Balance after mTBI

OHSU Balance Disorders Laboratory

DATE: October 20, 2023

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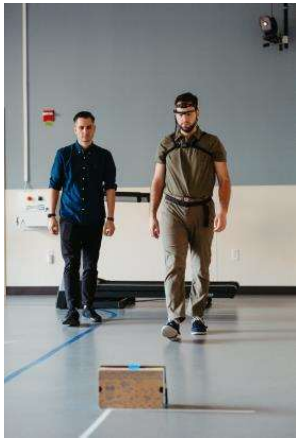
OHSU Balance Disorders Laboratory



Funding: This work was supported by the Assistant Secretary of Defense for Health Affairs under Awards: #W81XWH-15-1-0620 (King; PI); #W81XWH-17-1-0424 (King; PI); #W81XWH-18-2-0049 (King; PI) and #HT9425-23-1-0845 (King; PI) Opinions, interpretations, conclusions and recommendations are those of the author and are not necessarily endorsed by the Department of Defense.

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Update on current research on balance disorders after mTBI: Going beyond the guidelines

Consensus statement

American Medical Society for Sports Medicine position statement on concussion in sport

Kimberly G Harmon,[1] James R Clugston,[2] Katherine Dec,[3] Brian Hainline,[4] Stanley Herring,[5] Shawn F Kane,[6] Anthony P Kontos,[7] John J Leddy,[8] Michael McCrea,[9] Sourav K Poddar,[10] Margot Putukian,[11,12] Julie C Wilson,[13] William O Roberts[14]

g 2014;49(2):245–265
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Concussion crosses many domains of practice reflected in multiple Position Statements and Consensus Statements

- American Academy Neurology
- American Academy PMR
- American Medical Society Sports Medicine
- National Athletic Training Association
- Concussion in Sports Group international consensus

National Athletic Trainers' Association Position Statement: gement of Sport ussion

P. Broglio, PhD, ATC*; Robert C. MD†; Gerard A. Gioia, PhD‡; Kevin M. wicz, PhD, ATC, FNATA, FACSM§; Kutcher, MD*; Michael Palm, MBA, amara C. Valovich McLeod, PhD, ATC, ¶

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POSITION STATEMENT ON CONCUSSION IN YOUTH SPORTS

The American Academy of Physical Medicine and Rehabilitation (AAPM&R) is the national medical society representing more than 8,000 physiatrists - physicians who are specialists in the field of physical medicine and rehabilitation. With a focus on restoring function, physiatrists treat children and adults. Physiatrists treat persons with acute and chronic pain, acute sports injuries including concussion as well as chronic injury, persons who have experienced catastrophic events resulting in paraplegia, quadriplegia, or traumatic brain injury, musculoskeletal injuries, and individuals with neurologic disorders such as stroke, multiple sclerosis, or any other disease process that results in impairment and/or disability. PM&R physicians treat any disability resulting from disease, sports-related activities or injury involving any organ system and their goal is to decrease pain and enhance performance without surgery. AAPM&R strongly supports public policies that reduce injuries, including concussions, in youth sports.

aaPM&R
American Academy of Physical Medicine and Rehabilitation

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AMERICAN ACADEMY OF NEUROLOGY

*******EMBARGOED UNTIL 12PM ET, MONDAY, NOVEMBER 1, 2010*******

AMERICAN ACADEMY OF NEUROLOGY POSITION STATEMENT ON SPORTS CONCUSSION

ment

Consensus statement on concussion in sport—the 5th international conference on concussion in sport held in Berlin, October 2016

Paul McCrory,[1] Willem Meeuwisse,[2] Jiří Dvorak,[3,4] Mark Aubry,[5] Julia Steven Broglio,[7] Robert C Cantu,[8] David Cassidy,[9] Ruben J Echemen Rudy J Castellani,[12] Gavin A Davis,[13,14] Richard Ellenbogen,[15] Caroly

NCAA | SPORT SCIENCE INSTITUTE

INTERASSOCIATION CONSENSUS:
DIAGNOSIS AND MANAGEMENT OF SPORT-RELATED CONCUSSION BEST PRACTICES

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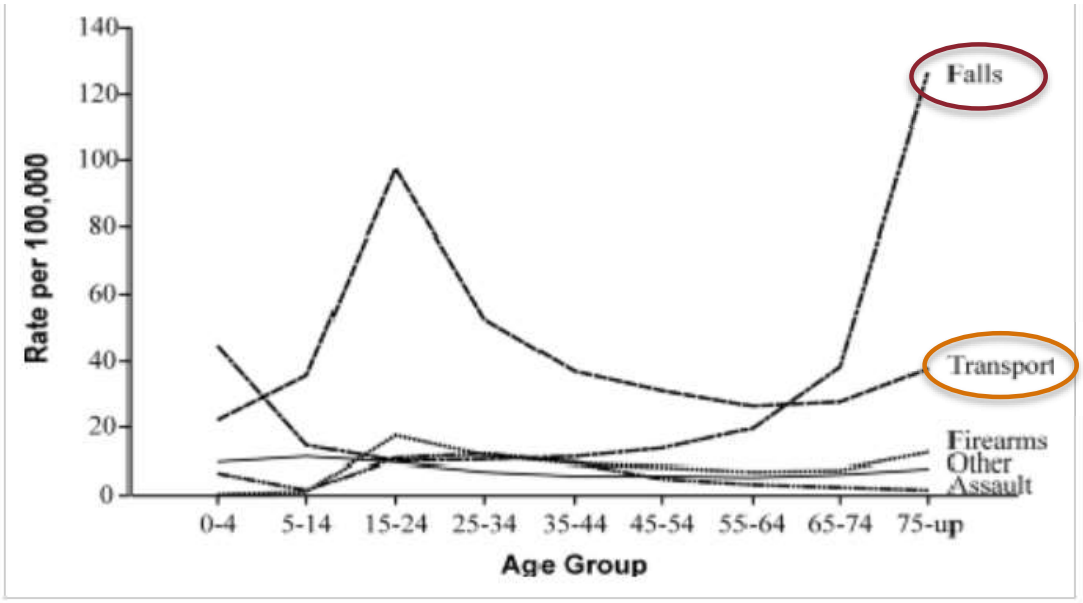
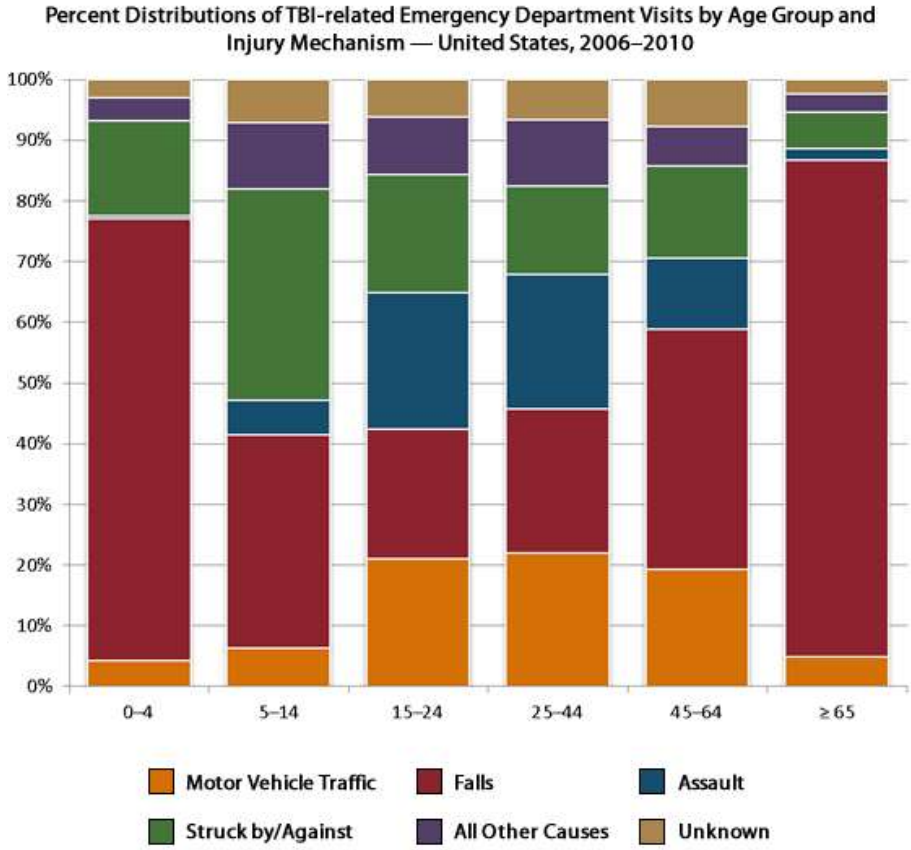
TBIs occur across the lifespan

*





CDC Report to Congress: Traumatic Brain Injury in the United States 1999, Traumatic Brain Injury and Concussion 2016

Older people unlikely to be seen by sports medicine where most rehabilitation referrals occur

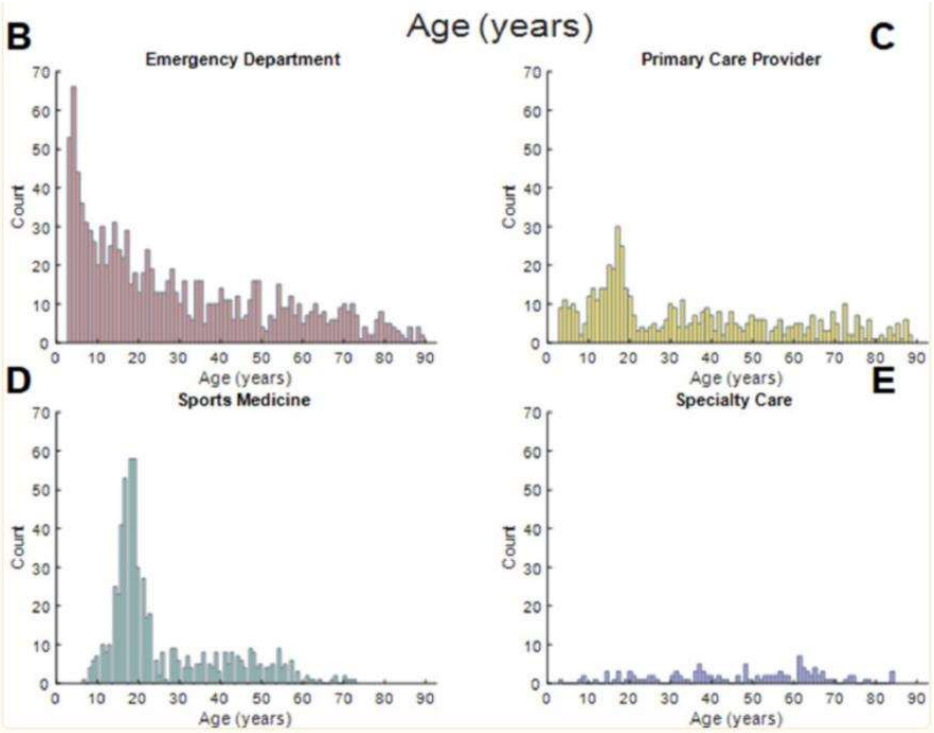


Fig 2

Histograms displaying the age distributions for **(A)** all points of entry (N=2417), **(B)** ED (n=1137), **(C)** primary care provider (n=554), **(D)** sports medicine (n=607), and **(E)** specialty departments (n=119).

Table 1

Odds ratios for rehabilitation referrals

	Odds Ratio	95% Confidence Interval	*P* Value
Sex (ref=male)	1.92	1.54-2.39	<.0001
Point of entry (ref=ED)			
Primary care provider	7.98	4.67-13.61	<.0001
Sports medicine	75.05	45.87-122.79	<.0001
Specialty care	7.62	3.64-15.99	<.0001
Comorbidity diagnosis (ref=no comorbidity)*	2.12	1.70-2.66	<.0001

Martini et al., 2022

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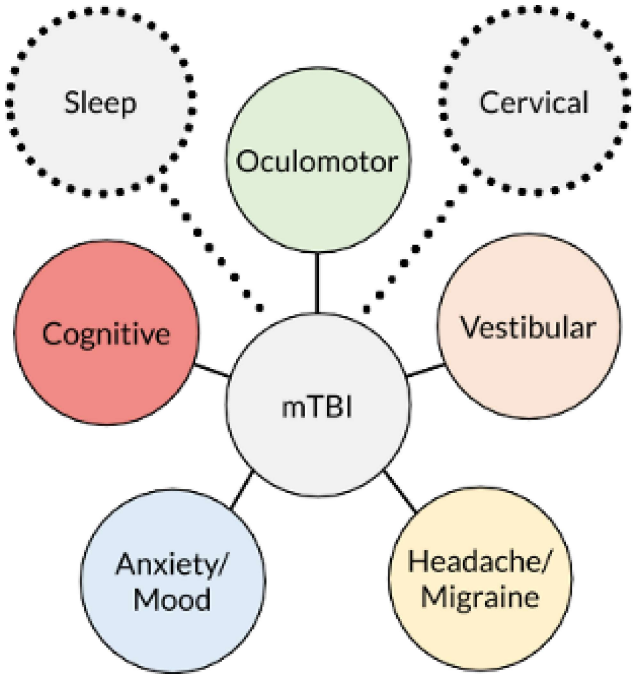
Concussion Subtypes



- Will using objective measures help define subtypes better to enable early rehabilitation?
- Would physical therapy be most effective for vestibular and oculomotor subtypes?
- Are there other subtypes or modifiers that we need to consider?

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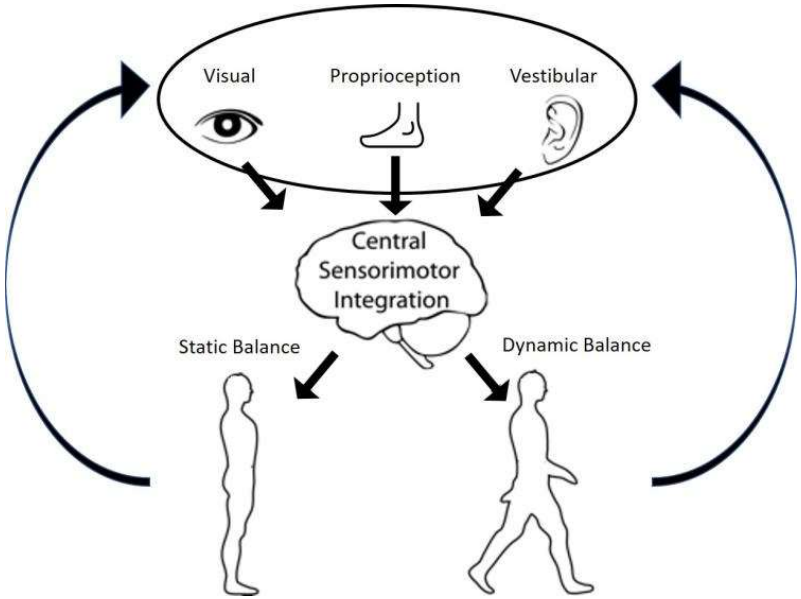
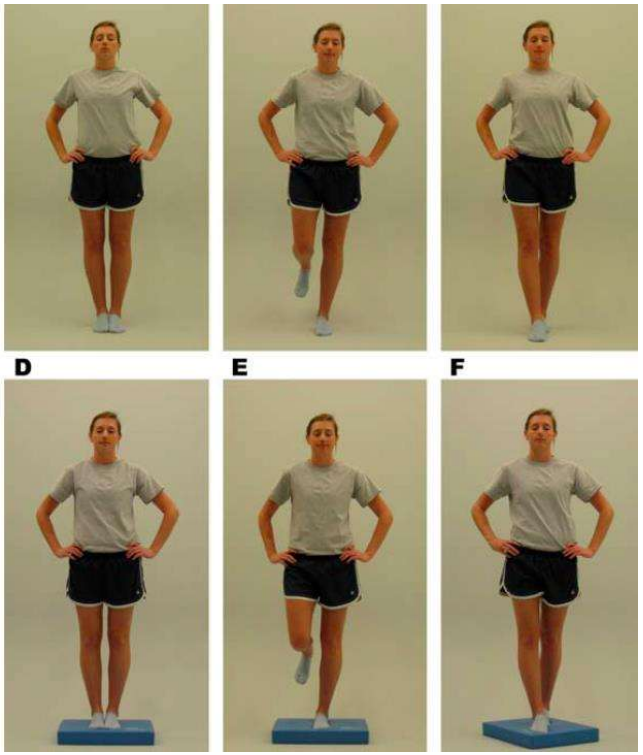
Central sensory motor integration: Is motor or sensory more impaired after mTBI?

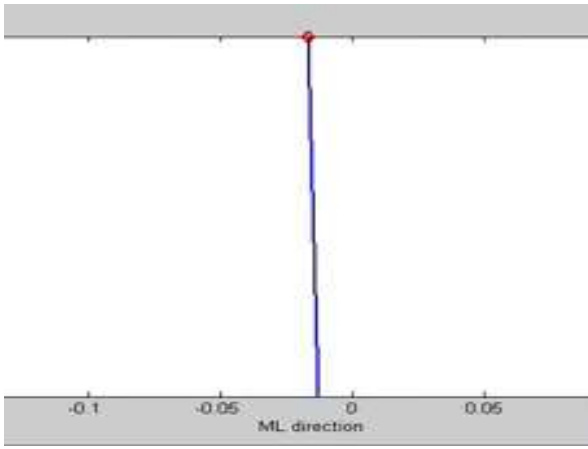
How do we measure balance?



Conceptual Model

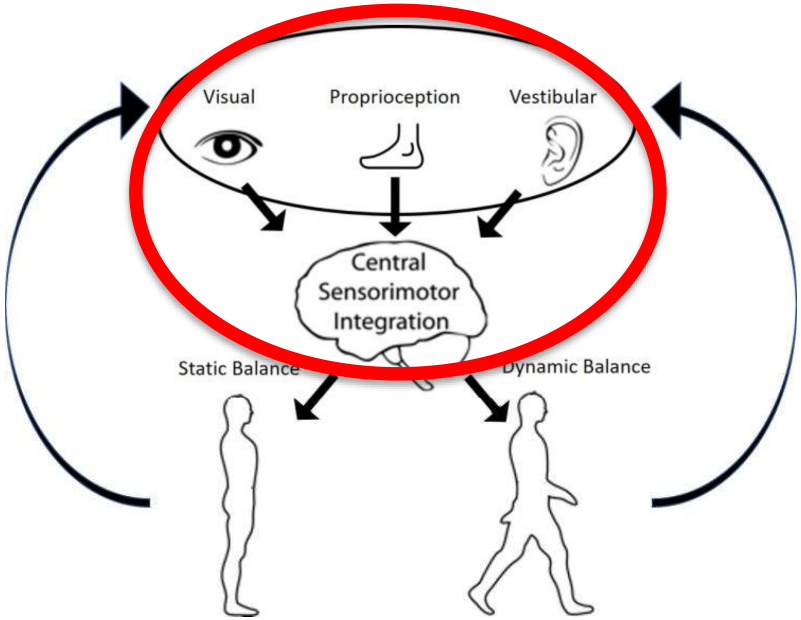


Common Clinical Test



Instrumented Clinical Test

How do we measure balance?



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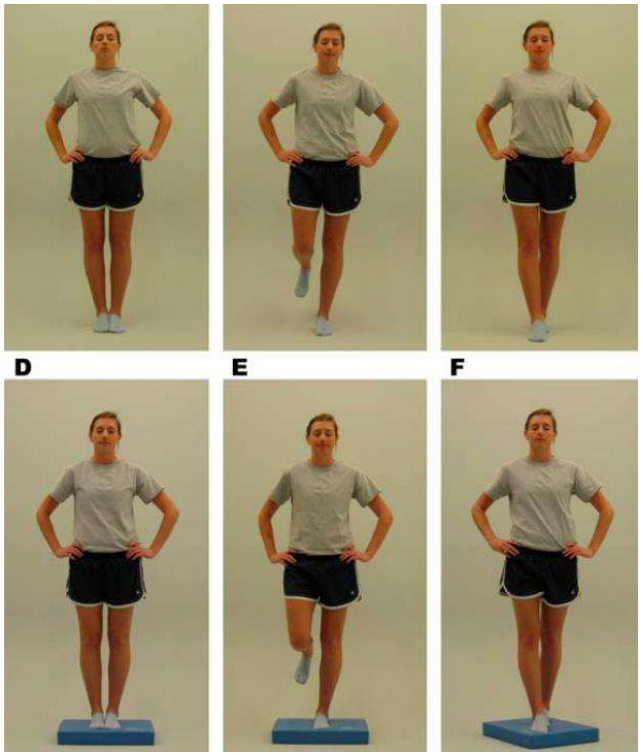

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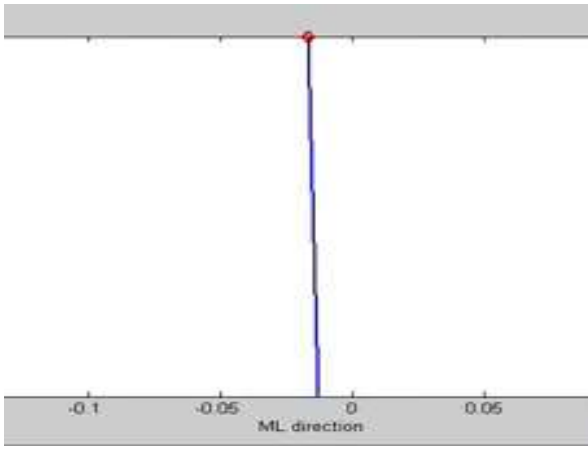

Instrumented Clinical Test

Peripheral Vestibular and Ocular motor function in chronic mTBI

Table 1: Overview of abnormal and normal oculomotor, peripheral vestibular, and central sensory integration for static balance function for healthy control and chronic mild traumatic brain injury (mTBI) groups.

Parameter	Abnormal Cutoff Value	Healthy Control N Abnormal / Total N (%)	Chronic mTBI N Abnormal / Total N (%)	Chi Square *p* Value
Oculomotor				
Saccades - Accuracy	< 85 %	5 / 52 (10%)	4 / 50 (8%)	1.000
Saccades - Latency	> 218 ms	6 / 52 (12%)	6 / 50 (12%)	0.942
Saccades - Velocity	< 339 deg/s	6 / 52 (12%)	1 / 50 (2%)	0.113
Smooth Pursuit – Average Velocity Gain	< 0.72	6 / 52 (12%)	5 / 49 (10%)	0.830
Smooth Pursuit - Velocity Gain Asymmetry	> 6 %	6 / 52 (12%)	7 / 49 (14%)	0.680
Peripheral Vestibular				
Caloric - Unilateral Weakness	> 30 %	4 / 49 (8%)	6 / 33 (18%)	0.302
Caloric - Average Slow Phase Velocity	< 9.35 deg/s	5 / 49 (10%)	5 / 33 (15%)	0.733
vHIT - Average VOR Gain	< 0.87	6 / 52 (12%)	1 / 49 (4%)	0.113
vHIT - VOR Gain Asymmetry	> 8% %	6 / 52 (12%)	7 / 49 (14%)	0.680
cVEMP - Asymmetry	> 31 %	5 / 49 (10%)	3 / 40 (8%)	0.726
oVEMP - Asymmetry	> 39 %	4 / 41 (10%)	5 / 29 (17%)	0.473
Central Sensory Integration				
SOT - Composite Score	< 61.8	6 / 60 (10%)	***28 / 54 (52%)***	***< 0.001***
SOT - Somatosensory Ratio	< 93.1	6 / 60 (10%)	***33 / 54 (61%)***	***< 0.001***
SOT - Visual Ratio	< 55.5	6 / 60 (10%)	***23 / 54 (43%)***	***< 0.001***
SOT - Vestibular Ratio	< 35.5	6 / 60 (10%)	***22 / 54 (41%)***	***< 0.001***

Abnormal cutoff values were derived from 10 percentile cutoffs calculated from healthy control data. Parameters bolded and italicized indicates a significant difference in the proportion of abnormal function for the mTBI group compared to the healthy control group ($p < 0.05$). N – number of participants; vHIT – video Head Impulse Test; VOR – Vestibular Ocular Reflex; cVEMP – cervical vestibular evoked myogenic potential; oVEMP – ocular vestibular evoked myogenic potential; SOT – Sensory Organization Test.

Campbell 2021, *J Vestib Res*

Award#: W81XWH-15-1-0620 (King; PI)

No Peripheral Vestibular or Ocular motor deficits in chronic mTBI

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Campbell 2021, *J Vestib Res*

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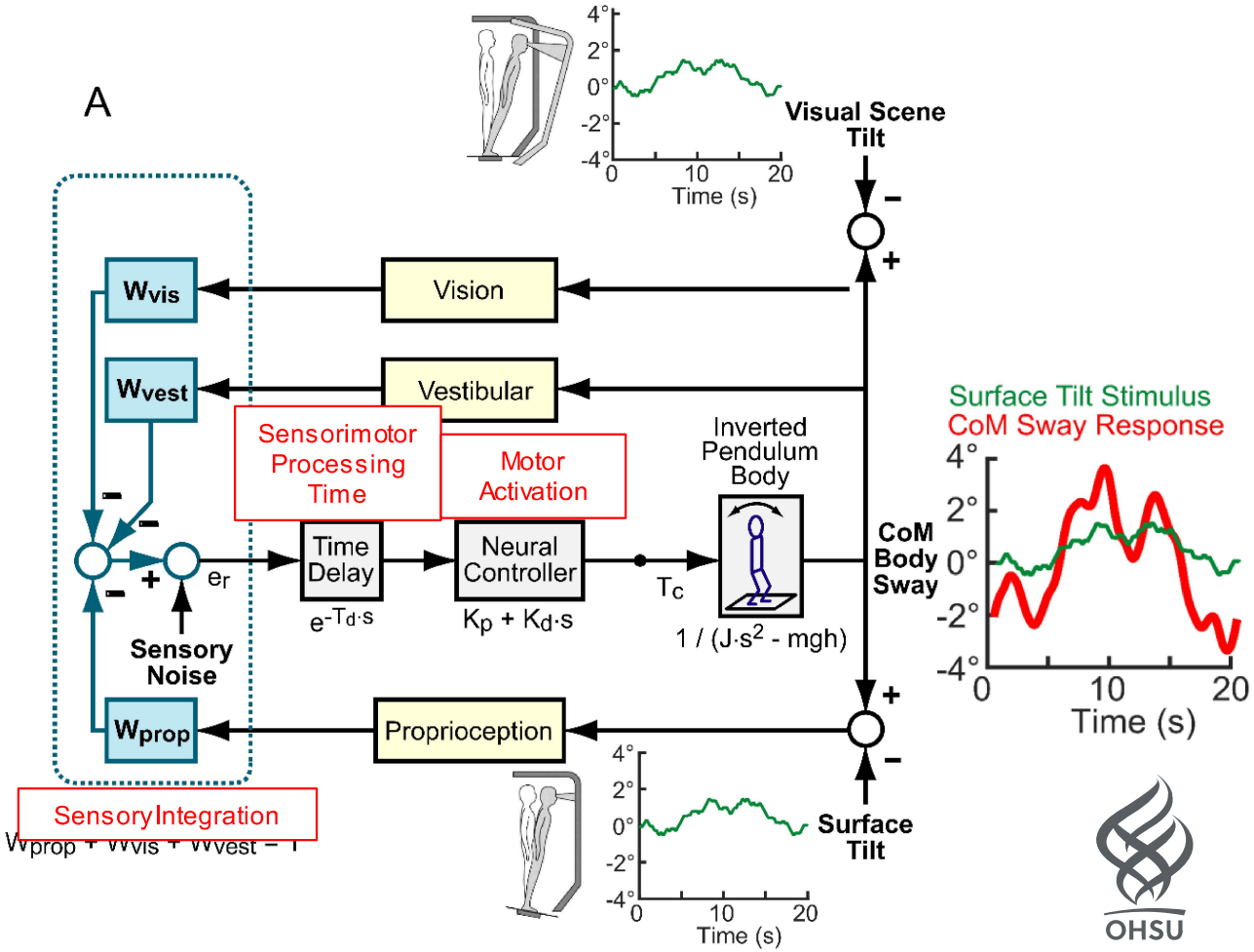
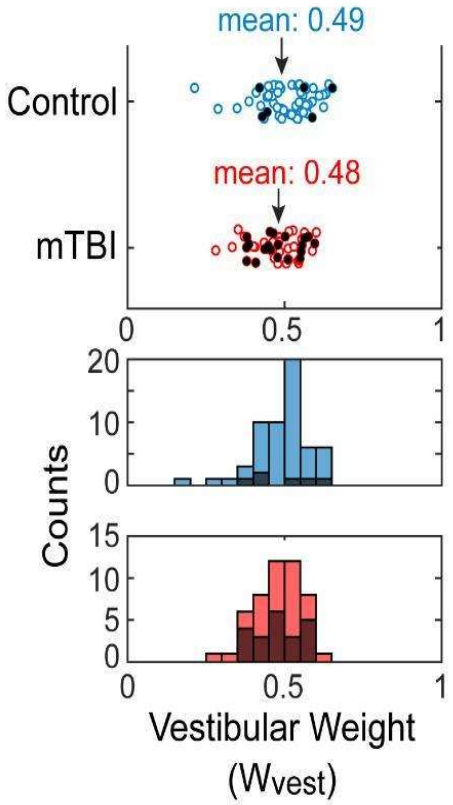
Central Sensorimotor Integration Test: CSMI Test



Peterka 2018, *Front Neurol;* Peterka 2002, *J Neurophysiol*

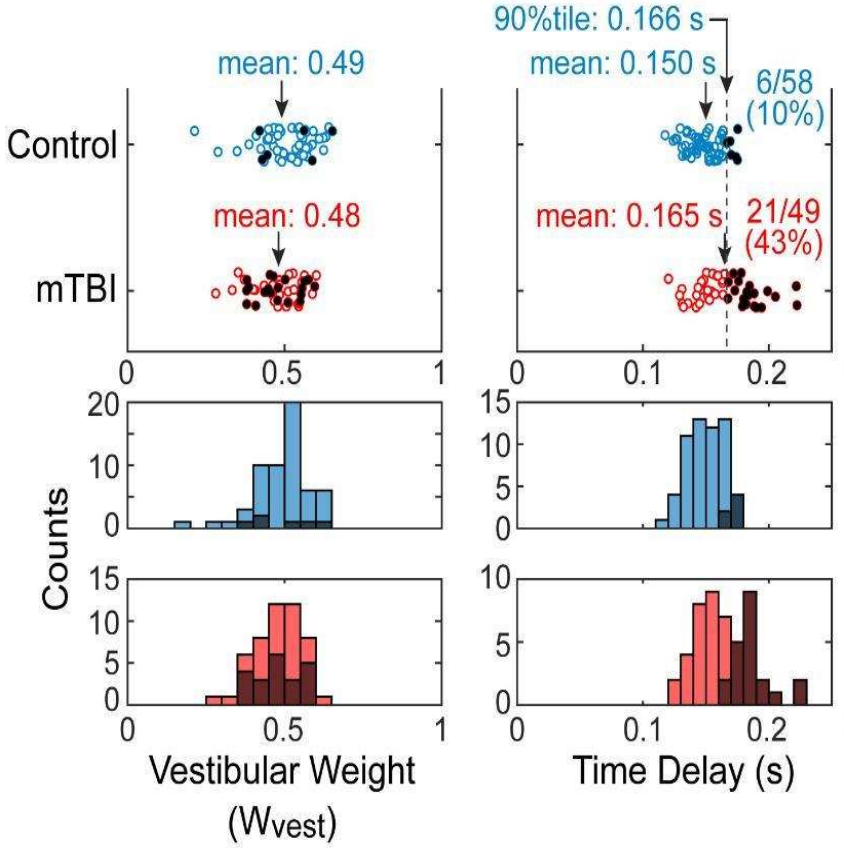
No difference in Vestibular Weight for people with chronic symptoms after concussion



CSMI model parameter distributions for HC (blue) and mTBI (red). Black data points had time delays > the HC derived 90%^{ile} cutoff.

Campbell 2022, *Front Neurol*

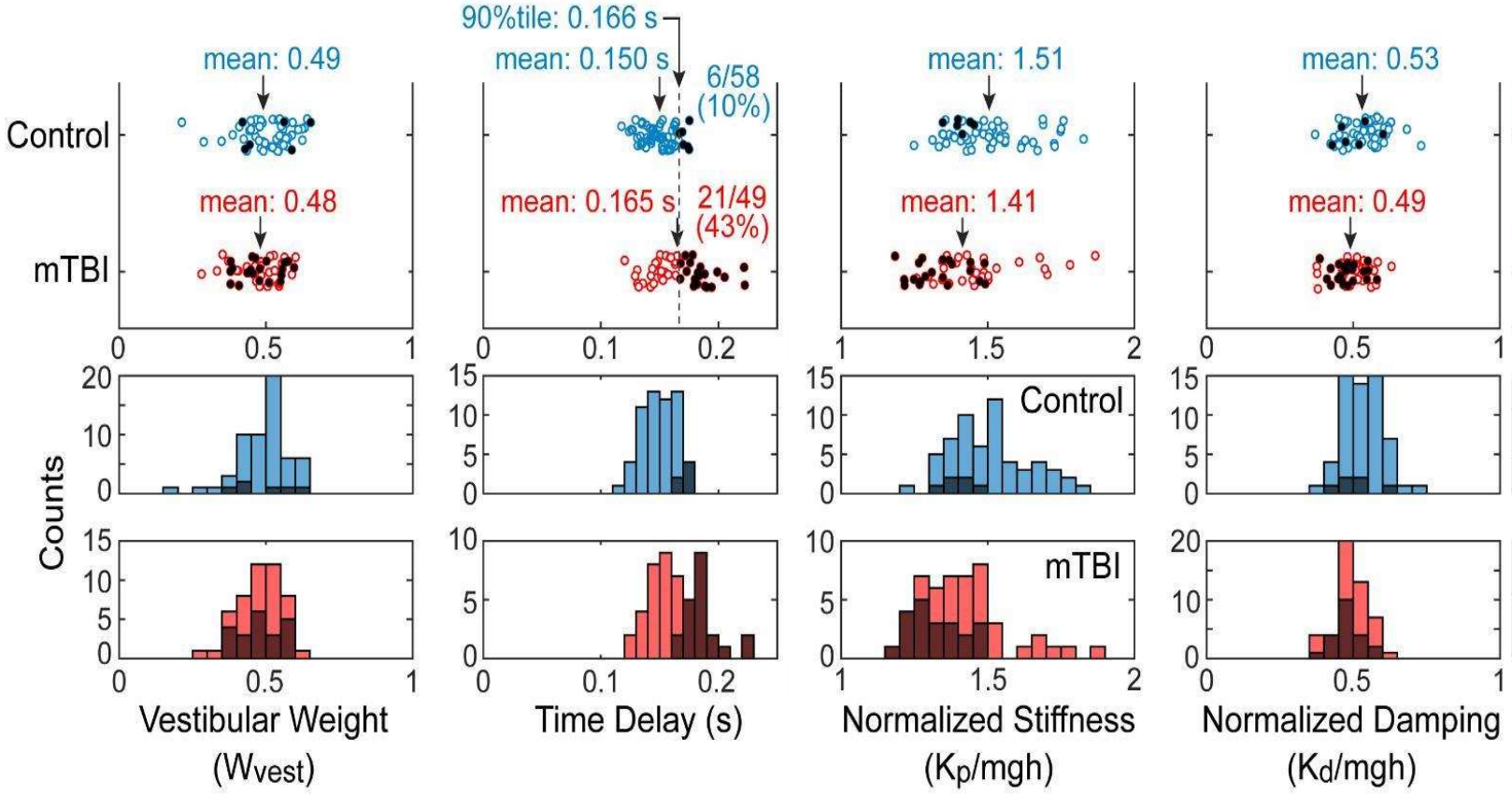
Significantly Longer Time Delays for people with chronic symptoms after concussion



CSMI model parameter distributions for HC (blue) and mTBI (red). Black data points had time delays > the HC derived 90%^{ile} cutoff.

Campbell 2022, *Front Neurol*

Significantly worse motor activation for people with chronic symptoms after concussion



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Campbell 2022, *Front Neurol*

Rehabilitation: Does early initiation of physical therapy after mTBI improve balance outcomes?

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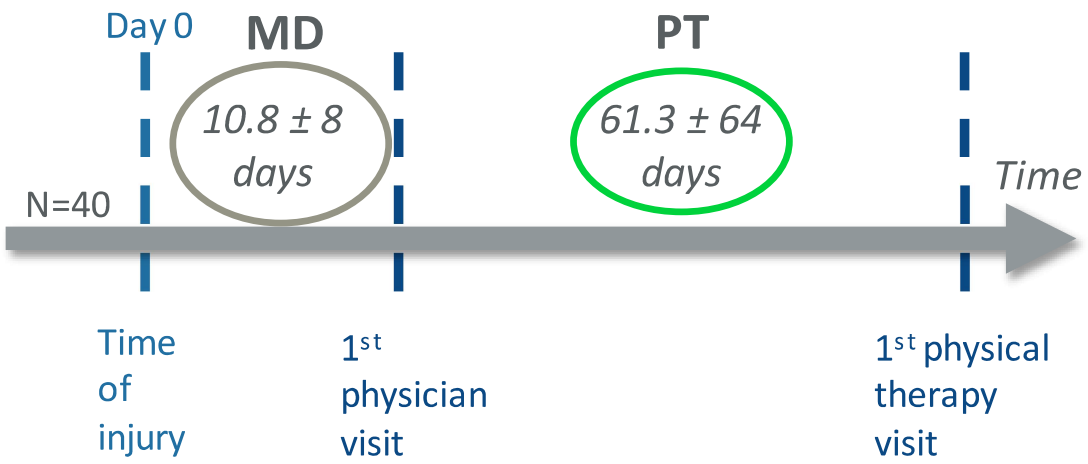
Guidelines for initiating rehabilitation inconsistent and unclear



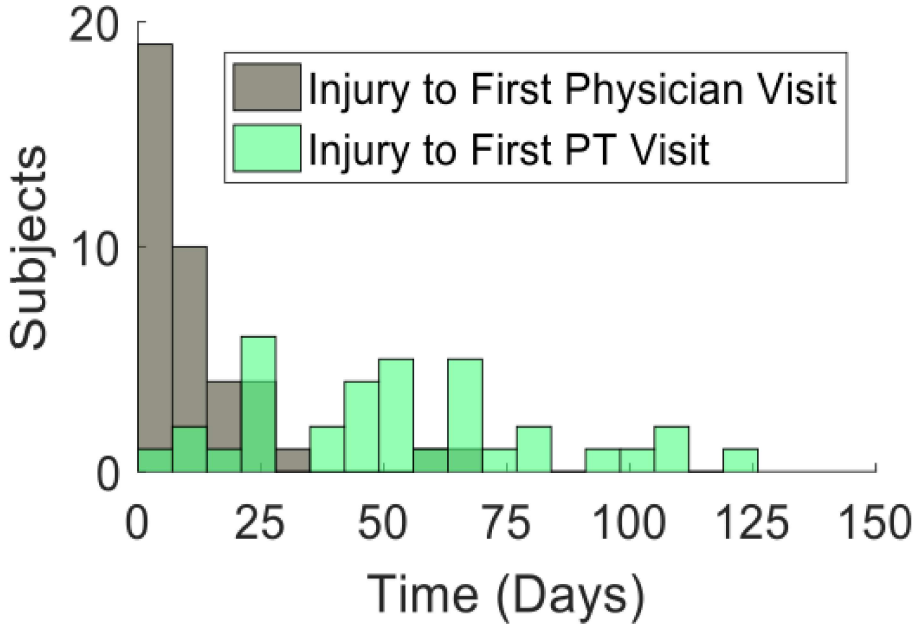


Figure 1. *Average time from injury to first visit with a physician and time from first physician visit to first visit with a physical therapist*

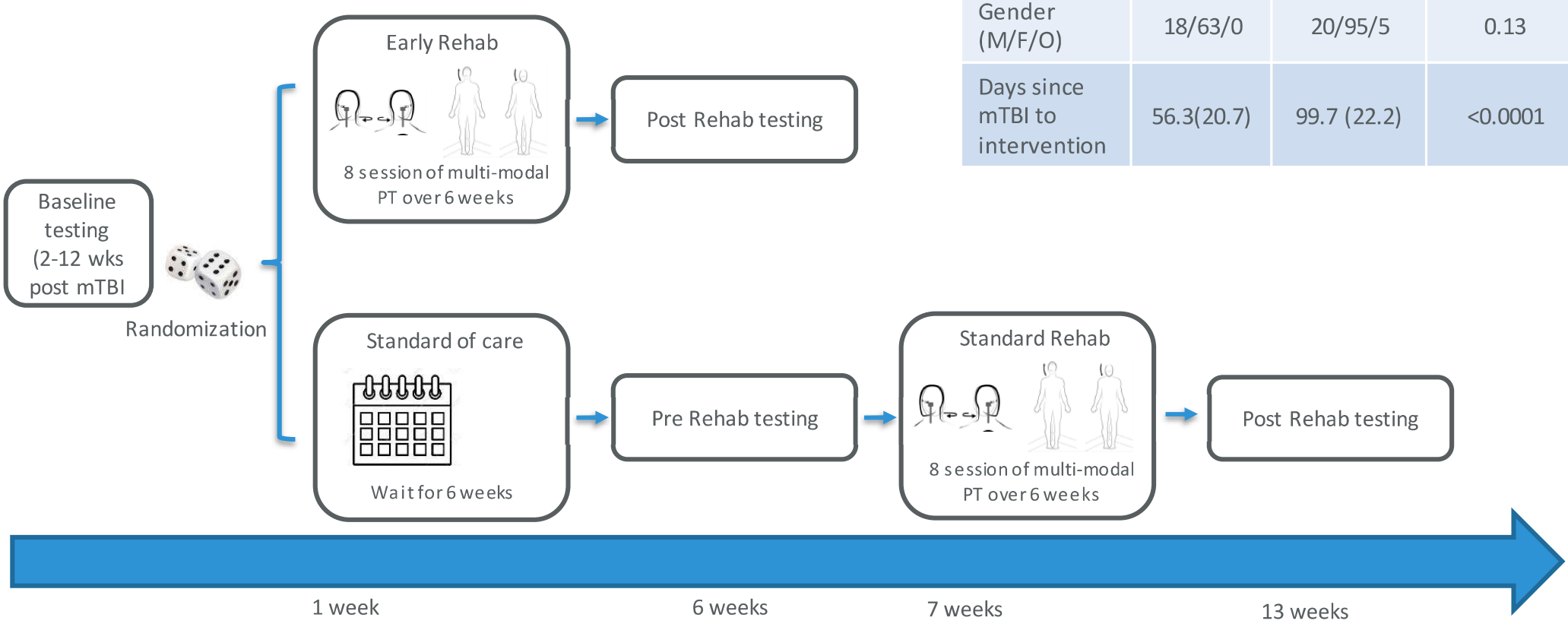
Figure 2. *Histograms showing distribution of time from injury until the first physician visit and until the first physical therapy visit.*

Award # W81XWH-17-1-0424 (King; PI, Pilot Data)

Overview of the Sensor Technology and Rehabilitative Timing (START) Study

*Now completed

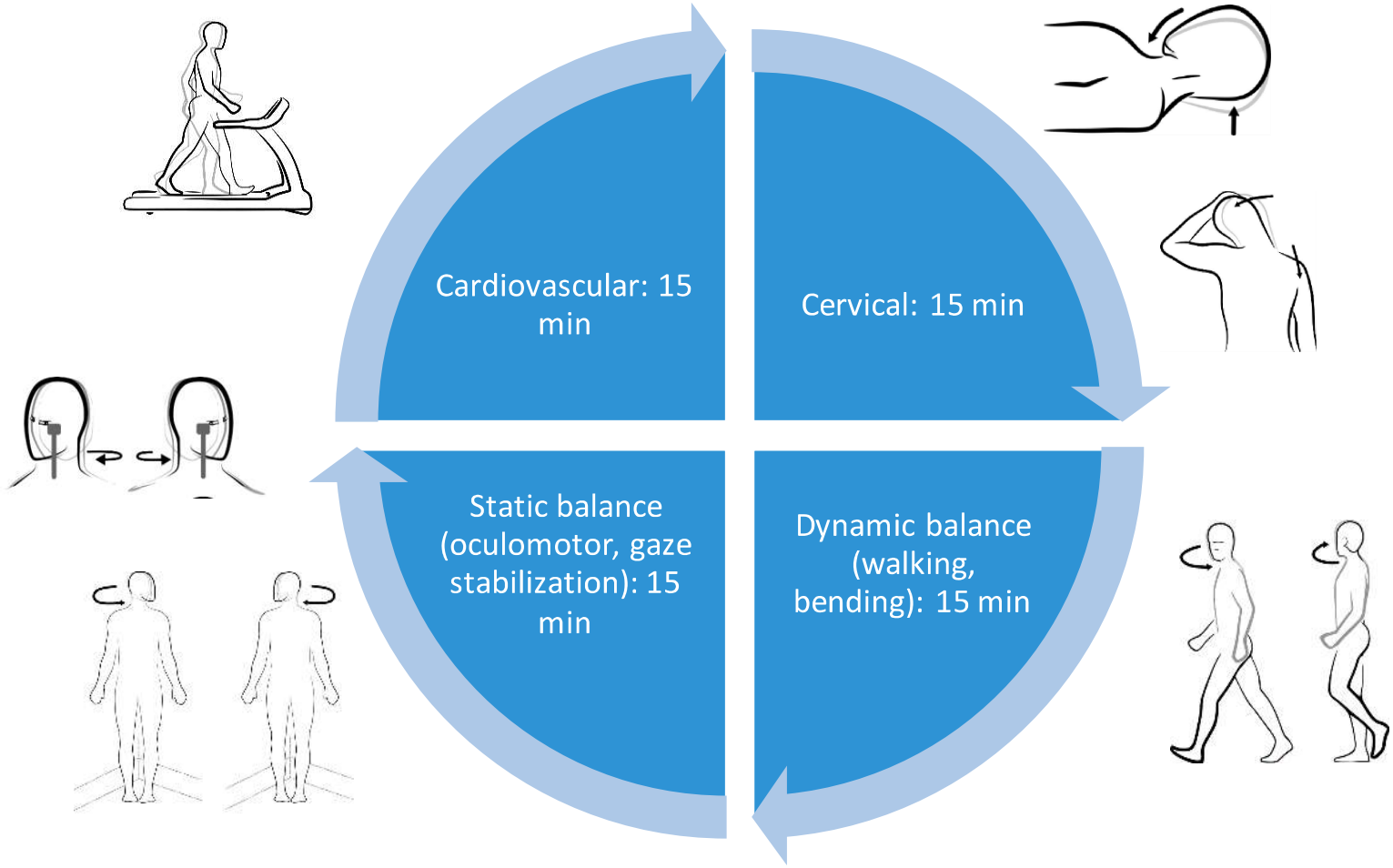
	Early Rehab (n=81)	Standard of care Rehab (n=121)	Group Difference p-value
Age, years (mean (SD))	35.6 (11.6)	36.0 (11.2)	0.80
Gender (M/F/O)	18/63/0	20/95/5	0.13
Days since mTBI to intervention	56.3(20.7)	99.7 (22.2)	<0.0001



Parrington et al; 2020

Award # W81XWH-17-1-0424 (King; PI)

Intervention based on Clinical Practice Guidelines



Parrington et al; 2020

Award # W81XWH-17-1-0424 (King; PI)

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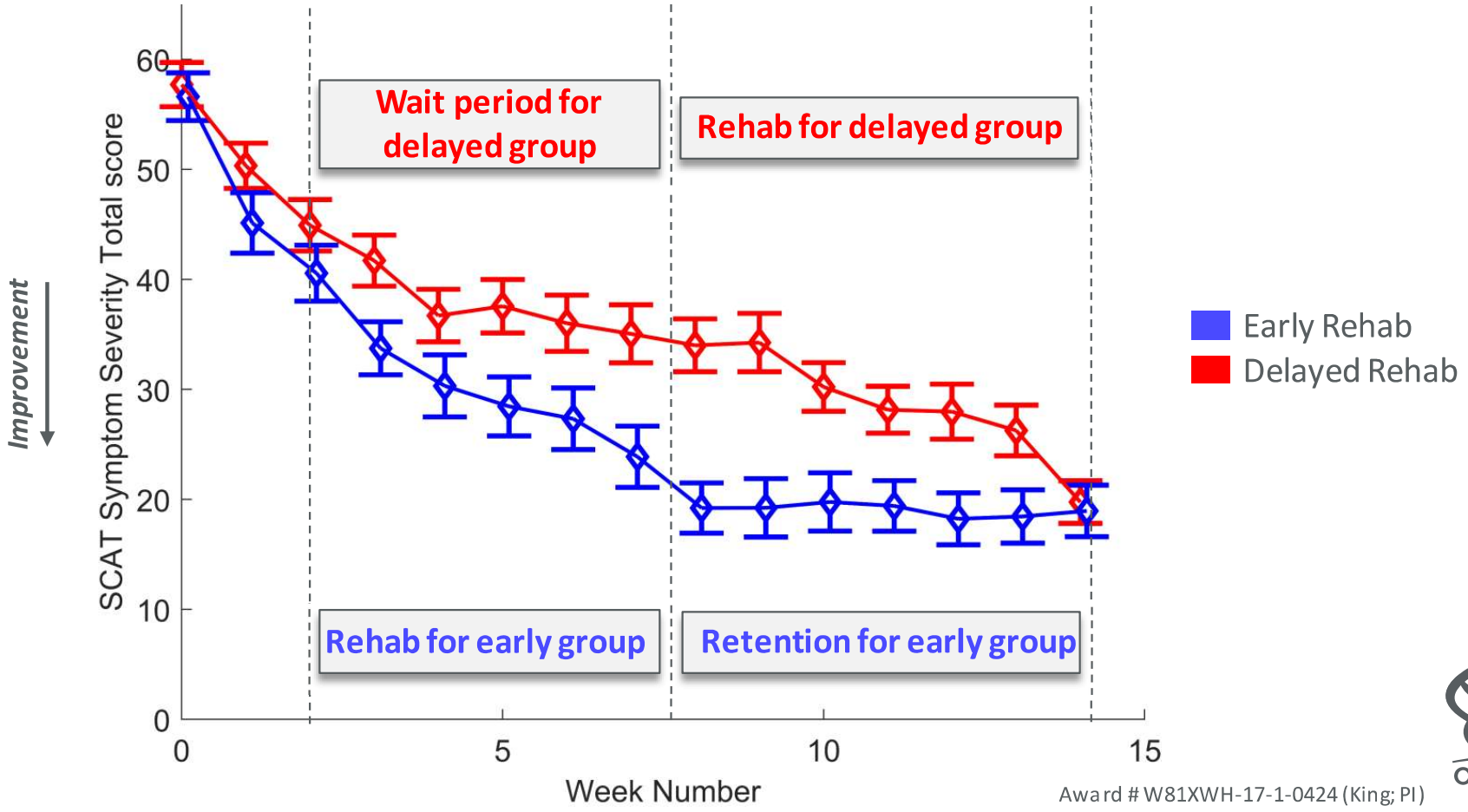
Early initiation of rehab leads to symptom improvement at a faster rate than delayed rehab



Award # W81XWH-17-1-0424 (King; PI)

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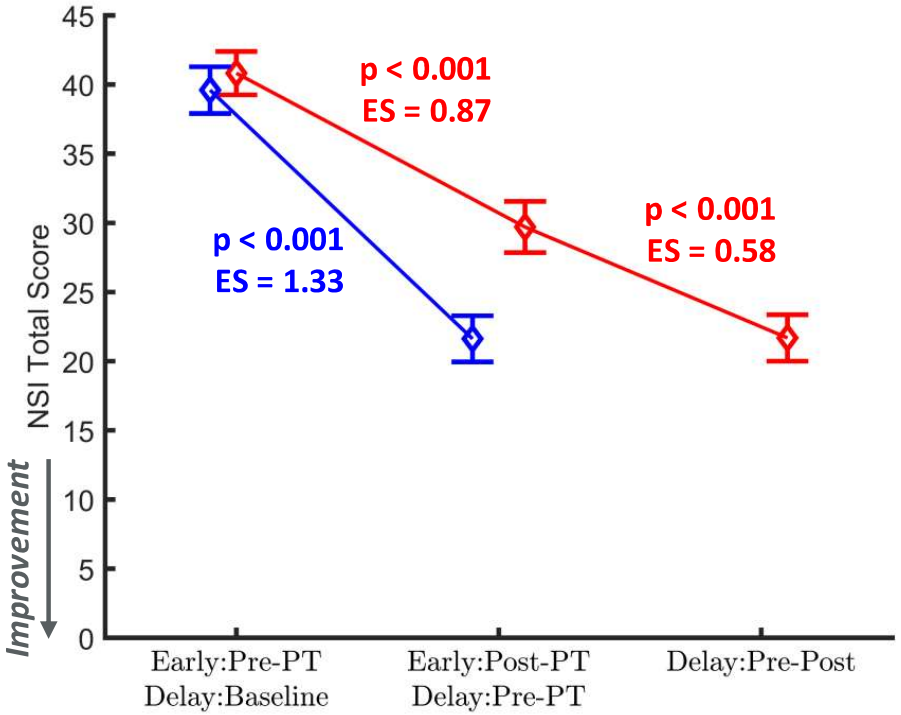
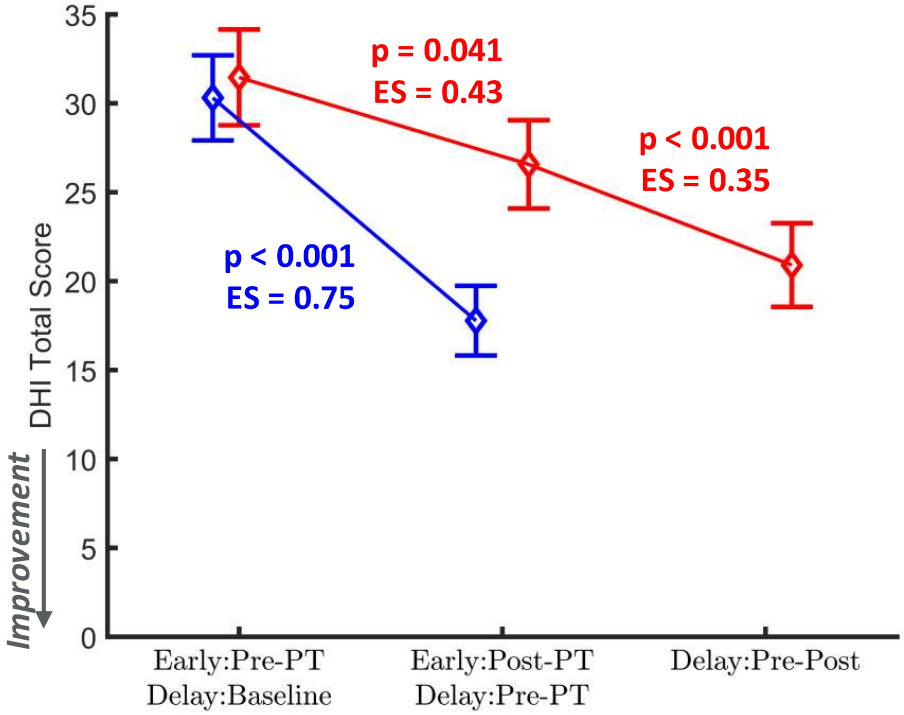
Improvements in global mTBI and vestibular specific symptoms faster more with early initiation of PT





Early Rehab
Delayed Rehab

Award # W81XWH-17-1-0424 (King; PI)

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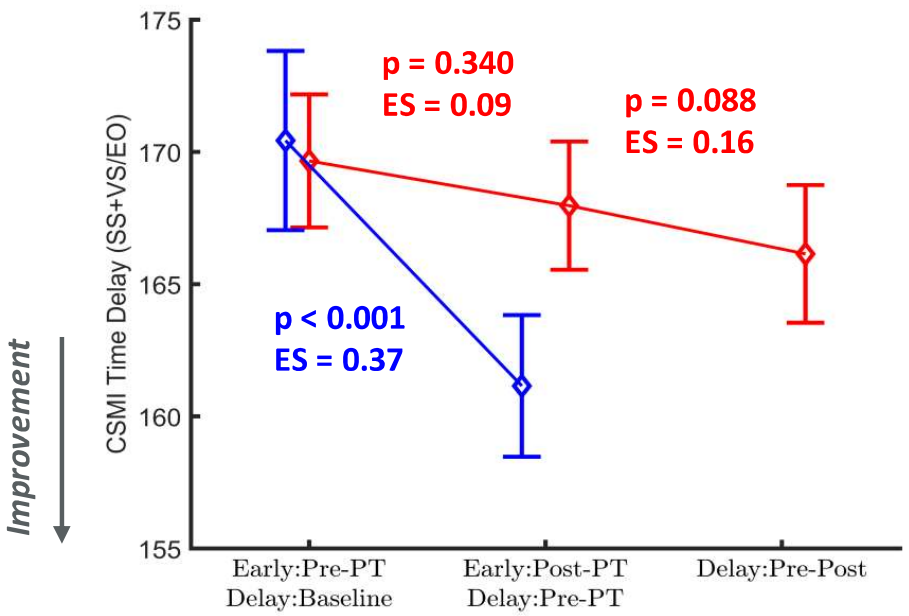
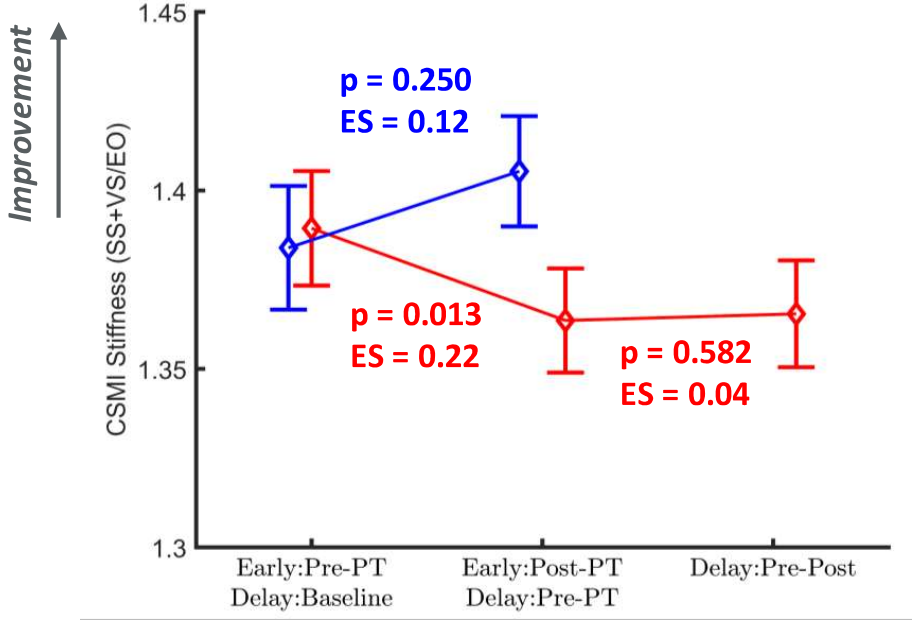
Delaying rehab may induce maladaptive motor activation responses that do not improve with rehabilitation





Early Rehab
Delayed Rehab

Award # W81XWH-17-1-0424 (King; PI)

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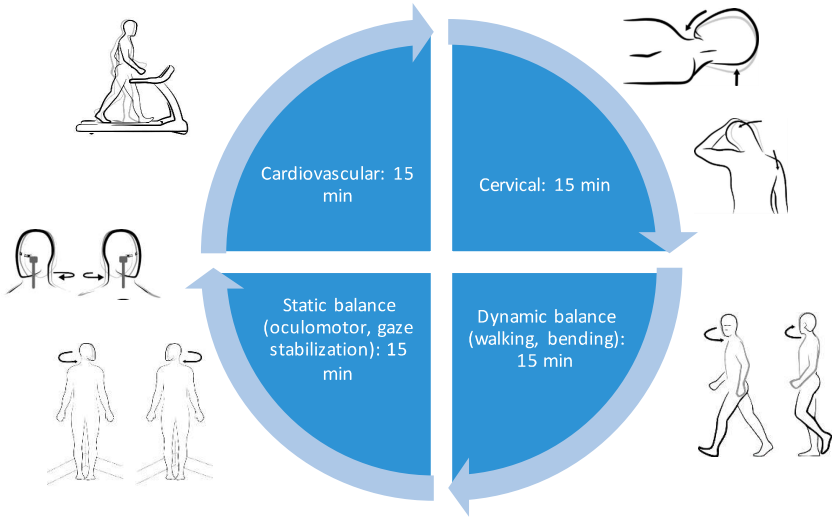
Clinical Implications

- Early rehabilitation
  - Improves symptoms at a faster rate than Delayed Rehab
  - May prevent maladaptive motor responses that occur with Delayed Rehab
- Current clinical guidelines do not include motor activation for assessment or rehabilitation
  - Musculoskeletal injuries and concussion reoccurrence in athletes that return without symptoms?



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Exercise intolerance after mTBI in an adult (non-athletic) population

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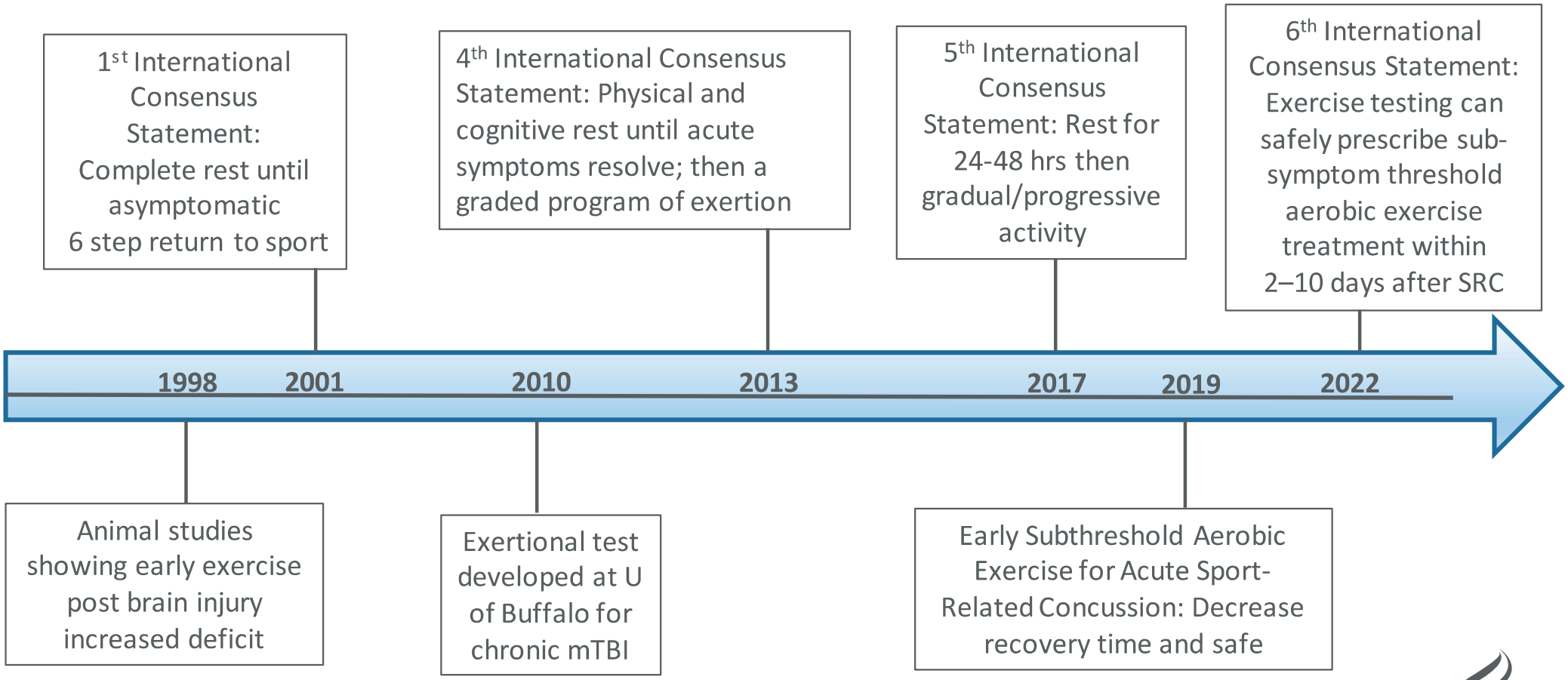
A move from complete rest to gradual activity



Humm JL et al Brain Res. 1998; Aubry M et al Br J Sports Med. 2002; Leddy JJ et al. Clin J Sport Med. 2010; McCrory P et al J Athl Train. 2013;
McCrory P et al Br J Sports Med. 2017; King LA et al Ann Biomed Eng. 2017; Leddy JJ et al. JAMA Pediatr. 2019;
Patricios, JS et al British Journal of Sports Medicine 2022

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Majority of people with concussion are not tested for exercise tolerance

Likely to be tested for exercise intolerance

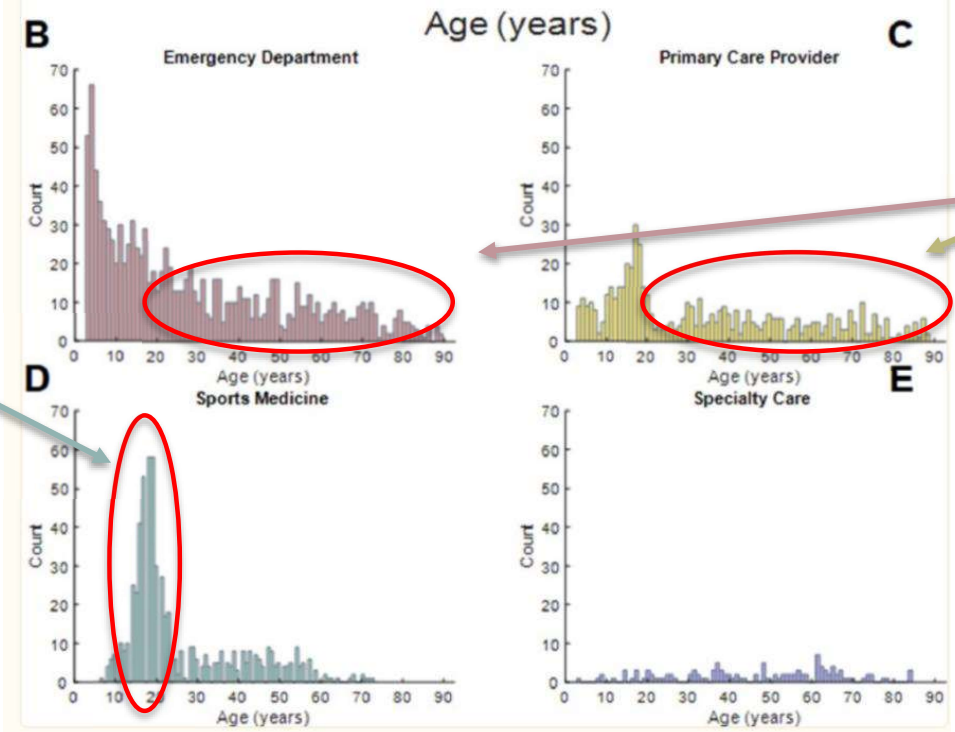

Fig 2

Histograms displaying the age distributions for **(A)** all points of entry (N=2417), **(B)** ED (n=1137), **(C)** primary care provider (n=554), **(D)** sports medicine (n=607), and **(E)** specialty departments (n=119).

Unlikely to be tested for exercise intolerance

Martini et al., 2022

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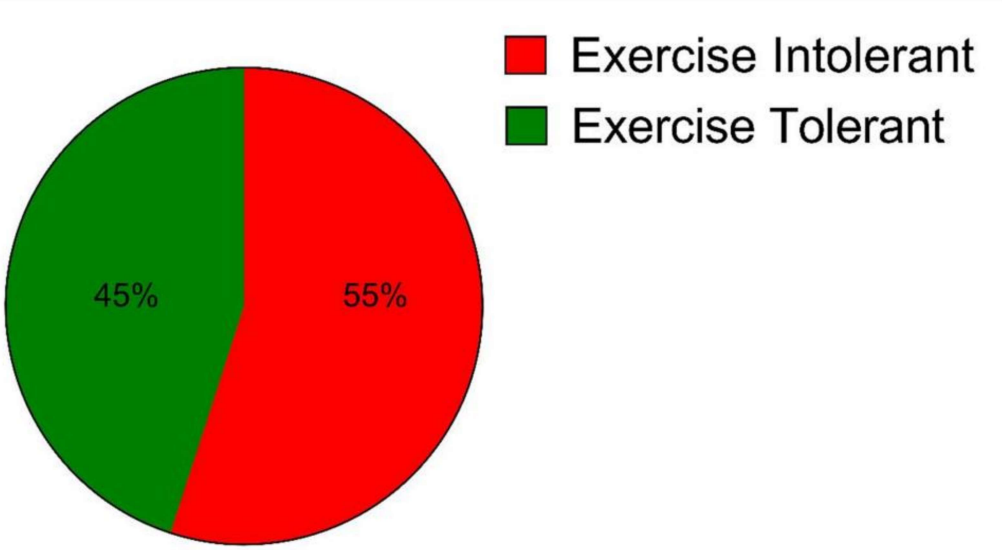
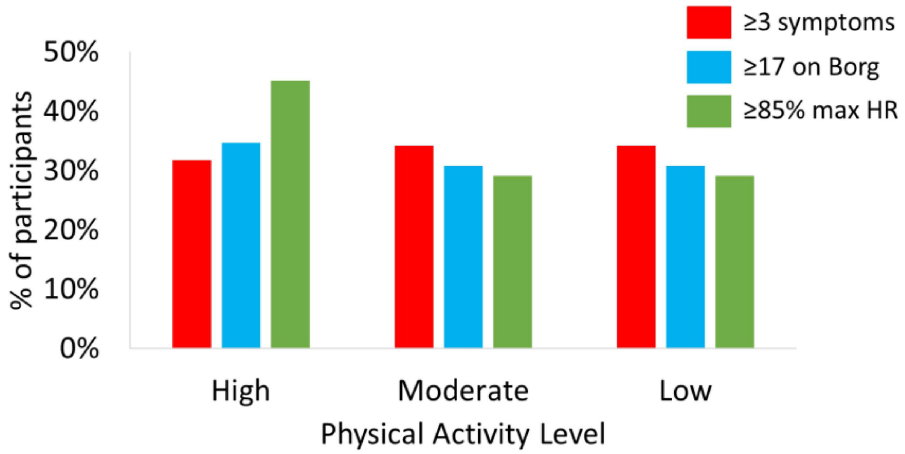
Exercise intolerance is common even in the subacute phase of mTBI and does not related to self reported activity level



N=78

- There was no difference in the % of exercise tolerance and intolerance according to activity levels (p>0.05)



Antonellis, P., Campbell, K. R., Wilhelm, J. L., Shaw, J. D., Chesnutt, J. C., & King, L. A. (2023). Exercise intolerance after mild traumatic brain injury occurs in all subtypes in the adult population. Journal of neurotrauma

Award # W81XWH-17-1-0424 (King; PI)

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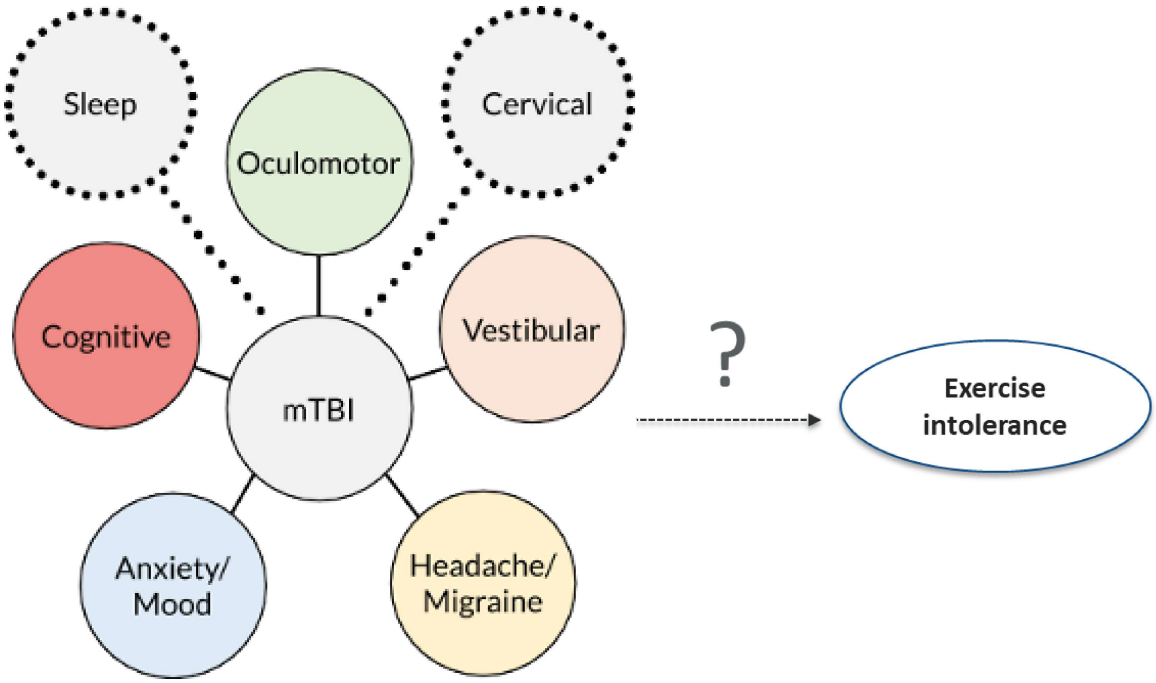
mTBI subtypes and relationship to exercise intolerance



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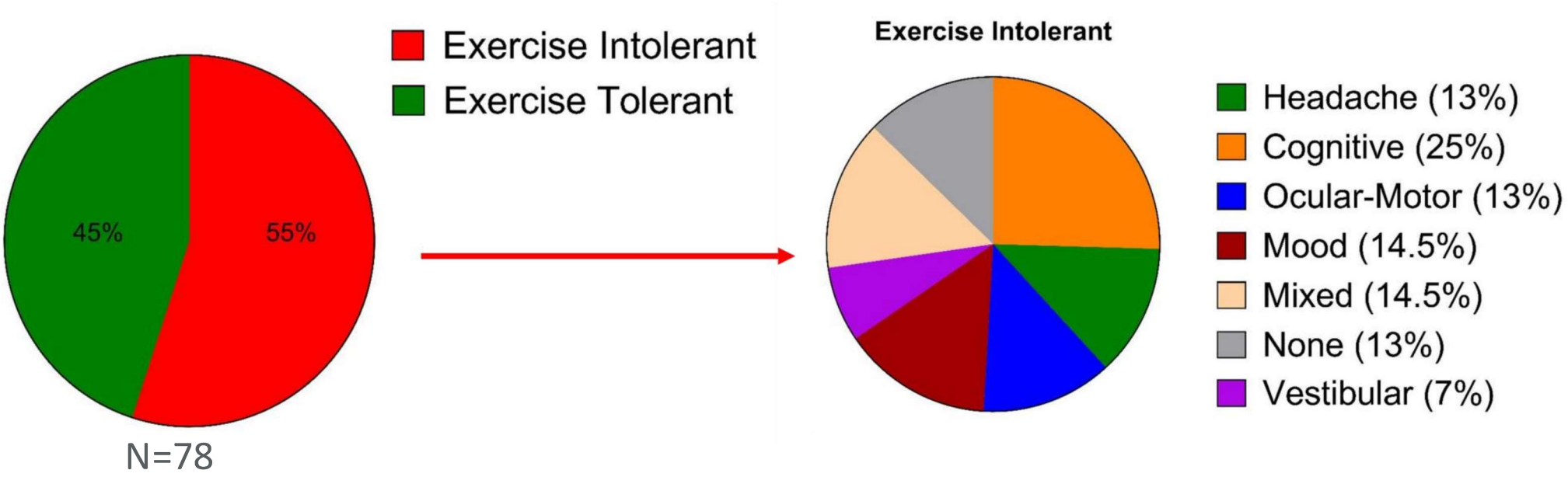
Exercise intolerance is not related to a singular subtype (defined by self-report)



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Award # W81XWH-17-1-0424 (King; PI)

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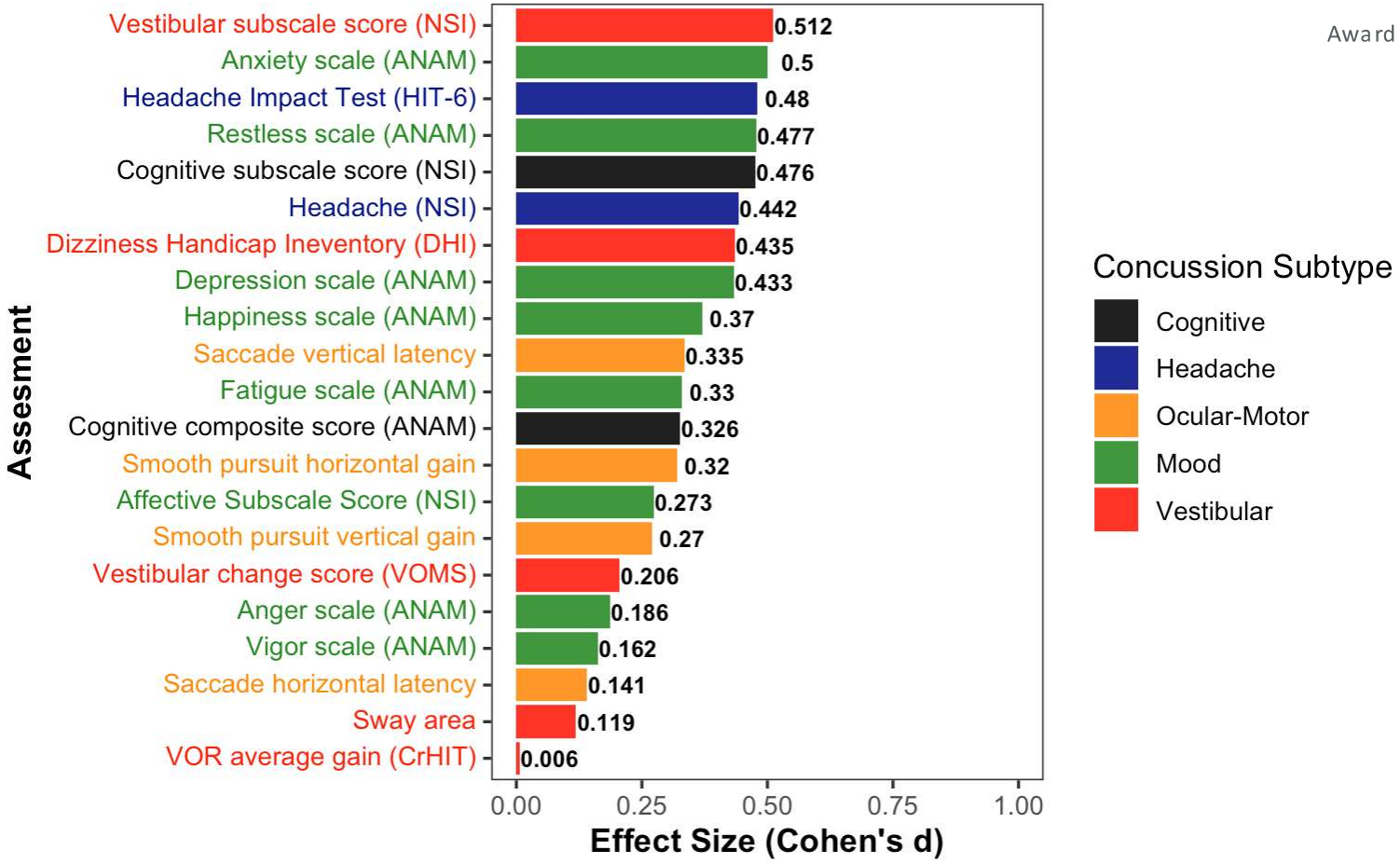
Exercise intolerance is spread across all subtypes even when using objective measures



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Summary

Take Homes

- Motor activation is impaired in untreated chronic mTBI
- Early physical therapy is important: improved rate of symptoms and may prevent maladaptive balance responses
- Exercise intolerance is not related to subtypes and not related to activity levels

Next steps

- Target therapy to sub-type
- Filter these results into guidelines for adult non-athletes

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Thank You