

CONCUSSION UPDATES 2024

LANCASTER GENERAL HOSPITAL PEDIATRIC GRAND ROUNDS 4/14/24

MATTHEW GRADY MD FAAP, CAQ SM
CO-CLINICAL DIRECTOR MINDS MATTER
CONCUSSION PROGRAM



**Children's Hospital
of Philadelphia®**

Minds Matter Concussion Program



Faculty Disclosure Information

I have no relevant financial relationships with the manufacturer(s) of any commercial product(s) and/or provider(s) of commercial services discussed in this CME activity.

I **do not** intend to discuss an unapproved/investigative use of a commercial product/device in my presentation.

Objectives

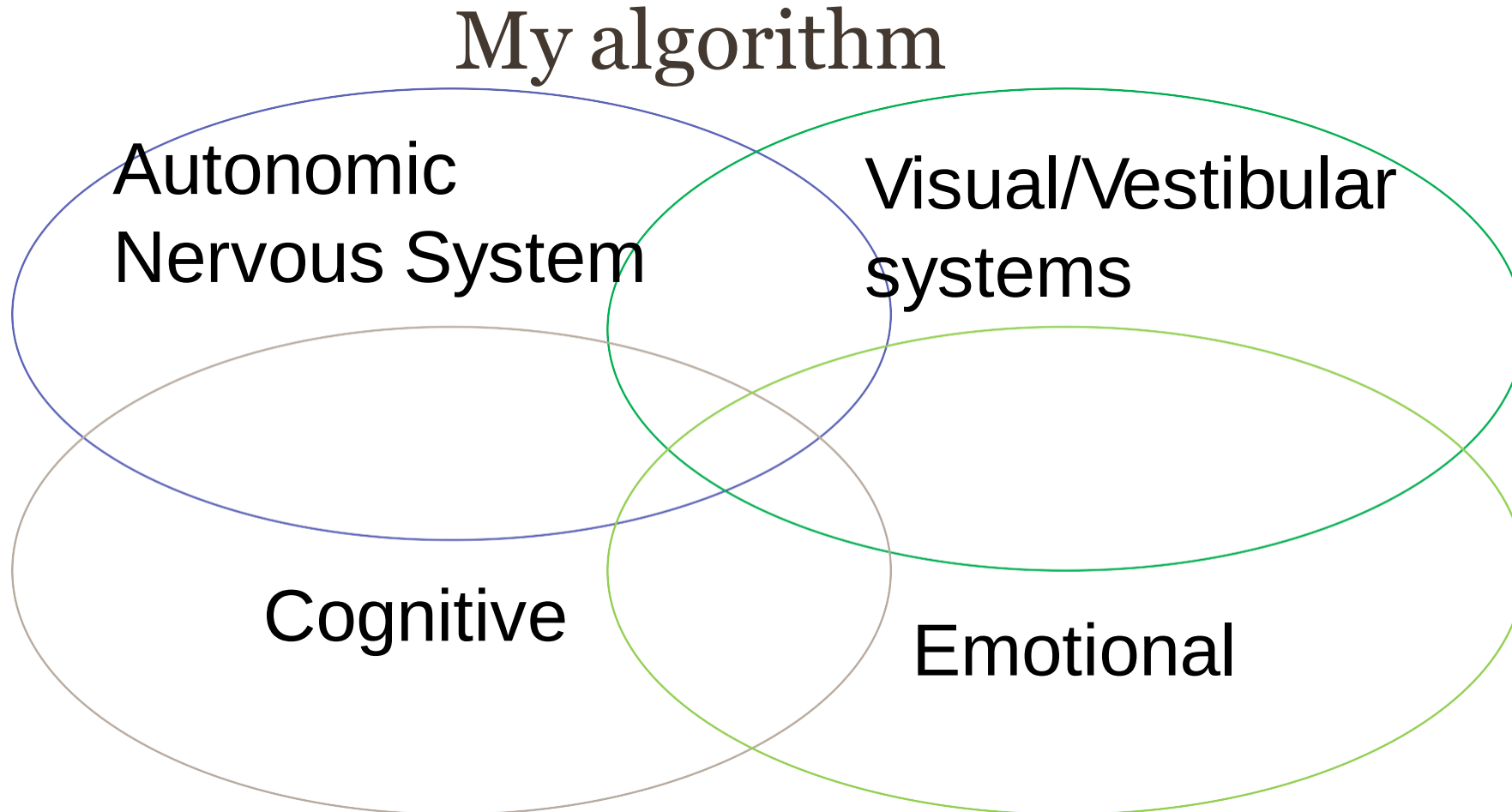
1. Discuss rational for early aerobic activity after concussion
2. Review updated return to play guidelines
3. Review recent updates in teen driving
4. Differential immediate first 48 hours, acute post 48 hours and subacute/chronic concussion management

Concussion Definition

- Concussion is **traumatic brain injury** induced by biomechanical forces. (Amsterdam Concussion in Sport Guidelines 2022).
 - No structural abnormalities on conventional imaging- so this is a functional injury.
- **Real life definition: the brain is injured, and it does not work right.**

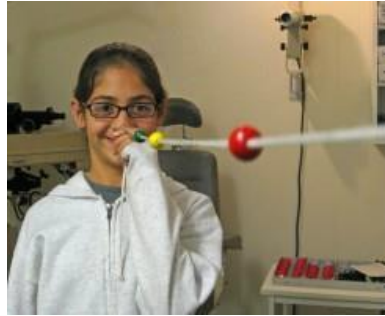
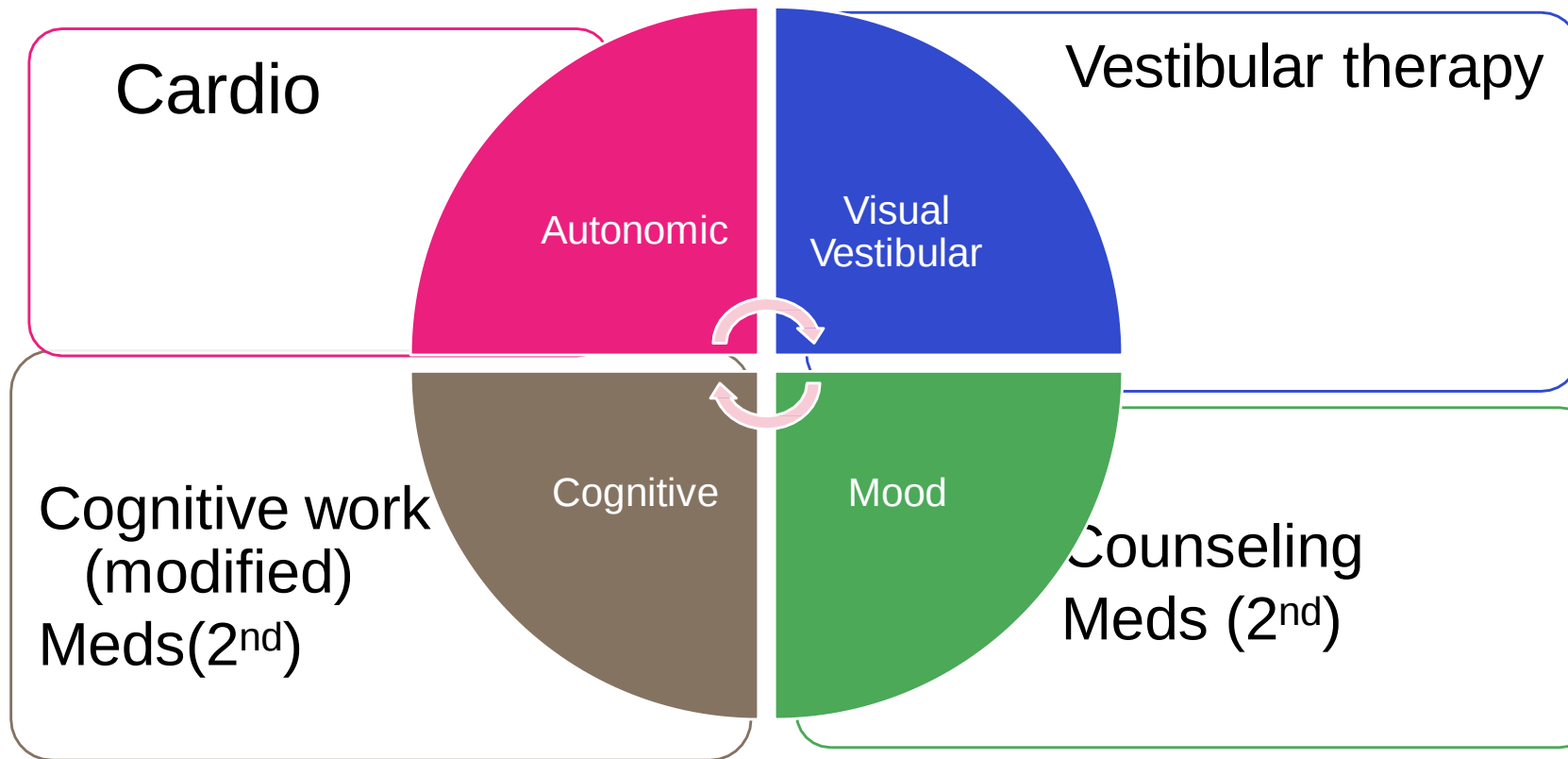
This includes dysregulation of normal functions: cerebral blood flow, balance and eye tracking, memory, processing, concentration, higher level thinking, impulse control, and emotional response

Concussion Signs and Symptoms



Grady MF and Master CL. Pediatr Ann. 2017 Mar 1; 46(3):e93-e98.

Concussion – Active Management



Clinical Concussion Updates last 3 years

- Increased Screen Time in first 48 hours is associated with delayed recovery *Macnow, JAMA Pediatr, 2021*
- Screen time in the first month seems to impact subset of patients

Take home points

1. In the first 48 hours, really try to limit screen time in absolute minutes - the closer to zero the better
2. After 48 hours, limit screen time based on symptoms - follow 2 point rule



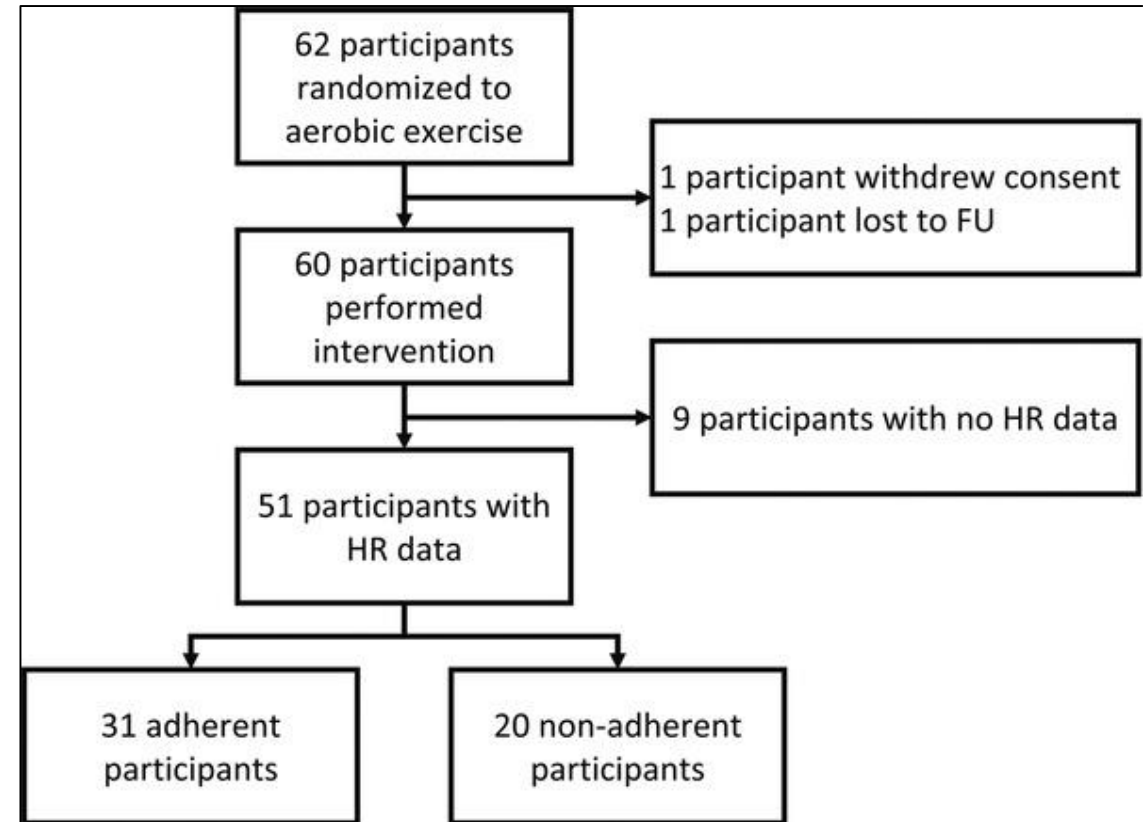
Clinical Updates- Cardio helps recovery

- Initiation of cardio after 48 hours is associated with faster recovery. *Leddy, Lancet Child Adolesc. Health, 2021*
- In those with more severe symptoms, particularly exercise intolerance, started cardio while symptomatic was more beneficial than rest. *Chizuk HM et al Medicine & Science in Sports & Exercise. 54(9):1410-1416, September 2022*
- Cardio is started with rules. No contact. 2 point rule- symptoms may go up maximum of 2/10 points. In clinical testing, HR threshold for initiation of symptoms was target starting point. In clinical practice, the 2 point rule accomplishes this. If in doubt - start cardio on lower intensity end (ie walking and gradually increase)



Aerobic Activity with high symptom burden

- This study showed that those who did (adhered to exercise prescription) aerobic activity starting at day three had less symptoms at day 10 than those who did not, regardless of initial symptom burden
- Implications - those with worse symptoms benefit more from starting aerobic activity early.



Chizuk HM, Willer BS, Cunningham A, Bezherano I, Storey E, Master C, Mannix R, Wiebe DJ, Grady MF, Meehan WP, Leddy JJ, Haider MN. Adolescents with Sport-Related Concussion Who Adhere to Aerobic Exercise Recover Faster. *Medicine & Science in Sports & Exercise*. 54(9):1410-1416, September 2022.

New updates- Visio-Vestibular Exam

- Part of concussion assessment should be evaluation of eye tracking and balance.
- CHOP has been on cutting edge of these recommendations- but they are now widely accepted - AAP policy statement 2023, International Concussion in Sports Guidelines 2023.

Vestibular/Vision Assessment: Visio-Vestibular Examination (VVE)

- Vision
 - Convergence (abnormal 6 cm or greater)
 - Accommodation (age-related; Hofstetter's formula)
- Vestibular-oculomotor
 - Smooth pursuit
 - Saccades (20 repetitions)
 - Vestibular-ocular reflex (20 repetitions)
- Vestibular-balance
 - Complex tandem gait
 - 5 steps, 4 conditions
 - Eyes open/closed, forwards/backwards



Corwin J Peds 2015; Master Clin Peds 2016; Storey Clin J Sports Med 2020

<https://www.youtube.com/watch?v=Uy8V5MGX8Ag>

Vestibular Recommendations: Home therapy

- New CHOP recommendations- start home eye exercises in week one- very slowly.
- Can do repetitions of the VVE exam- I start 1 min/ once a day for each physical exam component that produces symptoms.
- Goals Saccades 120 reps/min 13 -18 yo, 90 for 10-12 yo 60 for 8-9 yo.
- Gaze stability – about 60/min
- *I reserve formal vestibular therapy for at least 2 weeks post injury since spontaneous recovery is high in the first few weeks*



New updates: School Return

- School return within 2 days is associated with less symptoms at day 14. *Vaughan, JAMA Netw Open, 2023*
- Conditions- full academic load has been associated with slower recovery
 - Need accommodations – based on physical exam
 - School re-entry should follow 2 point rule
 - If there are no accommodations in place- restarted school work at home is an option.
 - Some cognitive activity should restart at latest on day 3.



New updates : Mood

- Increased recognition of mood complaints with concussion
 - Pre-existing Mood issues related to higher symptom burden and risk for prolonged recovery *Master. Sports Health 2024*
 - Untreated these are associated with delayed recovery
 - My take on mood issues: 2 fold
 - 1. Primary mood changes due to the injury-emotional lability seen early in concussion
 - 2. Secondary mood changes due to injury-concussion can cause a stressful situation (school, peers, sports participation) and the stressful situation contributes to secondary mood changes. These can be seen later in concussion so screening should be part of every visit.



New updates: Driving

- Some changes in reaction time in concussion drivers 16-24. *Kerwin T Accid Anal Prev. 2023*
- Simulator performance is statistically similar, but slightly decreased (mostly reaction time) in concussed vs control drivers. *Rivara FP J Neurotrauma. 2023*
- *My advice- based on VOMS, symptom burden- limit driving to simple decisions, familiar routes as long as eye tracking allows normal visual awareness.*



Concussion Return to Sport Guidelines: Update 2023

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 work/school
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 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 training involves any risk of inadvertent head impact, medical clearance should occur prior to	Sport-specific training away from the team environment (eg, 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

Patricios JS, et al Consensus statement on concussion in sport: the 6th International Conference on Concussion in Sport-Amsterdam, October 2022. Br J Sports Med. 2023 Jun;57(11):695-711

Concussion Return to Sport Guidelines

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.	

- *Mild and brief exacerbation of symptoms (ie, an increase of no more than 2 points on a 0–10 point scale for less than an hour when compared with the baseline value reported prior to physical activity). Athletes may begin Step 1 (ie, symptom-limited activity) within 24 hours of injury, with progression through each subsequent step typically taking a minimum of 24 hours. If more than mild exacerbation of symptoms (ie, more than 2 points on a 0–10 scale) occurs during Steps 1–3, the athlete should stop and attempt to exercise the next day. Athletes experiencing concussion-related symptoms during Steps 4–6 should return to Step 3 to establish full resolution of symptoms with exertion before engaging in at-risk activities. Written determination of readiness to RTS should be provided by an HCP before unrestricted RTS as directed by local laws and/or sporting regulations.

New Diagnosis Concussion: What should I do

First 48 hours

- Limit screens
- Limit strenuous physical activity
- Limit strenuous cognitive Activity

After 48 hours

- Start Cardio
- School work with accommodations
- Start Vestibular Exercises as needed
- Driving ?- ok if vestibular function is ok



Case 1

- 12 yo female soccer player mom calls the office. During the game today , she collided with another player and hit her head on the ground. She is coherent but complains of headache, light and noise sensitivity. She answers questions slowly and is irritable. She reports some nausea but no vomiting.
- Mom wants to know: Does she need to go to the ED? Should she go to school tomorrow? She is practicing for the school play which is next week- can she go to practice?

Case 1

- Phone Advice:
- Assess for serious head trauma- mental status changes need to go to the ED for urgent evaluation.
- If no concern for deteriorating clinical status- then recommendations for first 48 hours of concussion
 - Off electronics
 - Try to get adequate sleep
 - Avoid doing cognitive or physical tasks that provoke symptoms
 - Arrange for clinical evaluation
 - Getting to school is a priority but not in the first 48 hours unless school accommodations are already in place

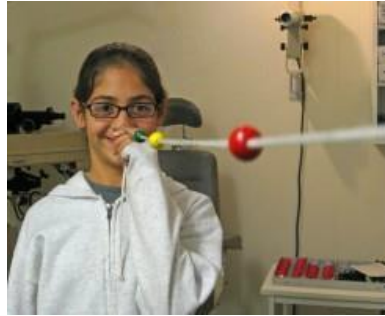
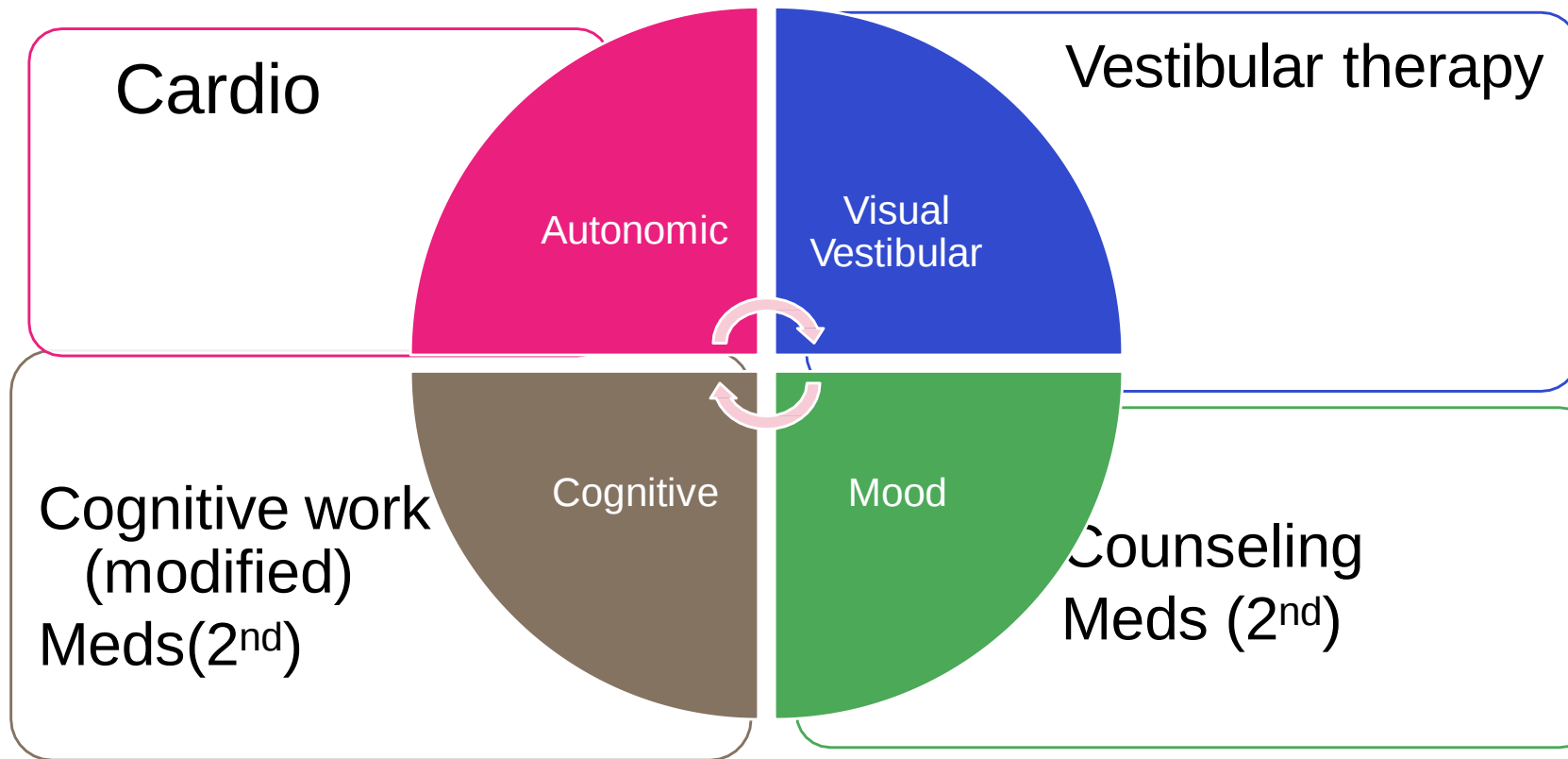
Case 1

Seen in the office on day 2 post concussion. She is feeling better, but she still has a constant headache and gets light-headed if she stands up quickly. She reports that she can be on her phone a little bit but gets some eye pain if she is on too long.

PE:

- No symptoms with 10 saccades but symptoms with 20- headache
- Symptoms with gaze stability- mild nausea with 15 reps horizontal
- Convergence 6, accommodation 9 R 9 L
- Gait- truncal sway with Heel toe walking eyes closed, normal eyes open

Concussion – Active Management



Case 1

Recommendations:

- Autonomic dysfunction – start cardio 20-30 minutes day following 2-point rule- no contact sports training
- Vestibular/Occular: home eye exercises- very slow 1 min once a day, balance practice – stand on one foot while brushing her teeth (dual task)
- Cognitive - plan school reentry - limit screen time, reading to 2-point rule, hold off on testing until caught up
- Mood - monitor for anxiety and depression
- Followup in one week - mostly to monitor school re-integration

Case 1- two week follow-up

- She reports that she feels much better. She wants to return to soccer. She has done some walking and light jogging with no symptoms. She is now in full days of school- had a headache at the end of the day yesterday. She is almost caught up on missed work/tests.
- PE no symptoms with VVE, normal balance.
- When can she play?

Case 1

- Clearance is all of the following:

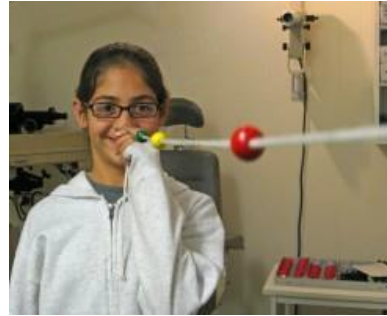
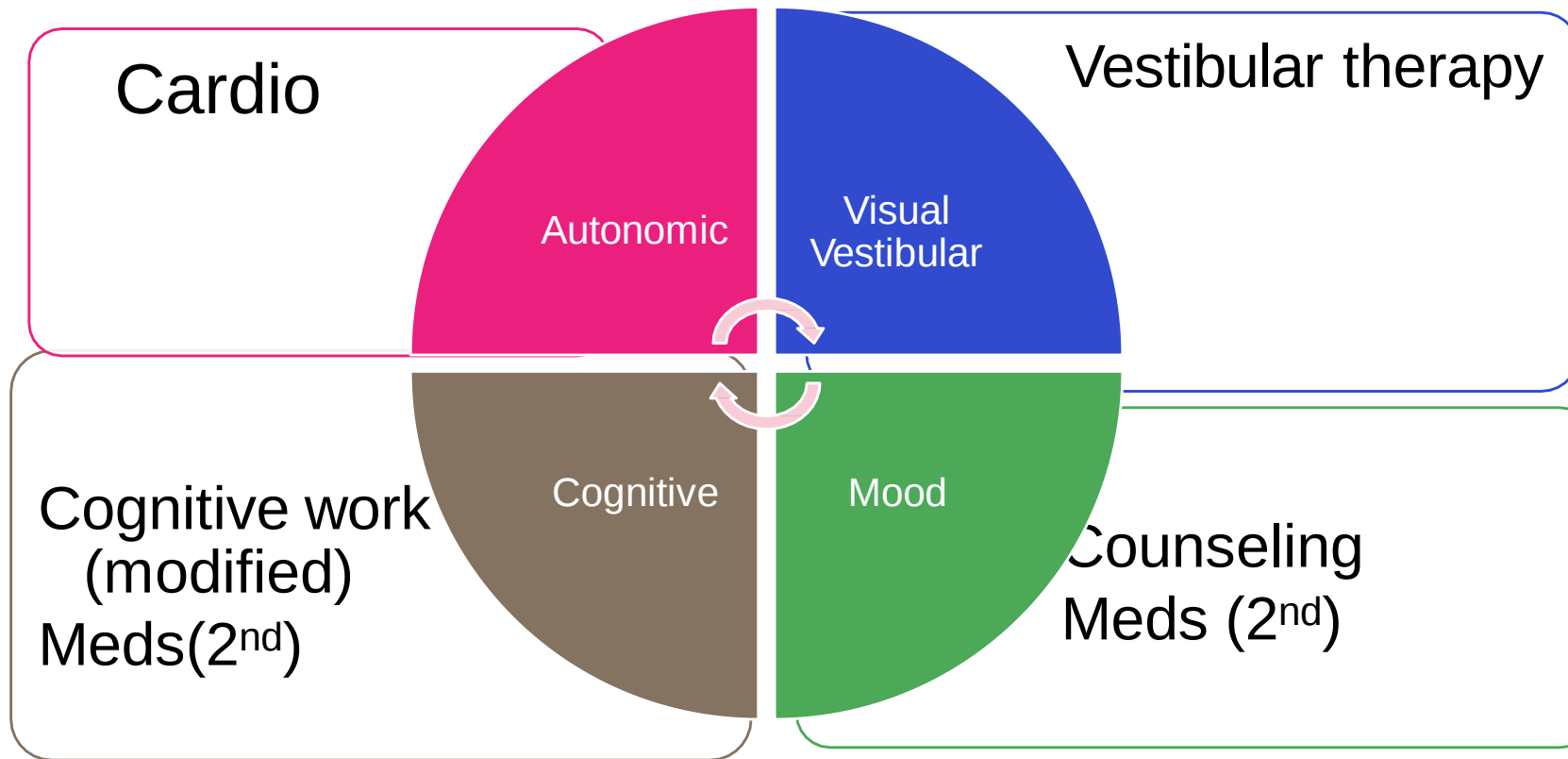
Generally, about 3 consecutive days of school and sports training with no symptoms

- 1.No symptoms with hard cardio and sports specific movements (i.e. you try to provoke symptoms and you can not)
- 2.No symptoms/return to normal cognitive function including testing
3. Normal VVE exam
- 4.Mood at baseline (this is hard since athletes maybe irritable until you let them play- clinical judgement but assess mood prior to return to play)

Case 2

- 17 year old squash player involved in MVA with airbags deployed.
- Initially seen in ED. Head CT was normal. Diagnosed with concussion.
- Seen by PMD: Very worried about keeping his number 1 class rank, unable to concentrate. Unable to read. Has a constant headache.
- PE: cannot track a fast moving object. Symptoms with 5 reps of vertical and horizontal saccades and gaze stability. Convergence is 12.
- Next steps

Concussion – Active Management



Case 2

- Appropriate for early referral to concussion team, but initial treatment still the same
- Concussion assessment- exercise challenge- fails step test (or Buffalo treadmill test).
- Plan:
- Autonomic: Start Cardio- 2 point rule
- Vestibular: Start home eye exercises today but expect to sent to vestibular therapy if not progressing (maybe needs vision therapy at later date)
- Cognitive : Start cognitive activity now- but markedly reduced level .
- Mood: At risk for mood issues- monitor with early referral

Case 2

- Two weeks later- still not able to do school work, now falling behind and worried about school. Reading makes headache worse. Walks 30 min day as directed- gets symptoms.
- PE- similar- still symptomatic with VVE.
- Plan
- More cardio
- Vestibular therapy
- School accommodations- long term solutions needed
- Referral to concussion psychologist, maybe neuropsych testing, maybe neurology referral to Headache specialist

Sample school re-entry accommodations

Use model of multiple areas that maybe affected
Each has its own set of accommodations



School Re-entry: Autonomic Dysfunction

- **Light sensitivity:** Sunglasses/hat, Decrease brightness on computer screen
- **Noise:** Ear plugs or testing in quiet environment (not in class), eat in quiet area
- **Fatigue mild:** Short frequent breaks if stamina is a problem, esp. in long classes,
- **Fatigue severe:** decrease the number of classes with breaks between classes, decrease overall work volume



School Re-entry: Vision- Vestibular Dysfunction

- **Saccades:**

- Decrease reading requirements (books on tape)
- Extra time for tests- (it takes longer to read)
- Pre-printed teachers notes (eliminates looking up and down)
- “Chunk” work- do in smaller segments

- **Convergence**

- Large print (18 font)- easier to track side to side
- Can use over the counter reading glasses (1.5 readers) for convergence deficits



School Re-entry: Cognitive Problems

- **Prioritize work:** Medically excuse some work, spend all available time and energy on core work – esp. classes that require work done in a certain order such as math etc.
- **Quiet testing environment**
- **Extra tutoring**
- **Self-pacing** on assignments
- **Extra time** to take tests/complete assignments



School re-entry: Cognitive Problems

- **Processing Speed:** Decrease cognitive load-decrease overall number of classes with breaks between classes to recover (try not to water-down classes),
- **Memory:** use memory banks for tests, limit rote memorization requirements, alter testing format
- **Attention span:** Stimulants may have a role, esp if pre-existing symptoms:
 - Methylphenidate



School Re-entry: Mood



- **Anxiety:**
 - have clear expectations for when work is due
 - School resource person if feeling overwhelmed
- **Depression**
 - Get counseling in place early
 - Recognize that school stress may contribute to poor compensating behaviors like cutting, esp. if previous history

Minds Matter ConcussionResources

- Practical Content
 - Families
 - Schools
 - Coaches
 - Clinicians
 - Video FAQ
- Downloads
 - Infographics
 - Posters
 - Fact sheets

www.chop.edu/concussion



Concussion?

Temporarily modify school work,
physical activity and screen time.

Minds Matter Frontier Team

Principal Investigators



Kristy Arbogast, PhD
CIRP Co-Scientific Director & Director of Engineering



Christina Master, MD, FAAP, CAQSM, FACSM
Sports Medicine, Brain Injury Medicine & General Peds

CIRP Co-Investigators



Dan Corwin, MD, MSCE
Assoc. Director of Research, ED



Catherine McDonald, PhD, RN, FAAN
Associate Professor, Penn Nursing



Declan Patton, PhD
Scientist (CIRP)



James Wilkes, PhD
Scientist (CIRP)

Research Collaborators



Grace Ren, PhD
Post-Doc (CIRP)



Olivia Podolak, PhD
Research Associate (CIRP)

Research Collaborators



Akiva Cohen, PhD
Anesthesia and Critical Care



Hakon Hakonarson, MD, PhD
Center for Applied Genomics



Todd Kilbaugh, MD
Anesthesia and Critical Care

Outreach



Suzanne Hill
Strategy Director (CIRP)



Greg Fry
Coordinator (CIRP)

Biostatisticians



Daniele Fedonni, MS



Joe Wu
Data Science & Biostatistics Unit



Pete Camacho, MS
Department of Biomedical and Health Informatics



Ian Barnett, PhD
Penn CCEB

Research Team



Leah Gaetz, MS
Program Manager (CIRP)



Madeline Consuelos, BA
Research Assistant (CIRP)



Jelsia Cottone, BS
Research Assistant (CIRP)



Melissa Godfrey, MPH
Project Manager (CIRP/EM)



Bhakti Marfatia, BS
Research Assistant (CIRP)



Natalie Maston, BS
Research Assistant (CIRP)



Anne Mozel, MS
Clinical Research Study Lead (CIRP)



Kate Rownd, MS
Research Coordinator (CIRP)



Karlie Pollock, BS
Research Assistant (CIRP)



Chelsea Ward McIntosh, MS
Project Manager (CIRP)



Kevin Pettijohn
Research Coordinator (EM)



Jenna Ratka, MS, ATC
Penn Athletics

Clinical Team



Jeffrey Albaugh, PT, MS, ATC
Program Manager



Naomi Brown, MD
Ortho



Mary Daley, MD
Ortho



Matt Grady, MD
Ortho



Brian Vernau, MD
Ortho



Edward Re, MD
Ortho



Chris Renjilian, MD
Ortho



Thomas Swaffield, MD
Ortho



Mary Iampietro, PhD
Neuropsych



Jamie Shoop, PhD
Psychology



Michael Nance, MD
Trauma



Natali Baner, MD
Neurology



Carlyn Patterson-Gentile, MD, PhD
Neurology



Christina Szperka, MD, MSCE
Neurology



Lindsey Calandra, MSN, CRNP
Ortho



Roni Robinson, MSN, CRNP
Trauma



Kelsy Stenger, BSN, RN
Ortho



Justin Cobb, ATC
Ortho



Kate Easby, DAT, ATC
Ortho



Colleen Ford, ATC
Ortho



Helen Gallagher, ATC
Ortho



Pam Grondski, ATC
Ortho



Ian McGinnis, ATC
Ortho



Dzovig Parsehian, ATC
Ortho



Liz Poturalski, ATC
Ortho



Kerri Schmanek, ATC
Ortho



Mary Stein, ATC
Ortho



Lindsey Perno, OD
Ophthalmology



Megan Beam, PT, DPT, PCS
Rehab



Alyssa Butkus, PT, DPT
Rehab



Michael Karl, PT, DPT, OCS, FAAOMPT
Rehab



Jordan Porter, MS, OTR/L
Rehab



Colleen McCabe
Nurse Navigator



Laura Keyes
Social Work

References

- Macnow T, Curran T, Tolliday C, Martin K, McCarthy M, Ayturk D, Babu KM, Mannix R. Effect of Screen Time on Recovery From Concussion: A Randomized Clinical Trial. *JAMA Pediatr*. 2021 Nov 1;175(11):1124-1131. doi: 10.1001/jamapediatrics.2021.2782. PMID: 34491285; PMCID: PMC8424526.
- Leddy JJ, Master CL, Mannix R, Wiebe DJ, Grady MF, Meehan WP, Storey EP, Vernau BT, Brown NJ, Hunt D, Mohammed F, Mallon A, Rownd K, Arbogast KB, Cunningham A, Haider MN, Mayer AR, Willer BS. Early targeted heart rate aerobic exercise versus placebo stretching for sport-related concussion in adolescents: a randomised controlled trial. *Lancet Child Adolesc Health*. 2021 Nov;5(11):792-799. PMID: 34600629.
- Vaughan CG, Ledoux AA, Sady MD, Tang K, Yeates KO, Sangha G, Osmond MH, Freedman SB, Gravel J, Gagnon I, Craig W, Burns E, Boutis K, Beer D, Gioia G, Zemek R; PERC 5P Concussion Team. Association Between Early Return to School Following Acute Concussion and Symptom Burden at 2 Weeks Postinjury. *JAMA Netw Open*. 2023 Jan 3;6(1):e2251839. doi: 10.1001/jamanetworkopen.2022.51839. PMID: 36662524; PMCID: PMC9860528.
- Langdon R, Taraman S. Posttraumatic Headache. *Pediatr Ann*. 2018 Feb 1;47(2):e61-e68. doi: 10.3928/19382359-20180131-01. PMID: 29446796.

References

- Rivara FP, Ebel BE, Binjolkar M, Wang J, Hanron A, Kroshus E, Boyle LN, Patrick KE. Cognitive Impairment and Driving Skills in Youth After Concussion. *J Neurotrauma*. 2023 Jun;40(11-12):1187-1196. doi: 10.1089/neu.2022.0308. Epub 2022 Dec 26. PMID: 36416238; PMCID: PMC10259608.
- Kerwin T, McManus B, Wrabel C, Kalra V, Stavrinos D, Yang J. Driving performance acutely after mTBI among young drivers. *Accid Anal Prev*. 2023 Dec;193:107299. doi: 10.1016/j.aap.2023.107299. Epub 2023 Sep 25. PMID: 37757657; PMCID: PMC10641870.
- Patricios JS, Schneider KJ, Dvorak J, Ahmed OH, Blauwet C, Cantu RC, Davis GA, Echemendia RJ, Makdissi M, McNamee M, Broglio S, Emery CA, Feddermann-Demont N, Fuller GW, Giza CC, Guskiewicz KM, Hainline B, Iverson GL, Kutcher JS, Leddy JJ, Maddocks D, Manley G, McCrea M, Purcell LK, Putukian M, Sato H, Tuominen MP, Turner M, Yeates KO, Herring SA, Meeuwisse W. Consensus statement on concussion in sport: the 6th International Conference on Concussion in Sport-Amsterdam, October 2022. *Br J Sports Med*. 2023 Jun;57(11):695-711. doi: 10.1136/bjsports-2023-106898. PMID: 37316210.
- Chizuk HM, Willer BS, Cunningham A, Bezherano I, Storey E, Master C, Mannix R, Wiebe DJ, Grady MF, Meehan WP, Leddy JJ, Haider MN. Adolescents with Sport-Related Concussion Who Adhere to Aerobic Exercise Prescriptions Recover Faster. *Medicine & Science in Sports & Exercise*. 54(9):1410-1416, September 2022

References

- Master CL, Corwin DJ, Fedonni D, Ampah SB, Housel KC, McDonald C, Arbogast KB, Grady MF. Dose-Response Effect of Mental Health Diagnoses on Concussion Recovery in Children and Adolescents. Sports Health. 2024 Mar-Apr;16(2):254-268. doi: 10.1177/19417381241228870. Epub 2024 Feb 13. PMID: 38349046; PMCID: PMC10916772.