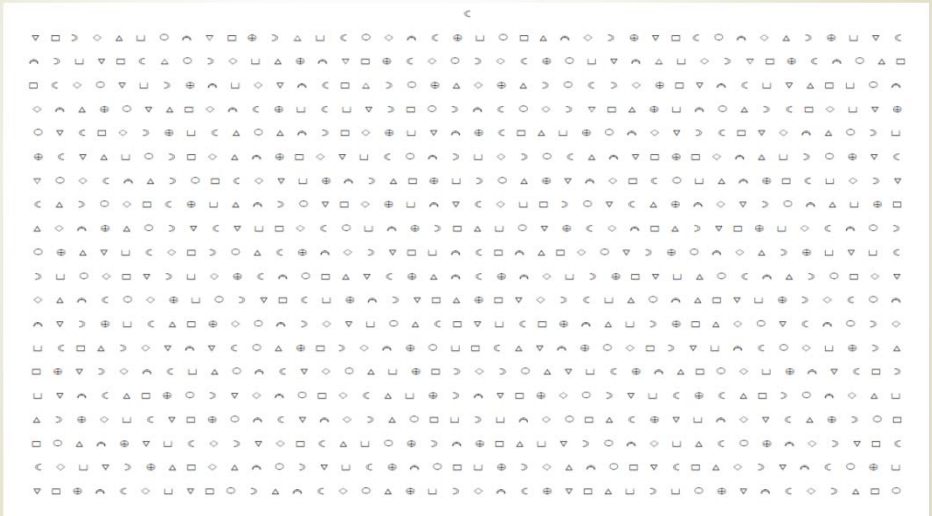
Window of Vulnerability (Prins, 2017)

- Duration of glucose metabolic depression reflects the duration of metabolic vulnerability to another TBI.
- When a second injury occurs before the metabolic recovery of the first injury, the effects are cumulative. (Prins et al., 2013) and recovery trajectory takes longer
- **Window of vulnerability in adult humans: 7-15 days**

Neuropsychological Assessment

- **Post injury NP assessment typically includes ImPACT** (computerized NP test) **and paper-pencil measures** of verbal and visual learning/memory, attention, visual scanning, processing speed, multi-tasking, rapid verbal fluency
- Per Berlin Guidelines (2017): Post injury neuropsychological assessment is not required for all athletes
- **Consider referral for NP assessment when the recovery is atypical** (taking longer than expected or cognitive complaints are unusual/severe)
- **Post injury NP exams are typically done when the athlete is asymptomatic to establish return to neurocognitive baseline,** but sometimes done earlier to assist in management decisions

Sample NP Test (Penn State Cancellation Task)



Are baseline NP exams mandatory?

- The short answer is “NO”.
  - Peds: Routine computerized baseline NP testing for children and adolescents is NOT recommended due to issues with reliability and validity
  - Adults: Baseline or preseason computerized NP testing in adults is not mandatory but may be helpful

Managing Concussion

Do	Don’t
Remove an athlete from play while they are still recovering	Tell them to lie down in a dark room with “no stimulation” for days
Encourage them to rest (24-48h) and then start moving as soon as possible	Prescribe full rest for >3 days, as it has been shown empirically to be detrimental
Provide accurate education about what to expect, including written information or websites	Deprive them of all reinforcing activities that provide positive emotional experiences and social support
Prioritize return to school over return to sport	Refer them to providers who are not well trained and could cause an iatrogenic effect

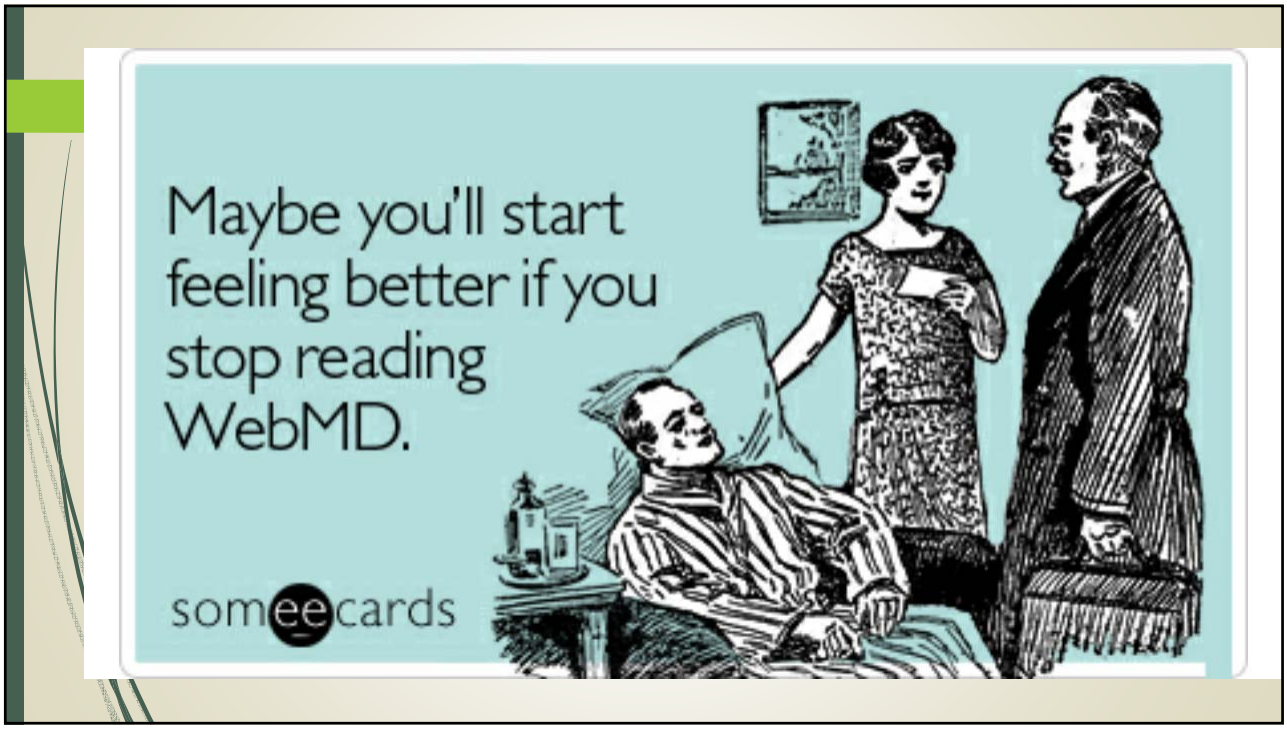
Persistent symptoms

- *"The Berlin expert consensus is that use of the term 'persistent symptoms' following SRC should reflect* ***failure of normal clinical recovery****—that is, symptoms that persist beyond expected time frames (****i.e., >10–14 days in adults and >4 weeks in children).****"*
- *"The strongest and most consistent predictor of slower recovery from SRC is the severity of a person's initial symptoms in the first day, or initial few days, after injury. Conversely, and importantly, having a low level of symptoms in the first day after injury is a favourable prognostic indicator. The development of subacute problems with migraine headaches or depression are likely risk factors for persistent symptoms lasting more than a month. Children, adolescents and young adults with a pre-injury history of mental health problems or migraine headaches appear to be at somewhat greater risk of having symptoms for more than 1 month."*

Treatment of Persistent Symptoms

- **New section in the 2017 Paper regarding Rehabilitation:**

"A variety of treatments may be required for ongoing or persistent symptoms and impairments following injury. The data support interventions including psychological, cervical and vestibular rehabilitation. In addition, closely monitored active rehabilitation programmes involving controlled sub-symptom-threshold, submaximal exercise have been shown to be safe and may be of benefit in facilitating recovery. A collaborative approach to treatment, including controlled cognitive stress, pharmacological treatment, and school accommodations, may be beneficial."



Concussion information available to adolescents on Social Media (Kollia et al 2018)

- YouTube reaches more 18-34 year olds than any US based cable network and has over 1 billion users
- A search of concussion videos uploaded between 2007-2016 with more than 100,000 views resulted in 98 videos (English only)
- Collectively the videos were viewed 71,760,719 times
- **Origin of upload:**
- 48% were Consumer videos- nonprofessional member of the general public
- 50% were Television based videos – from a TV show or clip
- 2% were Internet based videos – from a website or other internet source
- **NONE were Professional videos – from a person qualified to discuss the topic based on credentials and training**

Public misconceptions about Concussion/mTBI (Merz, Van Patten & Lace, 2017)

- Original study in 1988 (Gouvier et al) found that 46% individuals (in Louisiana) felt a second blow to the head could reduce amnesia and restore lost memories
- Hux et al. (2006) replicated the study in Nebraska, found that 93% believed it is possible to have memory impairment so severe that they cannot recognize family members or remember past events but can be normal in every other way
- Merz et al. (2017) replicated the study (with a diverse, US + non US sample) and found that only 14% were accurate regarding "importance of resting and being inactive for at least a week" (F) compared to 36-62% accurate in 2006 study (more misinformation now on prolonged rest)
- At least 6 items regarding PCS and CTE were answered with very low accuracy (less than 40%) e.g., "Scientific evidence has shown that repeated concussions from playing contact sports, such as football, cause a brain disease called chronic traumatic encephalopathy (CTE)" (F). 10% US sample answered correctly, 23% non US sample answered correctly

Take Home Messages:

- Brief rest (24-48 hours) is indicated, then get active as soon as possible
- Do not expose the brain in it's window of vulnerability (10-14 days) to a repeat trauma (metabolic dysregulation will take longer to normalize)
- Baseline computerized NP testing may be helpful in adults, NOT recommended in kids
- Normal course of recovery in adults: 10-14 days
- Normal course of recovery in kids: up to 4 weeks
- Multi-disciplinary rehab efforts for persistent symptoms
- Concussion awareness: convey confidence that they will get better
- http://www.cdc.gov/headsup
  http://www.sportsneuropsychologysociety.com/resources-and-publications

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- Presentations at Sports Neuropsychology Society April 2017 Conference:
  - Yeates: Consensus Guidelines for Pediatric Concussion: Implications for Sports Neuropsychology
  - Prins: Current Understanding of Concussion Pathophysiology

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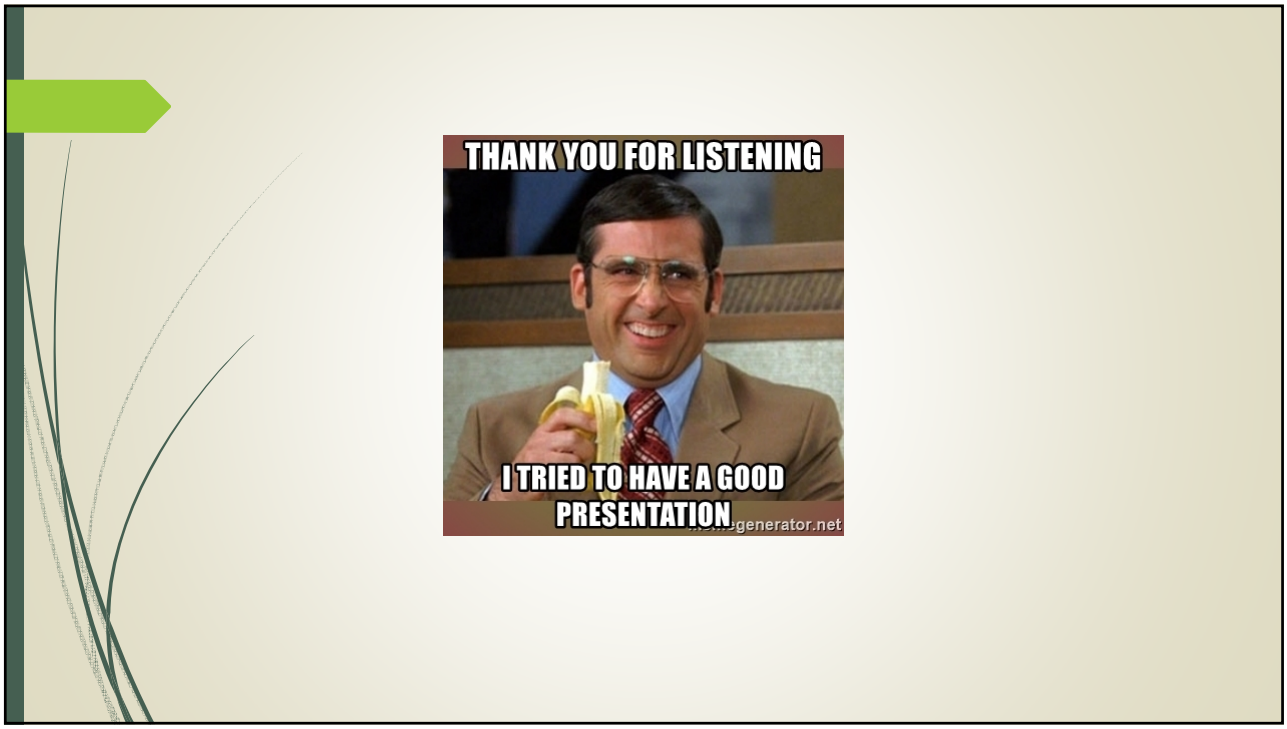
THANK YOU FOR LISTENING
I TRIED TO HAVE A GOOD PRESENTATION