
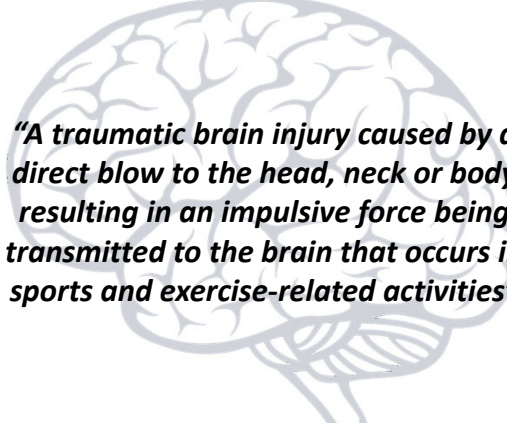


Concussion Return to Activity: School, Sports, and Life

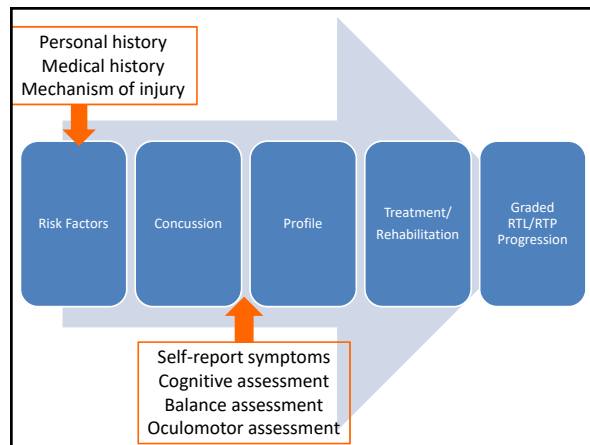
Interprofessional Cross Campus Collaborative Case

Tamara Valovich McLeod, PhD, ATC, FNATA, FNAK, FNAP
John P. Wood, DO, Endowed Chair for Sports Medicine
Chair, Professor, and Director, Department of Athletic Training
Research Professor, School of Osteopathic Medicine in Arizona

“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”

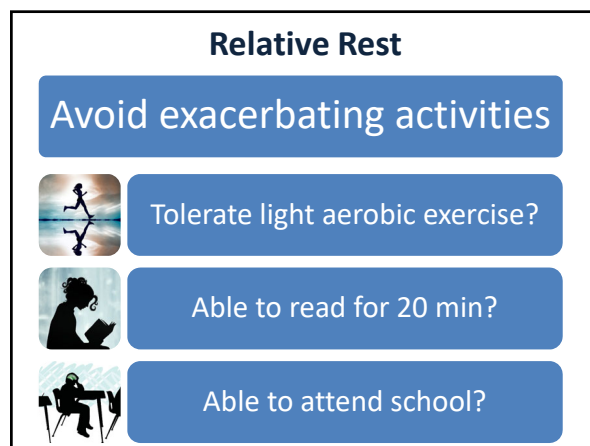
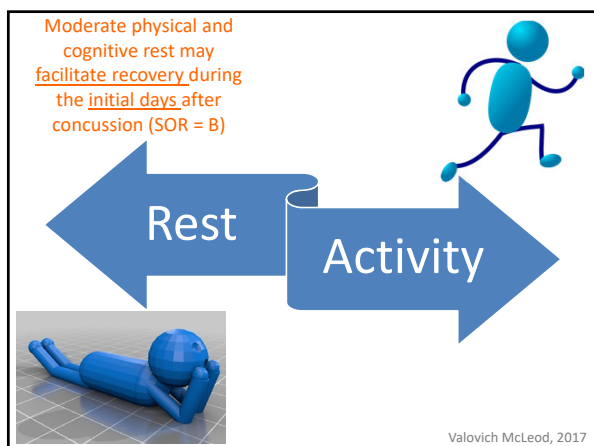
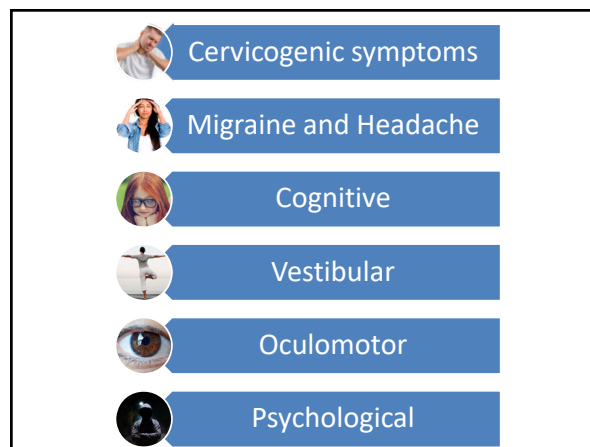
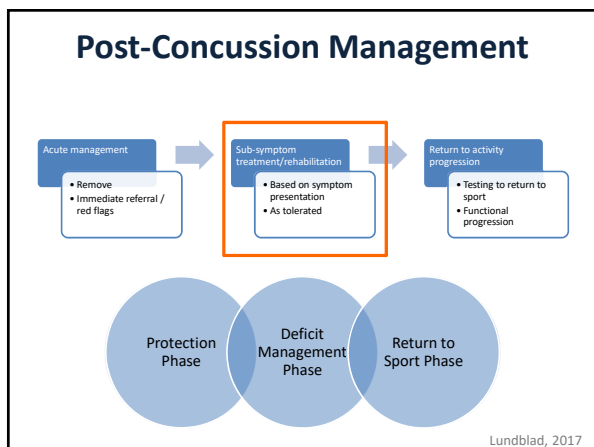
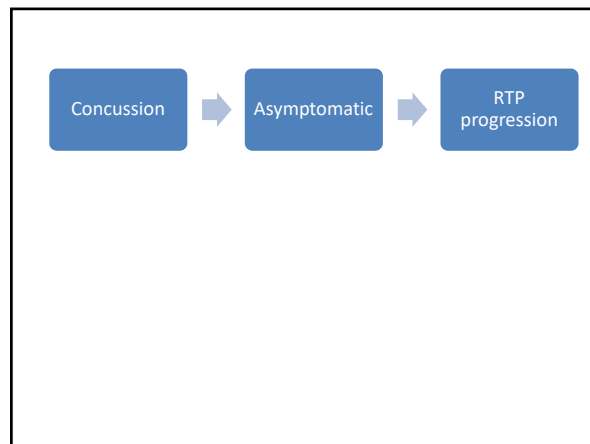
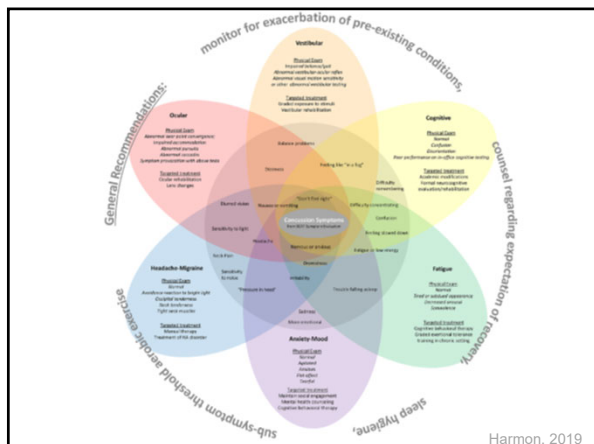
- Initiates a neurotransmitter and metabolic cascade, with possible axonal injury, blood flow change and inflammation affecting the brain
- S&S may present immediately, or evolve over minutes or hours
 - Commonly resolve within days, but may be prolonged
- No abnormality is seen on standard structural neuroimaging studies
 - In the research setting, abnormalities may be present on functional, blood flow or metabolic imaging studies
- Results in a range of clinical symptoms and signs
 - May or may not involve loss of consciousness
- Clinical S&S of concussion cannot be explained solely by (but may occur concomitantly with) drug, alcohol, or medication use, other injuries (such as cervical injuries, peripheral vestibular dysfunction) or other comorbidities (such as psychological factors or coexisting medical conditions)



Multifactorial Assessment	Concussion history	Personal and family medical history	Mental health screen
	Symptom inventory / interview	Neurocognitive	Motor control
	Vestibular-ocular	Physical cervical exam	Patient-report outcomes

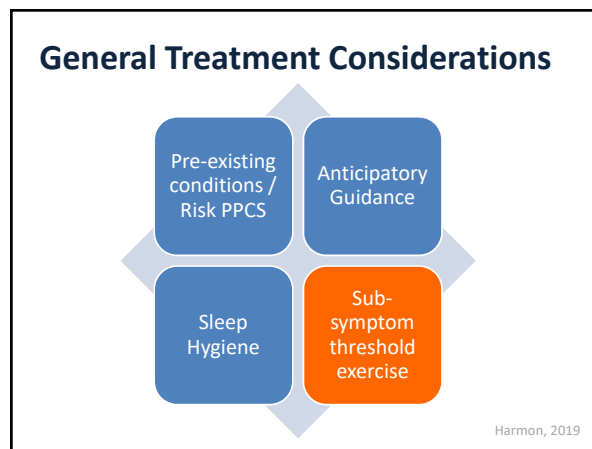
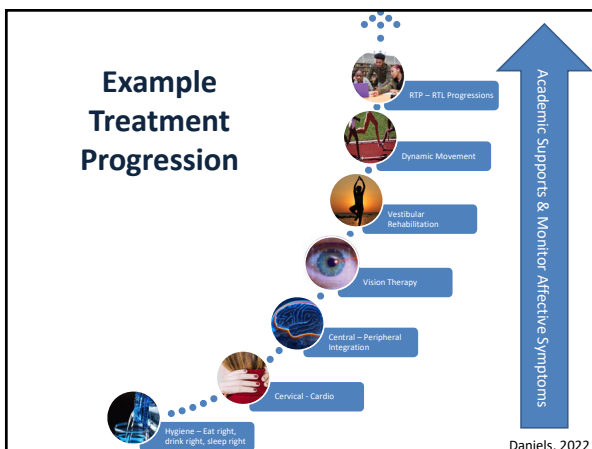
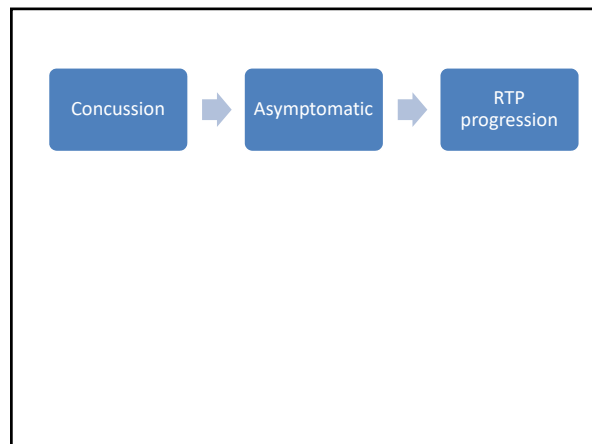
Concussion Subtypes

The collage includes images for: Cognitive (students), Ocular/Motor (eye), Headache/Migraine (person holding head), Vestibular (swirling green), Anxiety/Mood (person sitting), Sleep Disturbances (person sleeping), and Cervical Strain (person with neck pain). Source: Lumba-Brown, 2019.



Recommending strict rest until the complete resolution of concussion-related symptoms is not beneficial following SRC

Leddy, 2023



Return To Sport Strategy

Step	Exercise Strategy	Activity at Each Step	Goal
1	Symptom-limited activity	Daily activities that do not exacerbate symptoms (e.g., walking).	Gradual reintroduction of work/school.
2	Aerobic exercise 2A – Light (up to approx. 55% max HR) then 2B – Moderate (up to approximately 70% max HR)	Stationary cycling or walking at slow to medium pace. May start light resistance training that does not result in more than mild and brief exacerbation* of concussion symptoms.	Increase heart rate.
3	Individual sport-specific exercise NOTE: if sport-specific exercise involves any risk of head impact, medical determination of readiness should occur prior to step 3.	Sport-specific training away from the team environment (e.g., running, change of direction and/or individual training drills away from the team environment). No activities at risk of head impact.	Add movement, change of direction.
Steps 4-6 should begin after resolution of any symptoms, abnormalities in cognitive function, and any other clinical findings related to the current concussion, including with and after physical exertion.			
4	Non-contact training drills.	Exercise to high intensity including more challenging training drills (e.g., passing drills, multiplayer training). Can integrate into 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.	

Patricios, 2023

Step	Exercise Strategy	Activity at Each Step	Goal
1	Symptom-limited activity.	Daily activities that do not exacerbate symptoms (e.g., walking).	Gradual reintroduction of work/school.

- Avoid prescribing absolute physical and cognitive rest in the first 24–48 hours
- Step 1 is relative rest
 - Encourage engagement in activities of daily living, including walking and brief cognitive loads
- OK to engage in these activities with mild symptoms
 - Educate patients to back off if symptoms worsen

SORT=A

Patricios, 2023

Step	Exercise Strategy	Activity at Each Step	Goal
2	Aerobic exercise 2A – Light (up to approx. 55% max HR) then 2B – Moderate (up to approximately 70% max HR)	Stationary cycling or walking at slow to medium pace. May start light resistance training that does not result in more than mild and brief exacerbation* of concussion symptoms.	Increase heart rate.

- Safe controlled environment
- Light aerobic exercise, as part of the treatment plan (2A)
- Progress to moderate aerobic exercise and low intensity strength training (2B)
 - When no more than mild and brief exacerbation of current concussion symptoms
 - Educate patients mild symptoms are OK
- This step may span numerous days

SORT=A Patricios, 2023



Exercise Interventions

- Concussion can result in ANS dysregulation
 - Control of cerebral blood flow and cardiac rhythm
- Manifests as exercise intolerance
 - Inability to exercise near to age-appropriate HRmax due to symptom exacerbation
- Subsymptom threshold aerobic exercise aims to restore ANS regulation and cerebral blood flow
 - Promoting brain vascularization
 - Increasing levels of brain-derived neurotropic factor

Exercise Interventions

Physical	Psychological
<ul style="list-style-type: none"> • Maintain fitness • Physiological benefits of exercise • Rehabilitation of affected systems 	<ul style="list-style-type: none"> • Improved compliance • Remove isolation • Reduction in anxiety • Psychological benefits of exercise

Exercise as an Intervention

Crane, 2012, Majerske 2008, Gomez-Pinella, 2011; Maerlender, 2015; Ahlskog, 2011; Colcombe, 2004; Lautenschlager, 2008

Early Aerobic Exercise vs Placebo (Stretching)






Aerobic exercise recovered significantly faster than stretching (13 vs 17 days)

No difference in delayed recovery (4% aerobic vs 14% stretching)

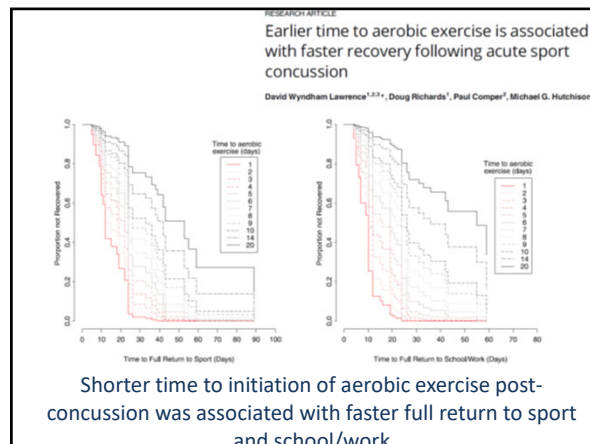
- “this is a **landmark study that may shift the standard of care** toward the use of rehabilitative exercise to decrease the duration of concussion symptoms” Chrisman, 2019

Leddy, 2019

Multi-Site RCT

-  Aerobic exercise more likely to recover within 4 weeks
-  Good adherence
-  No adverse events
-  Safely speeds recovery
-  48% reduced risk of persistent symptoms

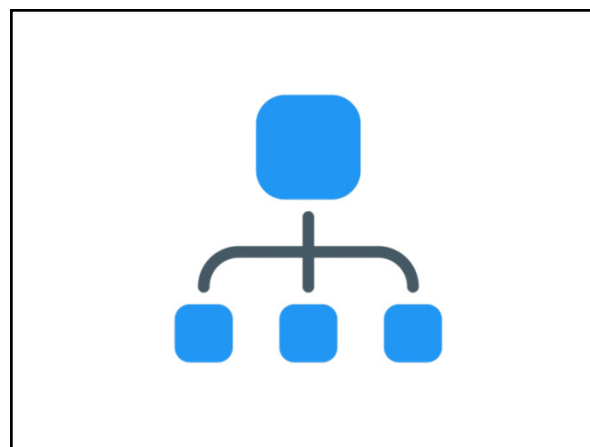
Leddy, 2021








Diagnostic Accuracy of Exercise Tolerance Testing

- Systematic review and exploratory meta-analysis
 - 12 included studies
 - Cycle ergometer (3), 6-minute step test (2), 15-minute march in place test (1), BCTT (7)
- Excellent diagnostic sensitivity and specificity for early (1-14 d) exercise intolerance testing
 - 94.4% sensitivity
 - 94.6% specificity
- Values comparable or superior to common assessments
 - ImPACT: D1 55.0% (Se), 97.5% (Sp); D3 91.4% Se, 69.1 (Sp)
 - King-Devick: 86% (Se), 90% (Sp)
 - SCAT: 80.4-89.1% (Se), 69-80.9% (Sp)

Haider, 2023



Treatment	}		Buffalo Concussion Treadmill/Bike Test <small>(Leddy, 2017, 2019, 2022; Haider, 2019)</small>
			Calgary Stationary Cycle Test <small>(Graham, 2021)</small>
RTA Decisions	}		Military Exertion Tests <small>(Prim, 2021)</small>
			Gapski-Goodman Test <small>(Marshall, 2018)</small>
			Dynamic Exertion Test <small>(Sinnott, 2022)</small>
Exercise Tolerance Testing			

Buffalo Protocol Resources



Return To Sport Strategy

Step	Exercise Strategy	Activity at Each Step	Goal
3	Individual sport-specific exercise NOTE: if sport-specific exercise involves any risk of head impact, medical determination of readiness should occur prior to step 3.	Sport-specific training away from the team environment (e.g., running, change of direction and/or individual training drills away from the team environment). No activities at risk of head impact.	Add movement, change of direction.

- Individual sport-specific activities **away from the team** environment, with no inadvertent risk for head contact
- Allows the introduction of movement and change of direction, challenging the sensorimotor systems as part of the treatment of SRC

SORT=A Patricios, 2023

- Dynamic warm up, agility, cutting, running patterns
- Agility cone drills, light passing, change of direction
- Ball handling, shooting, agility drills
- Floor choreography, low difficulty individual stunts
- Light swimming, limited head movement, open turns

Return To Sport Strategy

Step	Exercise Strategy	Activity at Each Step	Goal
Steps 4-6 should begin after resolution of any symptoms, abnormalities in cognitive function, and any other clinical findings related to the current concussion, including with and after physical exertion.			

SORT=A Patricios, 2023

Physiological Resolution of Concussion

Ability to exercise at 85-90% HR_{max} for 20 minutes without exacerbation of symptoms for several days in a row

Leddy, 2016

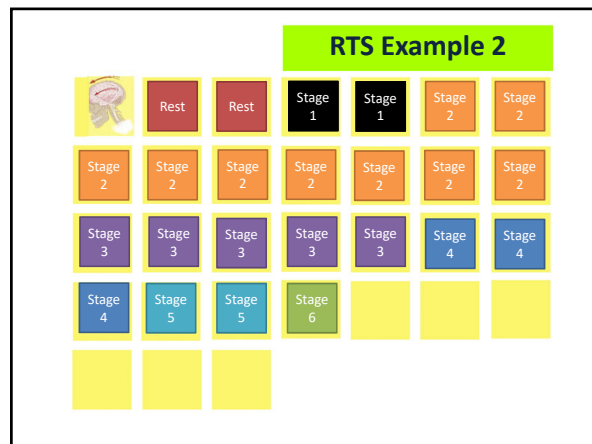
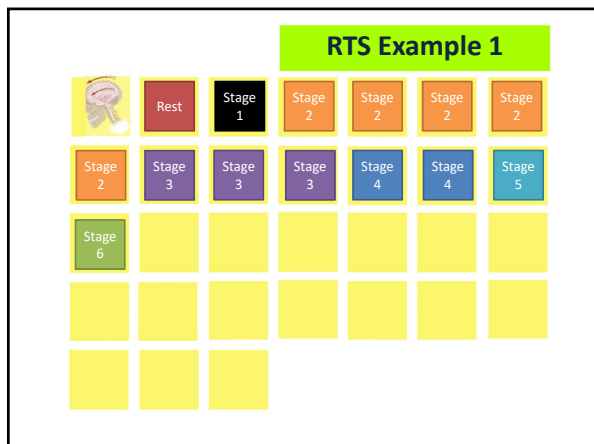
Return To Sport Strategy

Step	Exercise Strategy	Activity at Each Step	Goal
4	Non-contact training drills.	Exercise to high intensity including more challenging training drills (e.g., passing drills, multiplayer training). Can integrate into 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.	

SORT=B Patricios, 2023

RTS Recommendations

- Progression through each subsequent step typically taking a minimum of 24 hours
 - May take longer on steps 2 & 3
- Progression through Steps 4–6 should be monitored by an HCP
- Differentiating early activity (Step 1), aerobic exercise (Step 2) and individual sport-specific exercise (Step 3) as part of the **treatment** of SRC
 - From the remainder of the RTS progression (Steps 4–6) can be useful for the athlete and their support network (eg, parents, coaches, administrators and agents)



Return to School

- Physical presence in school **Must happen first**
- Directed by parent
- Symptom dependent

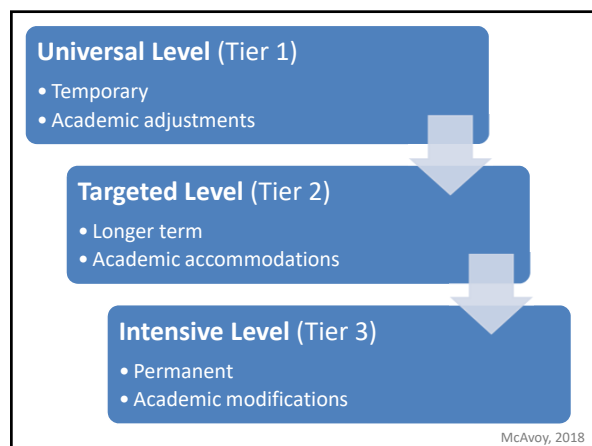
Return to Learn

- Helping students maximize learning while minimizing symptom exacerbation
- Directed by educators
- Progressed as tolerated

Readiness to Return

- When able to tolerate symptoms for 30-45 min
 - Consider starting RTL progression at home or at school with adjustments
 - Level of adjustments depend on severity, type and duration of symptoms

Halstead, AAP, 2013



General Adjustments

- Transportation to/from school
 - Should not be driving if symptomatic
 - Bus may be too busy of an environment
- Alternate mental rest with mental exertion
 - Avoid prolonged periods of exertion
 - Increase exertion / decrease rest as tolerated
- Avoid overstimulating environments
 - Avoid cafeteria, hallways during transition

General Adjustments

- Modified Schedule
 - Shortened day or class periods
 - Core vs electives
 - Late start
- Modified assignments
 - Shorter versions
 - Postpone due dates
 - Extended test time
- Prioritize work
 - Essential work only

Davies, 2016

Adjustments for Physical Symptoms

Headache	<ul style="list-style-type: none"> • Frequent breaks • Reduce exposure to aggravators • Rest in nurse's office
Dizziness	<ul style="list-style-type: none"> • Allow student to put head down • Early dismissal between classes to avoid crowded halls
Visual Symptoms	<ul style="list-style-type: none"> • Reduce exposure to computers, videos • Reduce brightness on screens • Allow hat or sunglasses • Audiotapes for books

Halstead, AAP, 2013; Nationwide Children's, REAP

Adjustments for Cognitive Symptoms

Difficulty Concentrating	<ul style="list-style-type: none"> • Avoid testing or major projects • Extra time • Consider notes, notetaker, scribe
Mentally Foggy	<ul style="list-style-type: none"> • Give breaks • Simplify tasks
Difficulty Paying Attention	<ul style="list-style-type: none"> • Have student sit in front of room • Work in quiet room

Halstead, AAP, 2013; Nationwide Children's, REAP

Adjustments for Emotional Symptoms

Anxiety	<ul style="list-style-type: none"> • Reassurance • Workload reduction • Alternate forms of testing
Depression	<ul style="list-style-type: none"> • Time built in for socialization
More Emotional	<ul style="list-style-type: none"> • Have signal with teacher to leave/rest • Allow student to leave from classroom

Halstead, AAP, 2013; Sady, 2011; Nationwide Children's, REAP

Adjustments for Sleep Symptoms

Sleep Disturbances	<ul style="list-style-type: none"> • Allow for late start or shortened day • Allow rest breaks
Fatigue	<ul style="list-style-type: none"> • Strategic rest • Schedule adjustments

Halstead, AAP, 2013; Nationwide Children's, REAP

Return to School Strategy

- Not all athletes will need an RTL strategy or academic support

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 (e.g., 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 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.

Patricios, 2023

Early Postinjury Screen Time and Concussion Recovery

Molly Camross, PhD,^{1,2,3} Keith Owen Yeates, PhD,^{1,2,3} Ken Tang, PhD,⁴ Sheri Madigan, PhD,^{1,2} Miriam H. Beauchamp, PhD,^{1,2} William Craig, MDOM,⁵ Quinn Doan, MDOM, PhD,^{1,2} Roger Zemek, MD,^{1,2} Kristina Kowalski, PhD,^{1,2} Ryan D. Siewelberg, PhD, on behalf of the Pediatric Emergency Research Canada A-GDP study team.¹⁻⁶

Association between early (7-10d) screen time & symptoms

Low and high screen time associated with more severe symptoms during first month

Higher screen time was not consistently associated with more symptoms especially after 30d

Advising moderation rather than blanket restrictions in screen time, especially beyond the first 48 hours

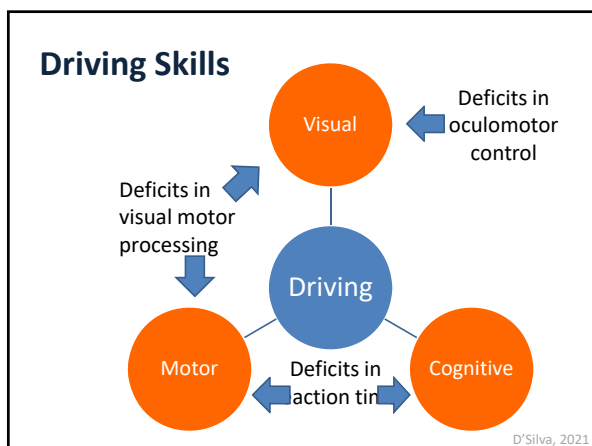
Academic Recommendations

- Healthcare providers (HCPs) should work with stakeholders on education and school policies to facilitate academic support for students with SRC when needed. (SORT A)
- Many athletes return to school without needing academic support. Risk factors for longer RTL duration should be assessed in all athletes with SRC to identify those who may benefit from academic support. (SORT B)
- While the RTL and RTS strategies can occur in parallel, student-athletes should complete full RTL before unrestricted RTS. (SORT B)

Driving After Concussion

- Patients who abstained from driving were younger, and fewer days post-injury
- 75%** resumed driving
 - **42%** resumed driving in first 14 days
- 62%** reported feeling safe while driving
- 44%** reported worsening symptoms when driving
 - Headache, concentration problems, dizziness, vision problems
- 75% made changes to driving habits

D'Silva, 2021



Driving After Concussion

Driving performance AFTER self-reported resolution of concussion symptoms

More frequent lane excursions	Greater SLDP on first and final curve
No difference in neurocognitive assessments	Significant correlations between neurocognitive and driving performance

Poorer driving performance, despite being asymptomatic

Schmidt, 2017

Use of Driving Recommendations

- Survey of athletic trainers regarding driving recommendations

38% always recommend refraining

Refrain 57% of patients from driving

44.7% refrain until symptom resolution

94% provide verbal instructions

65% use clinical exam to determine return

44% do not provide recommendations on how to return

Schmidt, 2017

Driving Recommendations

- Some evidence to restrict driving during the first 24-48 hours
- Insufficient evidence after 48 hours on specific return to driving recommendations

Christensen, 2019

Key Recommendations

- Time for clinical recovery and completing RTS strategy has increased
- Initial symptom burden is the most consistent predictor of recovery
- Many athletes return to school without needing academic support
- Students should complete full RTL before unrestricted RTS

Key Recommendations

- RTS guided by healthcare team
- Early steps 1-3 = treatment
- Unrestricted RTS typically occurs within 1 month post-injury
 - Account for individual pre- and post-morbid factors
- Medical determination of readiness to return to at-risk activities should occur prior to returning to any activities at risk of contact, collision or fall
 - Keeping with local laws/requirements
 - Athletes should be back to their pre-injury level of function

References

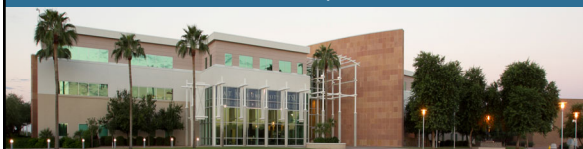
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