Sports Related Concussion (SRC) 2020 Updates: Recognize, Rest, Rehab, Return

Damion A. Martins, MD

Medical Director, Sports Medicine
Program Director, Sports Medicine Fellowship - ***Atlantic Health System***

Director of Internal Medicine - ***New York Jets***

Assistant Clinical Professor of Medicine & Orthopedics - ***Icahn School of Medicine,Mt Sinai***

OFFICIAL HEALTH CARE

Atlantic Health System

ATLANTIC HEALTH SYSTEM

DISCLOSURE

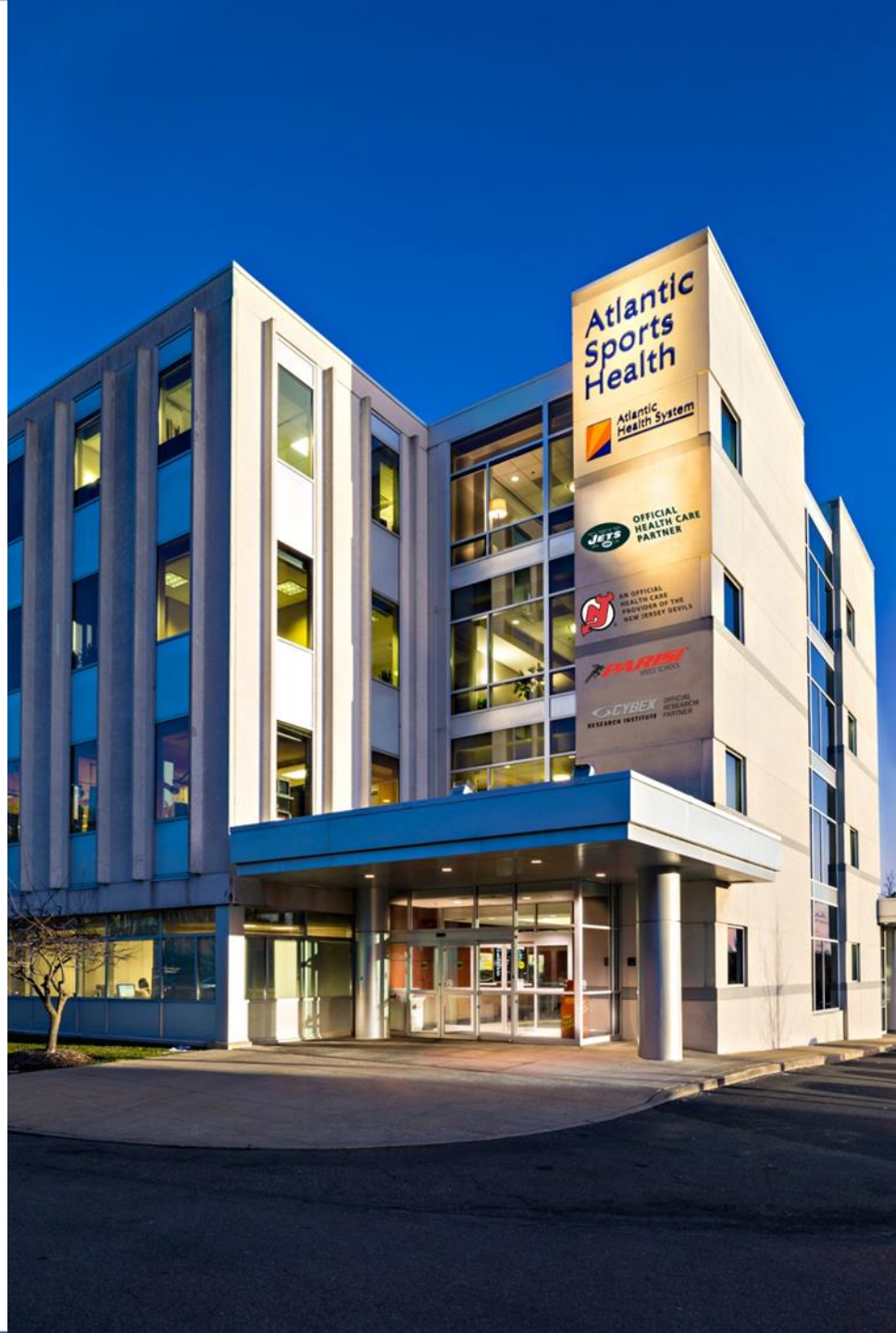
Neither I, (Damion Martins, MD), nor any family member(s), author(s), have any relevant financial relationships to be discussed, directly or indirectly, referred to or illustrated with or without recognition within the presentation.

Learning Objectives

- Identify new classifications of concussions
- Analyze the field of play to better predict athletes “at risk”
- Recognize signs and symptoms most predictive of outcome
- Evaluate sensitivity and specificity of various on the field assessment tools
- Analyze the evidence supporting rehab (early exercise) in the concussed athlete
- Understand which patients to refer for Balk-C versus progressive Return to Play protocol

Overview

- New Concussion Subsets
- Video Analysis
- On Field Assessment
  - PCS
  - SAC
  - SCAT 5
  - King-Devick
  - Balance
  - VOMS
- Predicting Outcome
- Exercise as Treatment

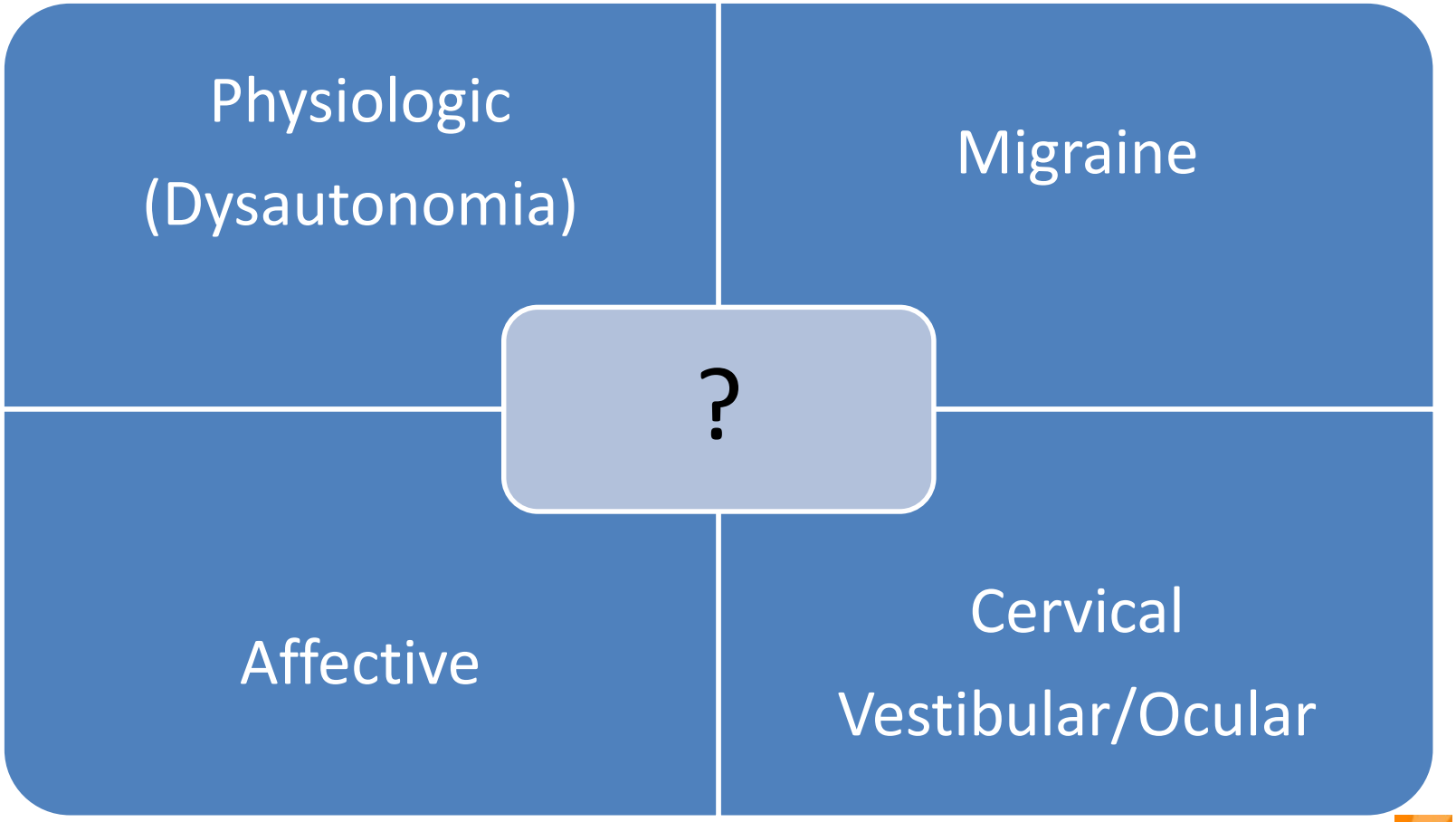


Newer Classifications: mTBI Signs and Symptoms

- **Symptoms**
  - Somatic (HA, nausea, dizziness, fatigue, sensitivity to light and noise)
  - Cognitive (feeling slowed down, feeling mentally "foggy")
  - Emotional (sadness, nervousness, feeling more emotional)
- **Physical Signs** (vomiting, balance problems, LOC, amnesia)
- **Behavioral Changes** (irritability, personality changes)
- **Cognitive Impairment** (slowed reaction time)
- **Sleep Disturbances** (change in sleep patterns, trouble falling asleep)
- **Neuro-ophthalmological abnormalities**:
  - Saccades (29%)
  - Convergence (49%)
  - Accommodation (51%)
  - Vestibular-ocular / Vestibular-spinal

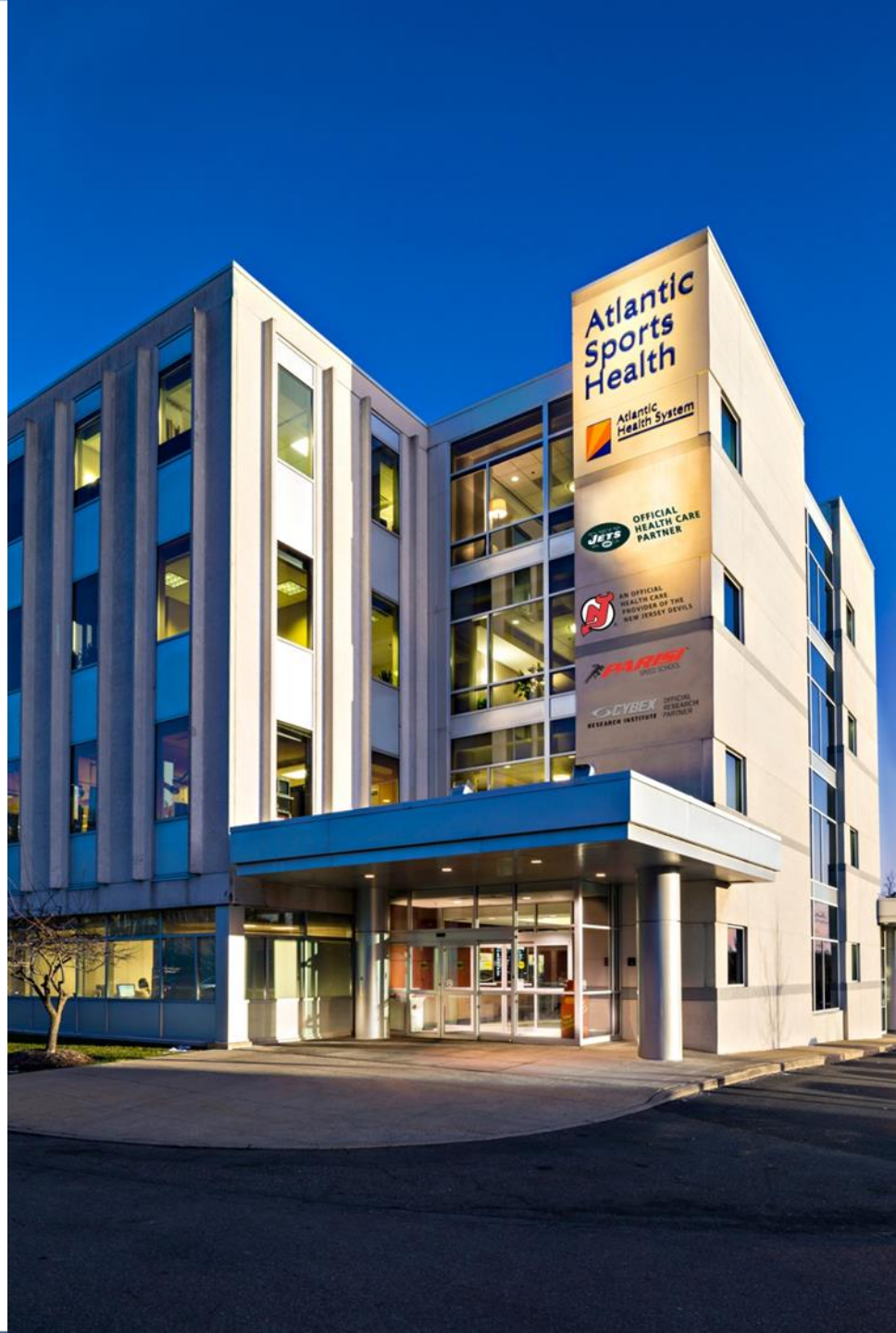
Zurich Consensus statement. *Clin J Sport Med* .Volume 23, Number 2, March 2013

Post Concussive Disorder (>3 months)

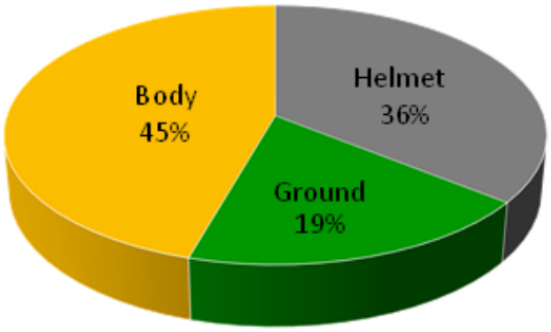


Overview

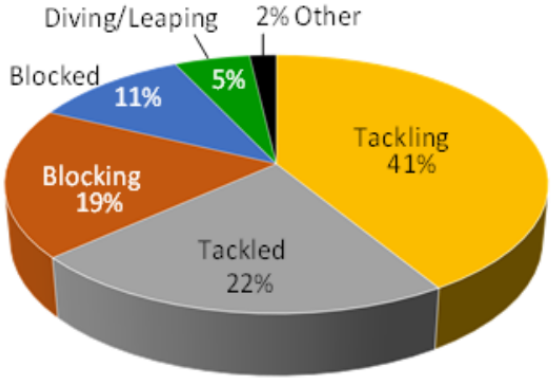
- Concussion Subsets
- **Video Analysis**
- On Field Assessment
  - PCS
  - SAC
  - SCAT 5
  - King-Devick
  - Balance
  - VOMS
- Predicting Outcome
- Exercise as Treatment



NFL Video Analysis



Impact Source



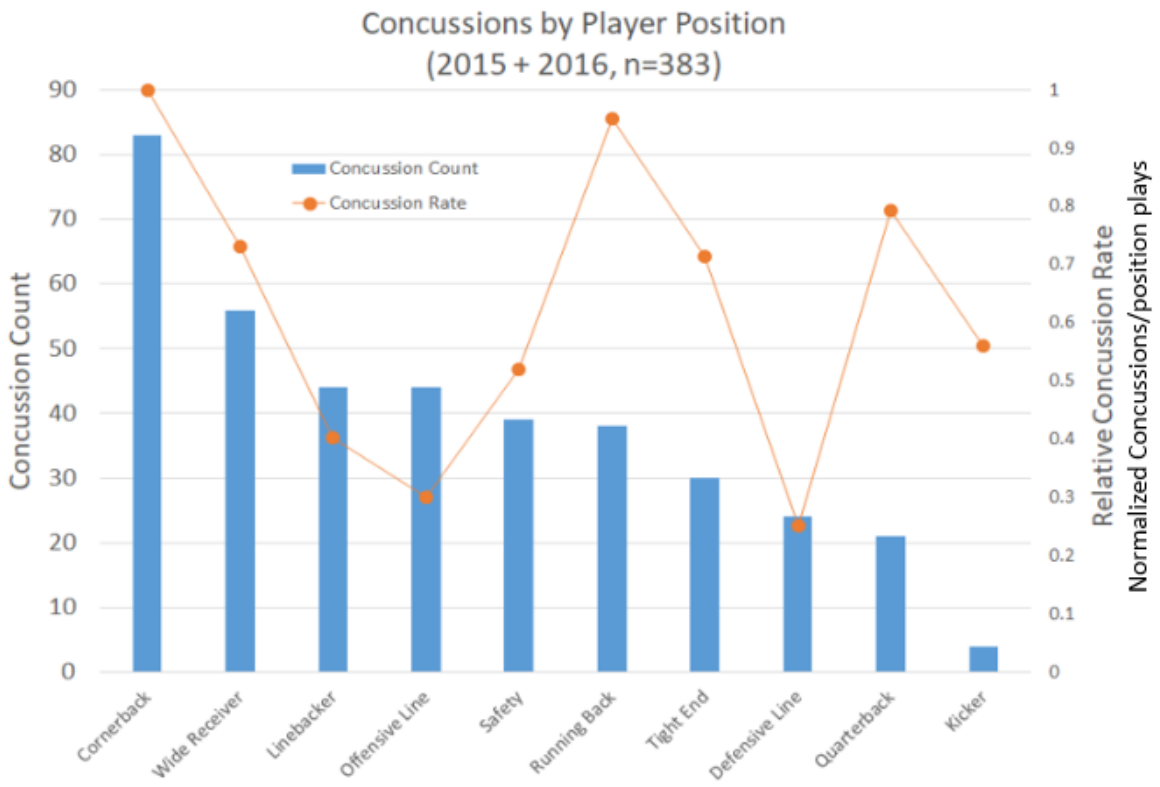
Player Activity

N=325

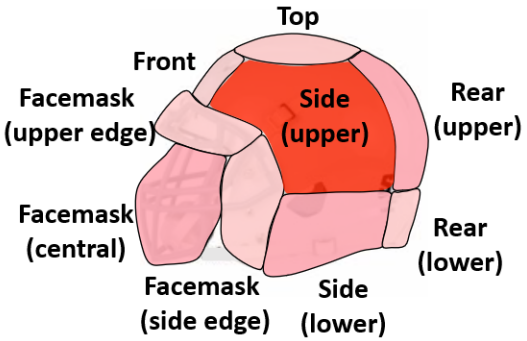
- While helmet-to-helmet concussions remain frequent, helmet-to-body (particularly shoulder) impacts and helmet-to-ground impacts are significant

- Tackling is the most common activity of concussed players

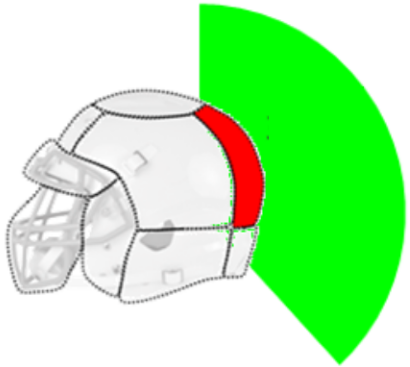
NFL Video Analysis



NFL Video Analysis



- Side of the helmet is the most common impact location

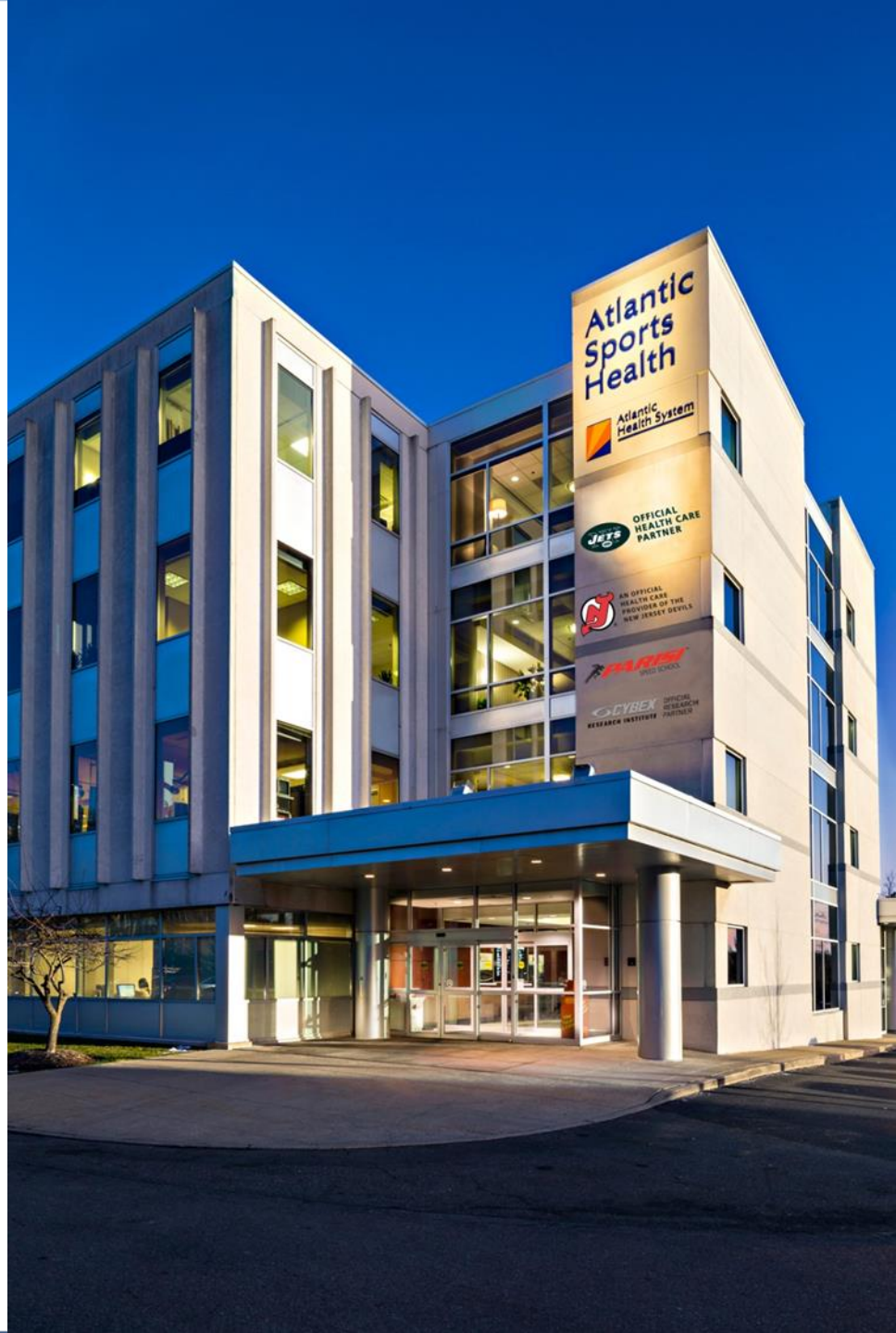


- Helmet-to-ground concussive impacts were notable for the high prevalence of impacts to the back of the helmet and their frequency during passing plays

ATLANTIC HEALTH SYSTEM

Overview

- Concussion Subsets
- Video Analysis
- **On Field Assessment**
  - **PCS**
  - **SAC**
  - **SCAT 5**
  - **King-Devick**
  - **Balance**
  - **VOMS**
- Predicting Outcome
- Exercise as Treatment



Sideline Testing

- Which field are we at?
- Which team are we playing today?
- Who is your opponent at present?
- Which quarter is it?
- How far into the quarter is it?
- Which side scored the last goal?
- Which team did we play last week?
- Did we win last week?

ATLANTIC HEALTH SYSTEM

Diagnostic Tools: How Good Are They?

- **SCAT III** (1 Class II study)
  - > 3.5 decrease from baseline is 96% sensitive and 81% specific
  - value < 74.5 associated with 83% sensitivity and 91% specificity
- **PCS** (Multiple Class III studies)
  - sensitivity 91-100%
  - specificity 64-89%
- **SAC score** (Multiple Class III studies)
  - sensitivity 80-94%
  - specificity 76-91%
- **Neuropsychological test** (1 Class II, multiple Class III studies)
  - sensitivity 71-88%
- **Deficits in BESS** (Multiple Class III studies)
  - sensitivity 34-64%
  - specificity 91%

Summary of evidence-based guideline update: Evaluation and management of concussion in sports. *Neurology* 2013; Published Ahead of Print on March 18, 2013 as 10.1212/WNL.0b013e31828d57dd

Table 3 Psychometric properties of sideline assessment tests*

Author	Type of athletes	Athletes (n)	Concussed	Controls	Test and/or criterion	Sensitivity (%)	Specificity (%)	Test–retest reliability	AUC
Symptoms									
McCrea *et al*[19]	College football	1631	94	56		89	100		
Putukian *et al*[22]	College athletes	263	32	23	SCAT2	84	100		
Chin *et al*[23]	High school and college athletes	2018	166	164					0.88
Resch *et al*[120]	College athletes		40	40	Revised Head Injury Scale	98	100		
Garcia *et al*[40]	College athletes		733		SCAT3	93	97		0.98
Broglio *et al*[33]	College athletes	4360						0.40†	
Total		**3192**	**1065**	**283**					
Standardized Assessment of Concussion									
Barr and McCrea[15]	High school and college football	1313	50	68	3-point decline	72	94	0.55‡	
McCrea *et al*[19]	High school and college football	1325	63	55	3-point decline	78	95	0.48§	
McCrea *et al*[17]	High school and college football	2385	91		<10th percentile of normative	79			
McCrea *et al*[19]	College football	1631	94	56	?	80	91		
Echlin *et al*[121]	Ice hockey (age 16–21)	67	21	–	1-point decline	54			
Barr *et al*[16]	High school and college football	823	59	31	?	46	87		
Marinides *et al*[20]	College athletes	217	30		2-point decline	52	82		
Galetta *et al*[21]	Hockey/lacrosse youth/ college	332	12	14	2-point decline	20	21		0.68
Putukian *et al*[22]	College athletes	263	32	23	<10th percentile of normative	41	91		
Chin *et al*[23]	High school and college athletes	2018	166	164				0.39†	0.56
Broglio *et al*[33]	College athletes	4874						0.39†	
Total		**15 284**	**618**	**411**					
BESS									
McCrea *et al*[19]	College football	1631	94	56	Modified BESS	36	95		
Broglio *et al*[122]	Young adults	48			BESS			0.60¶	
Barr *et al*[16]	High school and college football	823	59	31	Modified BESS	31	71		
Putukian *et al*[22]	College athletes	263	32	23	Modified BESS	25	100		
Chin *et al*[23]	High school and college athletes	2018	166	164	Modified BESS			0.54†	0.56
Broglio *et al*[33]	College athletes	2894			BESS			0.41†	
Total		**4735**	**351**	**274**					
Oculomotor (KD)									
Galetta *et al*[27]	Football, men's/women's basketball	219	10		Worsening of KD time	100			
Leong *et al*[123]	Boxing				Worsening of KD >5 s	100	100	0.9†	
Galetta *et al*[21]	Hockey/lacrosse youth/ college	332	12	14	Worsening of KD time	75	93		0.92
Leong *et al*[28]	College football, men's/ women's basketball	127	11		Worsening of KD time	89		0.95†	
King *et al*[124]	Amateur rugby					94	100	0.92†	
Marinides *et al*[20]	Football, women's lacrosse, soccer	217	30		Worsening of KD time	79			
Seidman *et al*[24]	High school football	343	9		Worsening of KD time	100	100		
Dhawan *et al*[29]	Youth hockey	141	20		Worsening of KD >5 s	100	91		
Fuller *et al*[125]	Elite English rugby		145		Worsening of KD time	60	39		0.51

Overview

- Concussion subsets
- On Field Assessment
  - SCAT 5
  - SCAT 5 Child
  - PCS
  - King-Devick
  - Balance
  - VOMS
- **Predicting Outcome**
- NFL Sideline Assessment

ATLANTIC HEALTH SYSTEM

On Field predictors of protracted recovery

TABLE 2
Frequencies of On-Field Sign/Symptoms and as Predictors of Protracted Recovery[a]

On-field Sign/Symptom	n	Rapid Recovery	Protracted Recovery	χ^2	*P*	Odds Ratio	95% Confidence Interval
Dizziness[b]	87	45	34	6.97	.01	6.42	1.39-29.7
Headache	100	58	35	0.64	.43	2.41	0.26-22.47
Posttraumatic amnesia	36	14	11	1.29	.26	1.72	0.67-4.42
Sensitivity light/noise	53	24	18	1.19	.28	1.58	0.70-3.63
Visual problems	60	25	35	0.62	.43	1.40	0.61-3.2
Retrograde amnesia	29	15	10	0.12	.73	1.18	0.46-3.00
Confusion	71	41	25	0.11	.74	1.16	0.48-2.82
Fatigue	66	31	19	0.04	.85	1.08	0.48-2.47
Balance problems	55	31	16	0.28	.60	0.80	0.35-1.83
Personality changes	26	17	7	0.86	.35	0.63	0.23-1.6
Vomiting[b]	15	11	2	2.73	.10	0.28	0.06-1.37
Numbness	20	15	5	1.34	.25	0.52	0.17-1.59
Loss of consciousness[b]	13	11	2	2.73	.10	0.28	0.06-1.37

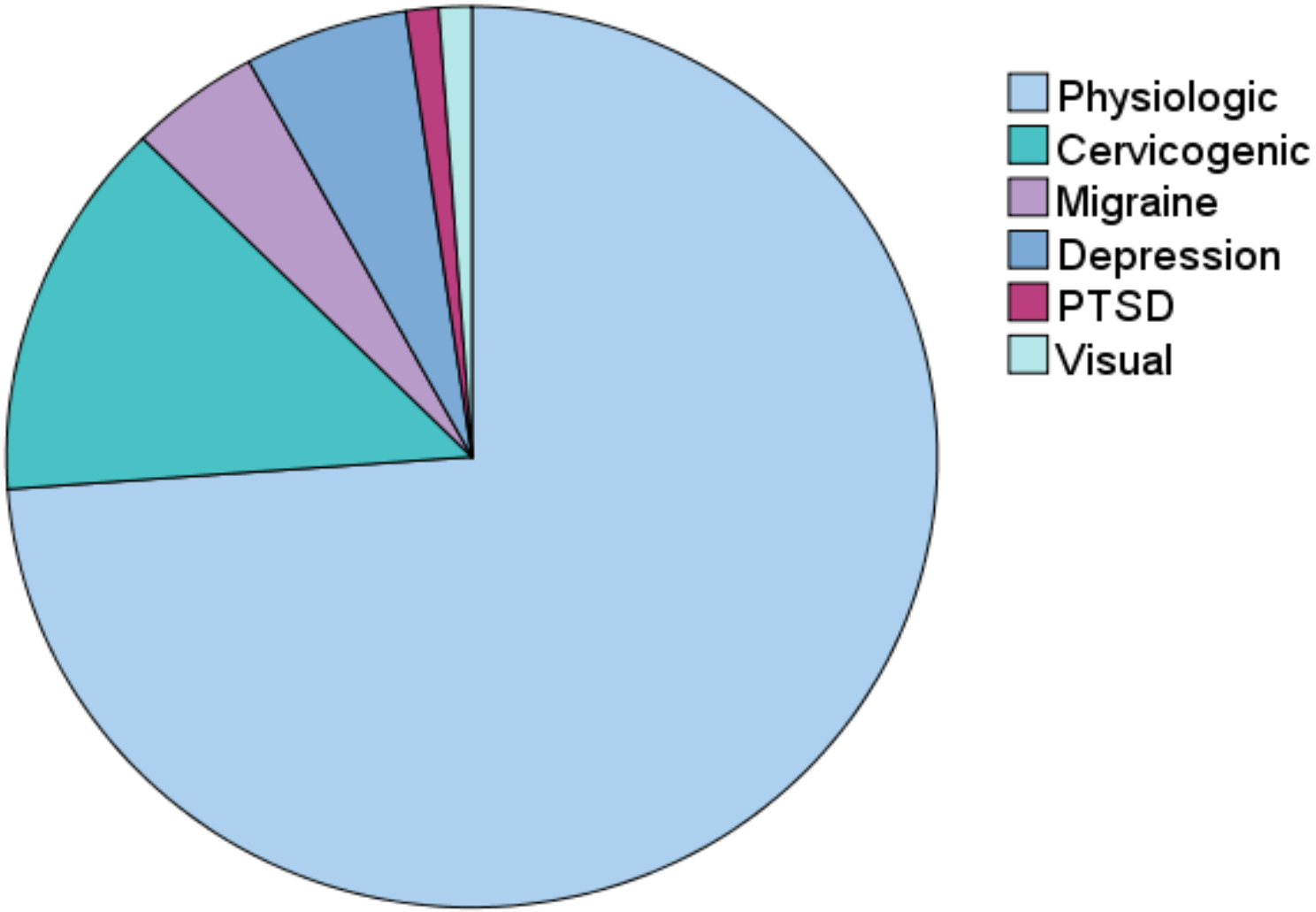
Lau et al, Which On-field Signs/Symptoms Predict Protracted Recovery From Sport-Related Concussion Among High School Football Players? *AJSM* . June 28, 2011

Recovery Prediction

- **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 (**PCS severity score**)
- 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
- **Physical activity within 7 days** of injury compared with no physical activity was significantly associated with reduced risk (24.6% vs. 43.5%) of symptoms at 28 days (Grool et al. *JAMA* 2017)
- **Degree of early exercise tolerance is a strong predictor of recovery** (p=0.0032): lower tolerance = longer recovery (Leddy et al. *CJSM* 2018)

Makdissi M, Schneider K, Feddermann-Demont N, et al. Approach to investigation and treatment of persistent symptoms following sport-related concussion: a systematic review. *Br J Sports Med*. 2017;0:1–12. doi:10.1136/bjsports-2016-097470

Post Concussive Disorder



Unpublished data: John Leddy, MD

Clinical Subtypes

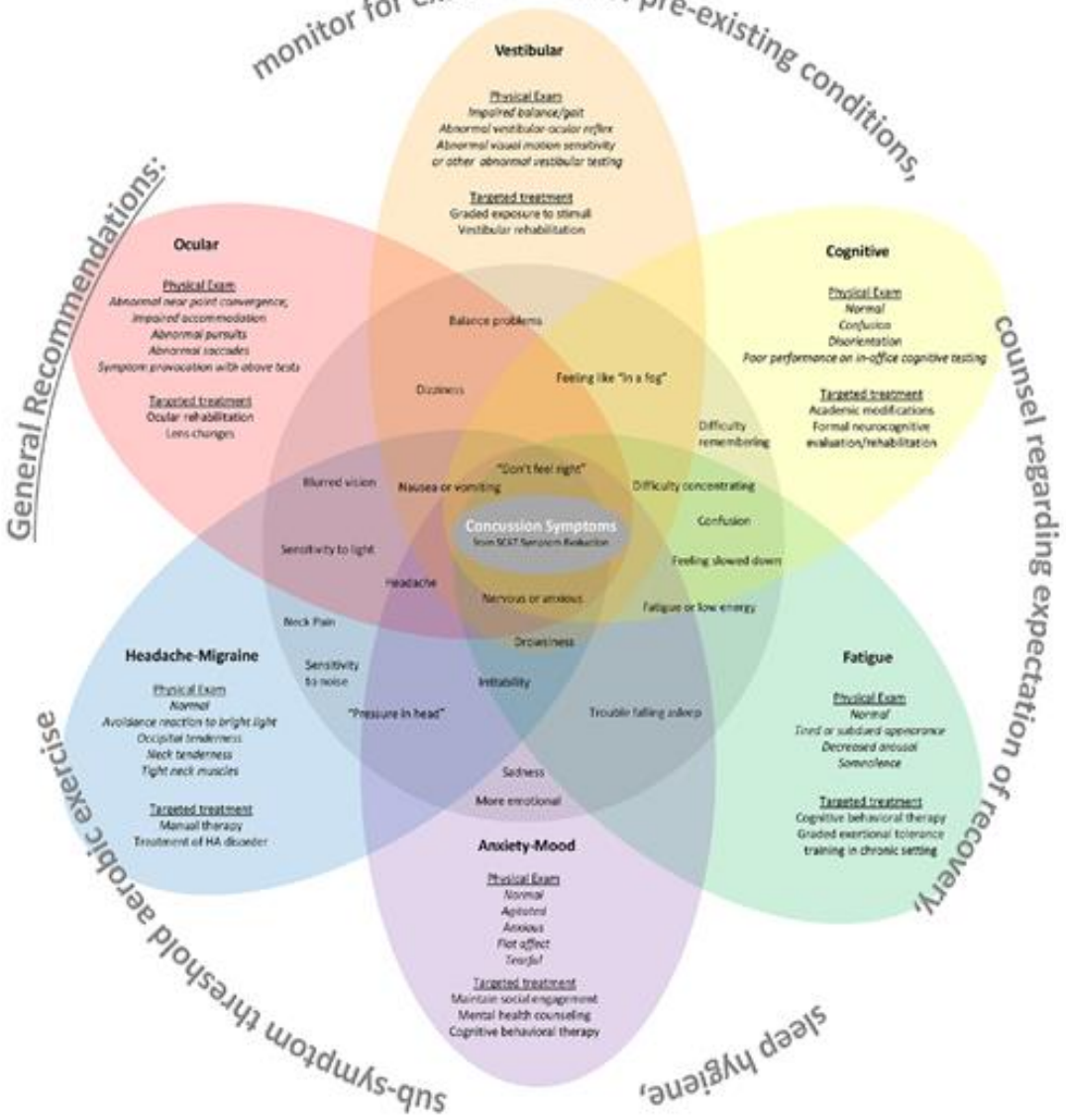


Figure 1 Overlapping clinical profiles: an emerging concept to facilitate individualised management after sport-related concussion. Most patients have features of multiple profiles. HA, headache; SCAT, Sports Concussion Assessment Tool.

Overview

- Concussion Subsets
- On Field Assessment
  - PCS
  - SAC
  - SCAT 5
  - King-Devick
  - Balance
  - VOMS
- Predicting Outcome
- **Exercise as Treatment**

ATLANTIC HEALTH SYSTEM

Rehabilitation of Concussion and PCS

- NO scientific evidence that prolonged rest is beneficial
- NO scientific evidence that medications speeds recovery
  - SSRI's, TCA's may help with depression and insomnia
  - Aricept, lecithin, CDP-choline may alleviate cognitive deficits ?
- Limited evidence that psychological interventions are beneficial
  - (*J Neurol Neurosurg Psych* 2010;81(10):87-93)
- Vestibular rehab has been shown to decrease vertigo and dizziness
  - (*J Neurol Phys Ther.* 2010;34(2):87-93)
- Neurocognitive rehab improves attention
  - (*Arch Phys Med Rehabil* 2005;86(8):1565-1574)

Leddy et al. *Sports Health* 2012 4(2):147-154

Exercise as Concussion Rehab ?

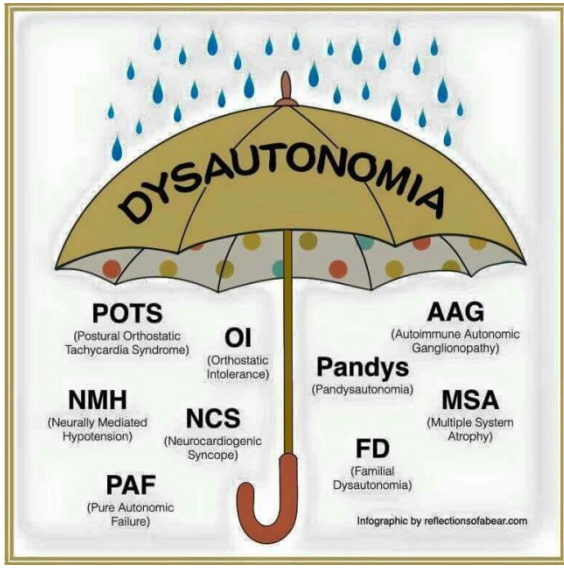
- Aerobic exercise 14 - 21 days after concussion upregulates neurotrophins in association with improved cognitive performance *(Neuroscience. 2004;125(1):129-139)*

- BEST available evidence suggests that complete rest exceeding 3 days is probably not helpful *(Journal of Head Trauma Rehab: 2013, 28(4): 250–259)*

- Brief period of rest during the acute phase (24–48 hours) after injury, followed by gradual/progressive activity while staying below their cognitive and physical symptom-exacerbation thresholds (ie, activity level should not bring on or worsen their symptoms). (*Consensus statement on concussion in sport—the 5th International conference on concussion in sport. McCrory P, et al. Br J Sports Med 2017;51:838–847. doi:10.1136/bjsports-2017-097699)*

Autonomic Nervous System Dysfunction

- Ventilation is inappropriately low for the level of exercise intensity
- Raising arterial carbon dioxide (PaCO2) levels
- Elevated PaCO2 increases cerebral blood flow (CBF) out of proportion to exercise intensity
- Increased CBF is associated with symptoms (headache & dizziness) that limit exercise performance
- Sub-threshold aerobic exercise treatment increased CO2 sensitivity to normal, which normalized PaCO2, exercise ventilation, CBF, and exercise tolerance



Benefit or No Harm of Moderate Physical Activity or Controlled Exercise for Concussion

Physical Activity

- Majerskeet al. (2008)-Retrospective
- Brown et al. (2014)-Retrospective.
- Thomas et al. (2015)-RCT
- Buckley et al. (2015)-Prospective cohort
- Silverberg et al. (2016)- analysis of RCT
- Groolet al. (2016)-Prospective multicenter cohort
- Howell et al. (2016)-Prospective cohort
- Taubmanet al. (2016)-Prospective cohort
- Sufrinkoet al. (2017)- analysis of RCT

Aerobic Exercise

- Gagnon et al. (2009)-Prospective case series
- Leddy et al. (2010)-Prospective case series
- Baker et al. (2012)- Retrospective
- Leddy et al. (2013)-Quasi experimental
- Clausen et al (2015)-Prospective cohort
- Maerlender et al. (2015)- RCT in acute SRC
- Dematteo et al. (2015)-Prospective X-sectional
- Cordingley et al. (2016)-Retrospective
- Gagnon et al. (2016)-Prospective case series
- *Kurowski et al. (2017)- RCT in PPCS.
- Chrisman et al. (2017)-Retrospective
- *Leddy et al (2017)- RCT of assessment exercise tolerance in first week after SRC.
- Chan et al (2018)-RCT in PPCS.

The Effect of Physical Exercise After a Concussion

CME

A Systematic Review and Meta-analysis

Avtar Lal,*† MD, PhD, Stephanie A. Kolakowsky-Hayner,† PhD,
Jamshid Ghajar,†‡ MD, PhD, and Maya Balamane,† MPH
Investigation performed at the Brain Trauma Foundation, Campbell, California, USA

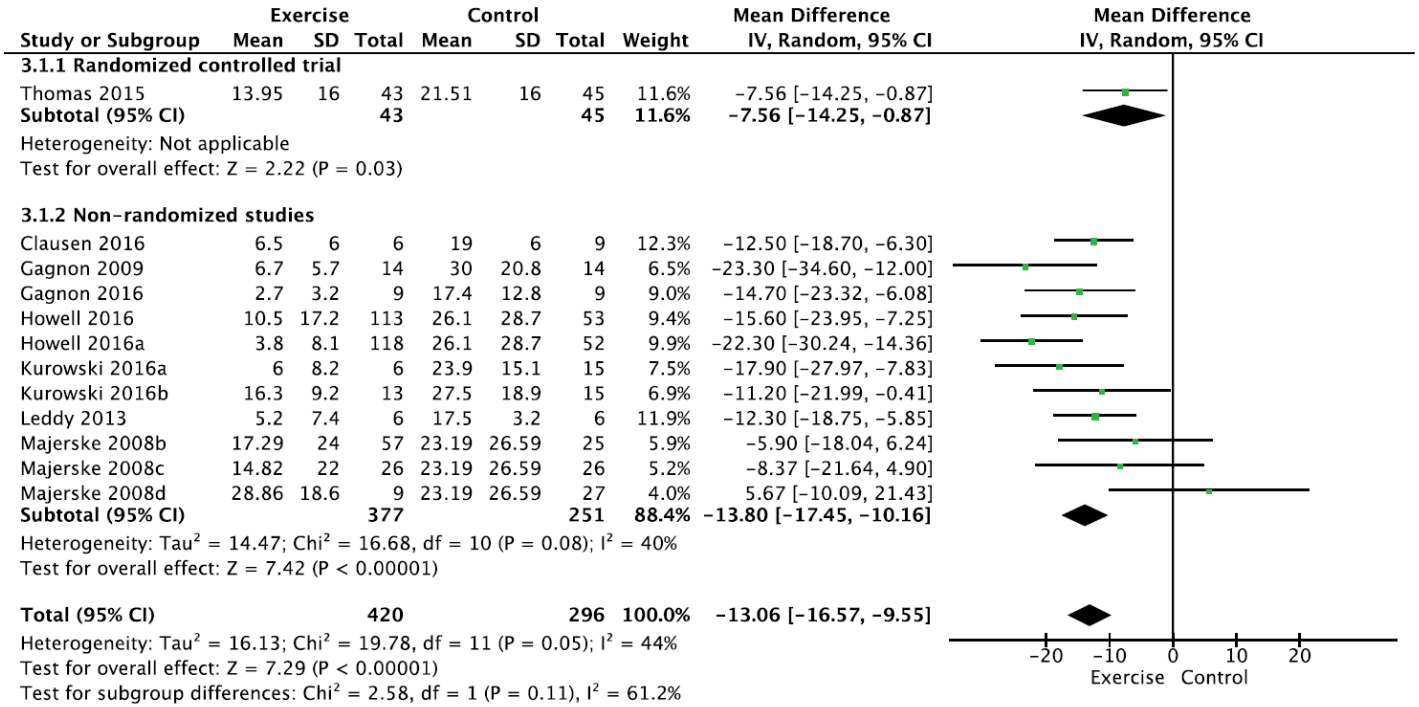
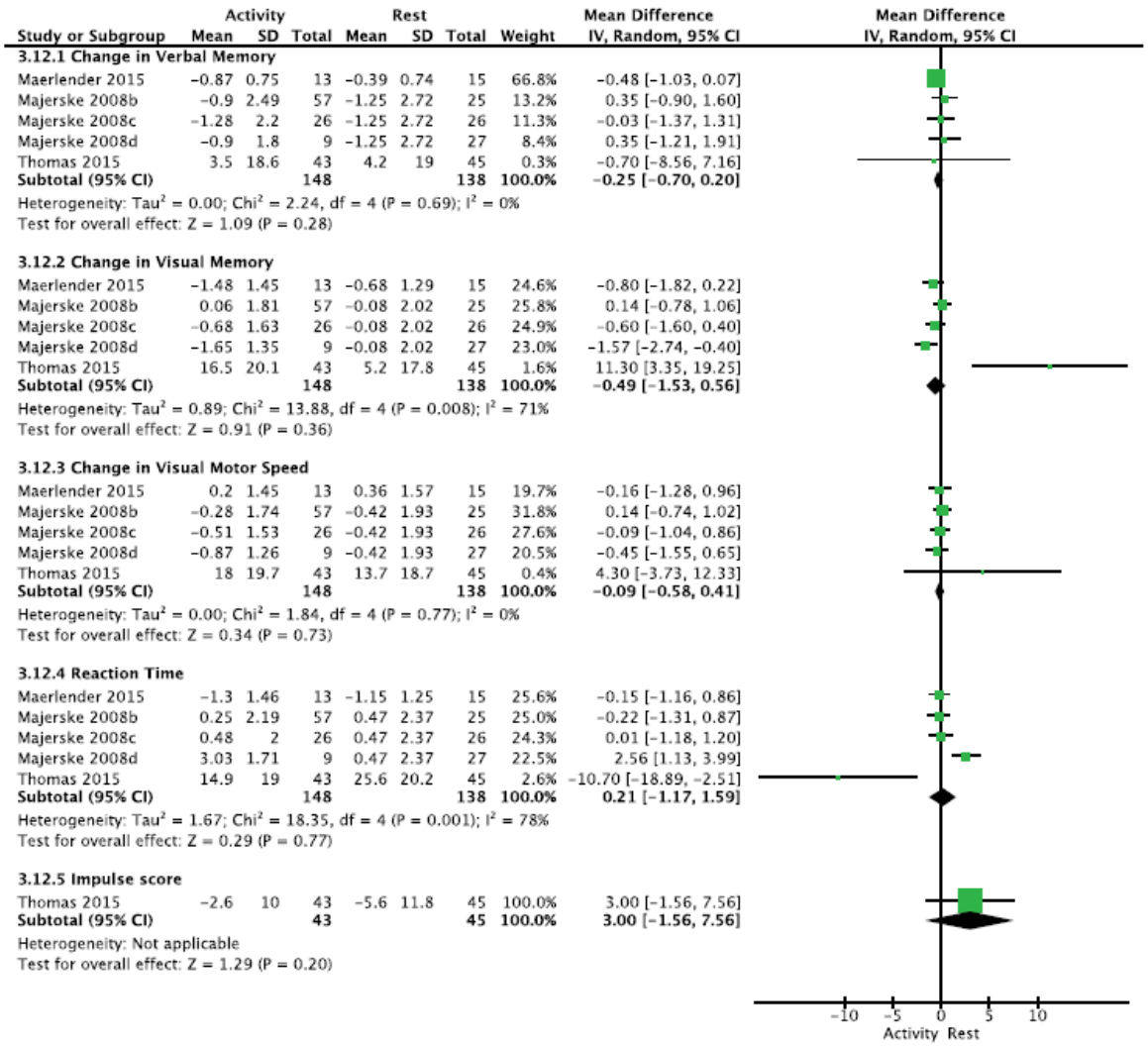


Figure 2. Effect of exercise on the Post-Concussion Symptom Scale (PCSS) score. I^2, heterogeneity; IV, inverse variance; RCT, randomized controlled trial.

Effect of Exercise on SCAT and ImPACT

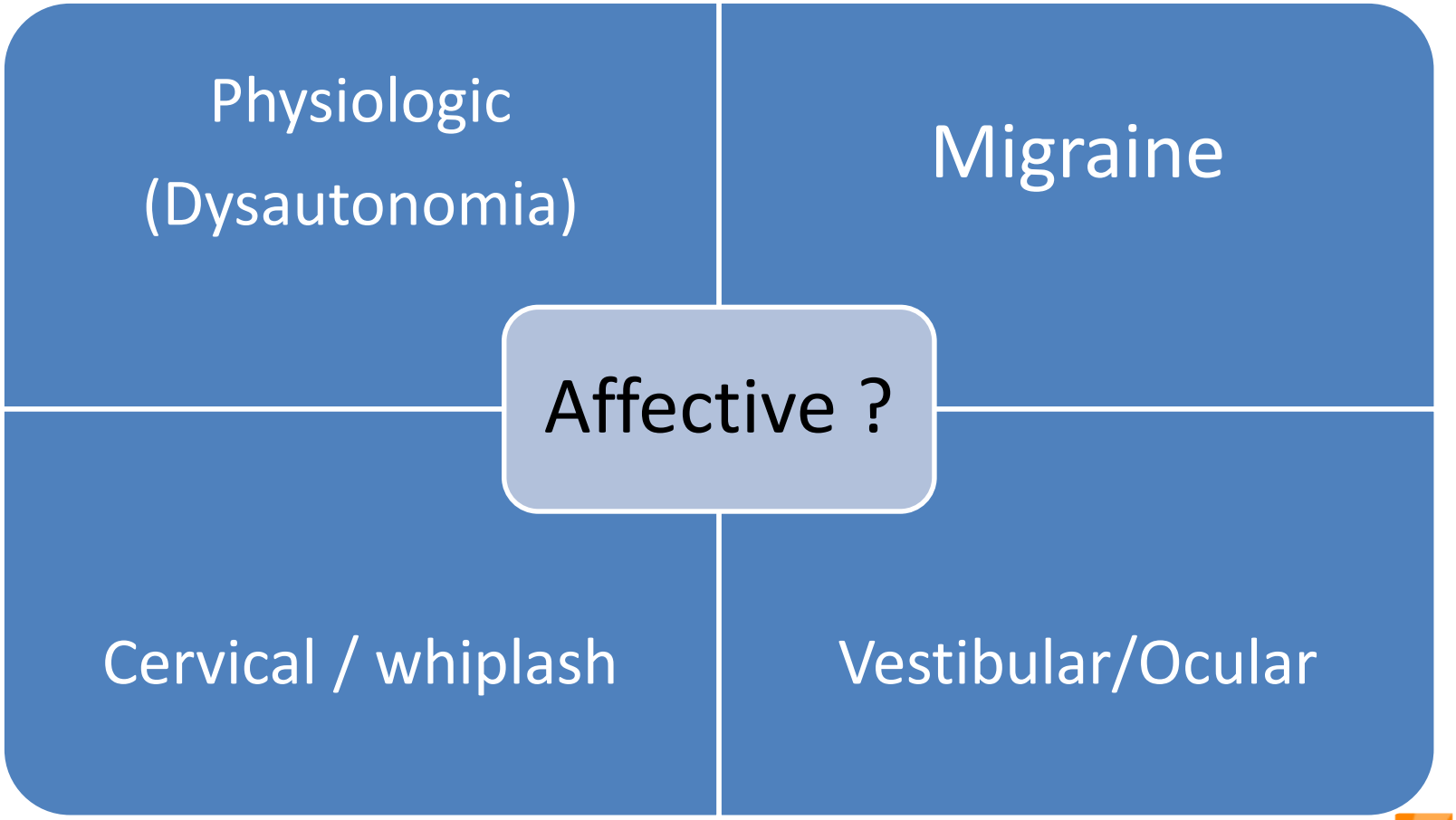


Study or Subgroup	Activity Mean	SD	Total	Rest Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
3.12.1 Change in Verbal Memory								
Maerlender 2015	−0.87	0.75	13	−0.39	0.74	15	66.8%	−0.48 [−1.03, 0.07]
Majerske 2008b	−0.9	2.49	57	−1.25	2.72	25	13.2%	0.35 [−0.90, 1.60]
Majerske 2008c	−1.28	2.2	26	−1.25	2.72	26	11.3%	−0.03 [−1.37, 1.31]
Majerske 2008d	−0.9	1.8	9	−1.25	2.72	27	8.4%	0.35 [−1.21, 1.91]
Thomas 2015	3.5	18.6	43	4.2	19	45	0.3%	−0.70 [−8.56, 7.16]
Subtotal (95% CI)			**148**			**138**	**100.0%**	**−0.25 [−0.70, 0.20]**
Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 2.24$, df = 4 (P = 0.69); $I^2 = 0\%$								
Test for overall effect: Z = 1.09 (P = 0.28)								
3.12.2 Change in Visual Memory								
Maerlender 2015	−1.48	1.45	13	−0.68	1.29	15	24.6%	−0.80 [−1.82, 0.22]
Majerske 2008b	0.06	1.81	57	−0.08	2.02	25	25.8%	0.14 [−0.78, 1.06]
Majerske 2008c	−0.68	1.63	26	−0.08	2.02	26	24.9%	−0.60 [−1.60, 0.40]
Majerske 2008d	−1.65	1.35	9	−0.08	2.02	27	23.0%	−1.57 [−2.74, −0.40]
Thomas 2015	16.5	20.1	43	5.2	17.8	45	1.6%	11.30 [3.35, 19.25]
Subtotal (95% CI)			**148**			**138**	**100.0%**	**−0.49 [−1.53, 0.56]**
Heterogeneity: $Tau^2 = 0.89$; $Chi^2 = 13.88$, df = 4 (P = 0.008); $I^2 = 71\%$								
Test for overall effect: Z = 0.91 (P = 0.36)								
3.12.3 Change in Visual Motor Speed								
Maerlender 2015	0.2	1.45	13	0.36	1.57	15	19.7%	−0.16 [−1.28, 0.96]
Majerske 2008b	−0.28	1.74	57	−0.42	1.93	25	31.8%	0.14 [−0.74, 1.02]
Majerske 2008c	−0.51	1.53	26	−0.42	1.93	26	27.6%	−0.09 [−1.04, 0.86]
Majerske 2008d	−0.87	1.26	9	−0.42	1.93	27	20.5%	−0.45 [−1.55, 0.65]
Thomas 2015	18	19.7	43	13.7	18.7	45	0.4%	4.30 [−3.73, 12.33]
Subtotal (95% CI)			**148**			**138**	**100.0%**	**−0.09 [−0.58, 0.41]**
Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 1.84$, df = 4 (P = 0.77); $I^2 = 0\%$								
Test for overall effect: Z = 0.34 (P = 0.73)								
3.12.4 Reaction Time								
Maerlender 2015	−1.3	1.46	13	−1.15	1.25	15	25.6%	−0.15 [−1.16, 0.86]
Majerske 2008b	0.25	2.19	57	0.47	2.37	25	25.0%	−0.22 [−1.31, 0.87]
Majerske 2008c	0.48	2	26	0.47	2.37	26	24.3%	0.01 [−1.18, 1.20]
Majerske 2008d	3.03	1.71	9	0.47	2.37	27	22.5%	2.56 [1.13, 3.99]
Thomas 2015	14.9	19	43	25.6	20.2	45	2.6%	−10.70 [−18.89, −2.51]
Subtotal (95% CI)			**148**			**138**	**100.0%**	**0.21 [−1.17, 1.59]**
Heterogeneity: $Tau^2 = 1.67$; $Chi^2 = 18.35$, df = 4 (P = 0.001); $I^2 = 78\%$								
Test for overall effect: Z = 0.29 (P = 0.77)								
3.12.5 Impulse score								
Thomas 2015	−2.6	10	43	−5.6	11.8	45	100.0%	3.00 [−1.56, 7.56]
Subtotal (95% CI)			**43**			**45**	**100.0%**	**3.00 [−1.56, 7.56]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 1.29 (P = 0.20)								

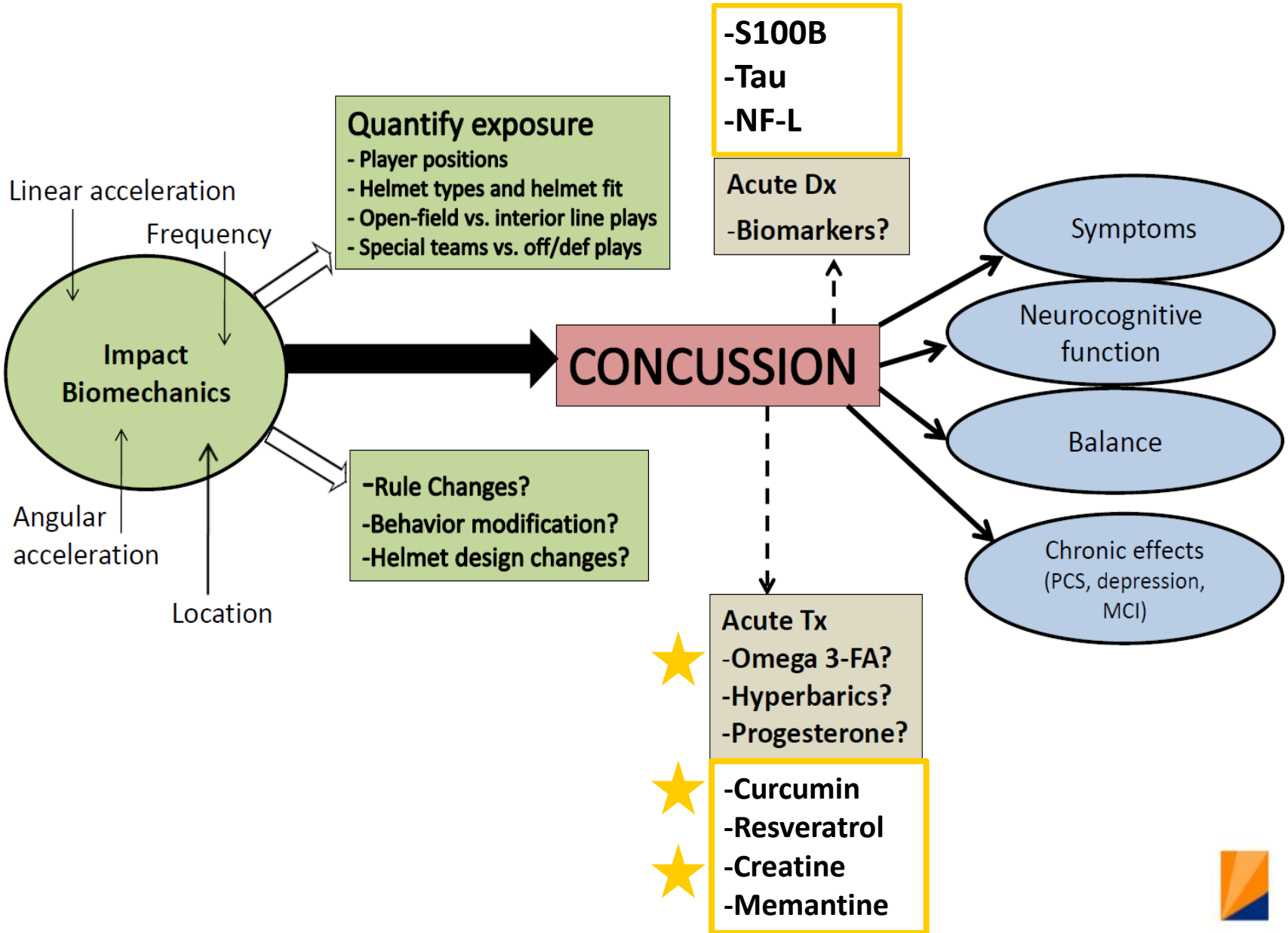
Figure 3. Effect of exercise on change in the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) score. I^2, heterogeneity; IV, inverse variance.

Lal et al. *AJSM* 2018;46(3):743-752

Concussions ?

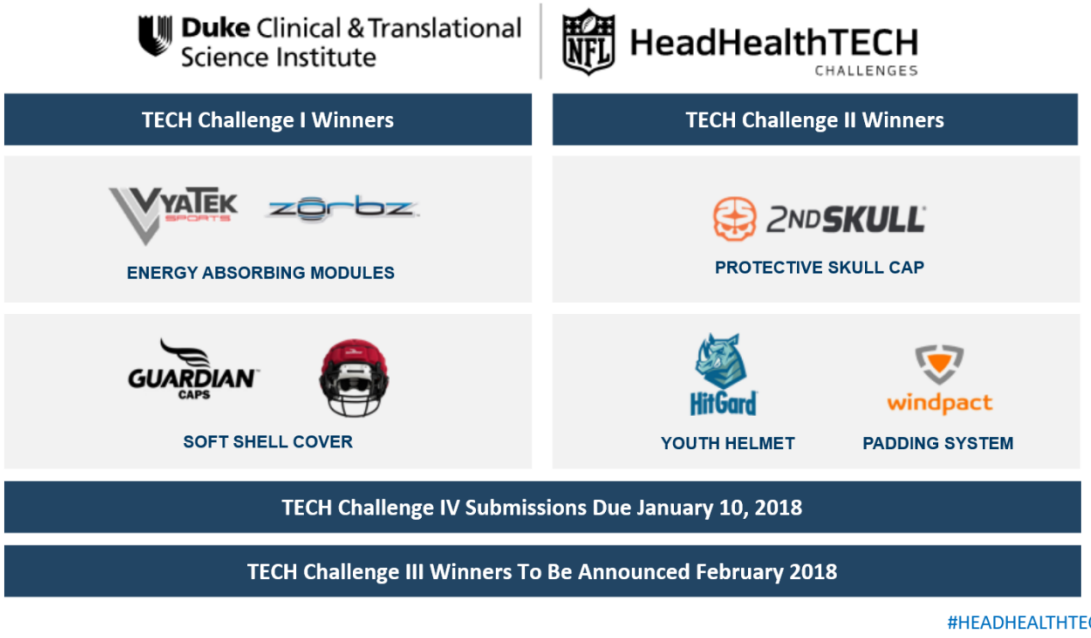


The Concussion Solution

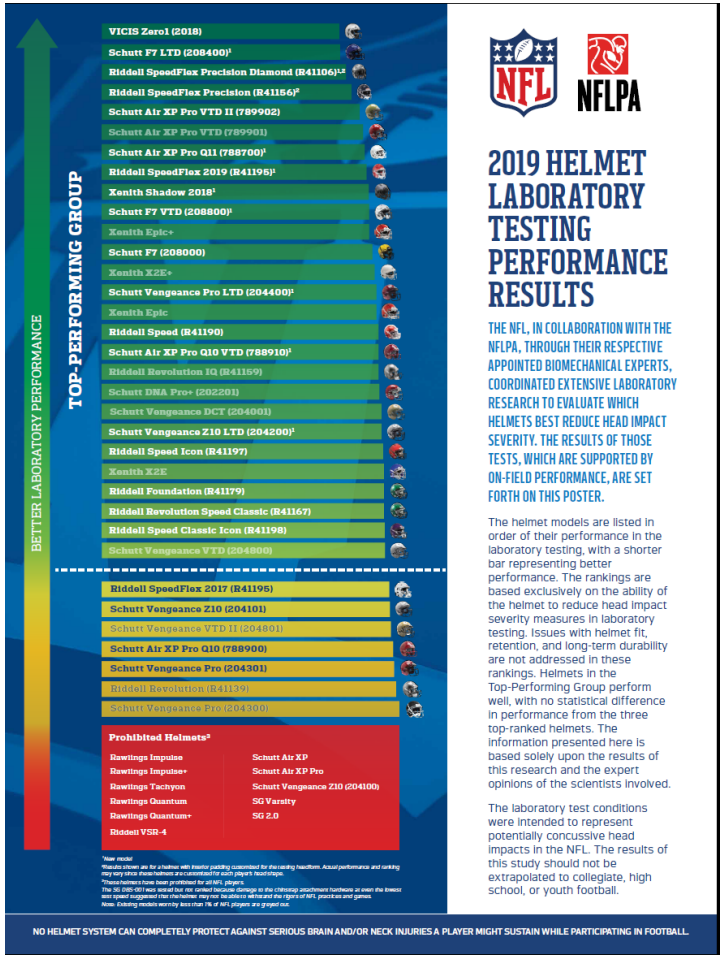


Future Research

- functional MRI (fMRI)
- diffusion tensor imaging (DTI)
- magnetic resonance spectroscopy (MRS)
- cerebral blood flow (CBF)
- electrophysiology / QEEG
- heart rate
- measure of exercise performance
- fluid biomarkers
- transcranial magnetic stimulation (TMS)



Biomechanical studies vs On Field Performance



ATLANTIC HEALTH SYSTEM

Thank You

Atlantic Sports Health

Morristown Medical Center
ATLANTIC HEALTH SYSTEM

Official Health Care of the NY Jets

Overlook Medical Center
ATLANTIC HEALTH SYSTEM

Official Sports Medicine and Rehabilitation Partner

Newton Medical Center
ATLANTIC HEALTH SYSTEM

An Official Health Provider of the New Jersey Devils