



# Concussion Recovery from Acute to Return to Play: What the Research Shows & Clinical Implications

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## Disclaimer

- I have no financial affiliations to disclose.
- I will not discuss any off-label products or devices.
- I have no conflicts of interest to disclose.


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### Consensus statement on concussion in sport—the 5<sup>th</sup> international conference on concussion in sport held in Berlin, October 2016

**Rest**  
Most consensus and agreement statements for managing SRC recommend that athletes rest until they become symptom-free.

- a. Symptoms ~~symptoms~~ (eg, headache), cognitive (eg, feeling like in a fog), and/or emotional symptoms (eg, irritability)
- b. Physical signs (eg, loss of consciousness, amnesia, neurological deficit)
- c. Balance impairment (eg, unsteadiness)
- d. Behavioural changes (eg, irritability)
- e. Cognitive impairment (eg, slowed reaction times)
- f. Sleep/wake disturbance (eg, somnolence, drowsiness) ★

There is currently insufficient evidence that describing the acute recovery period by minimizing post-concussion symptoms and rest may promote recovery by minimizing brain energy demands following concussion. There is currently insufficient evidence that describing the acute recovery period by minimizing post-concussion symptoms and rest may promote recovery by minimizing brain energy demands following concussion. There is currently insufficient evidence that describing the acute recovery period by minimizing post-concussion symptoms and rest may promote recovery by minimizing brain energy demands following concussion. There is currently insufficient evidence that describing the acute recovery period by minimizing post-concussion symptoms and rest may promote recovery by minimizing brain energy demands following concussion.

(McCrory et al., 2017)


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# Post-Concussion Balance Impairments




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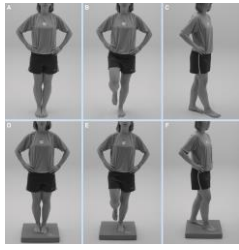
## BESS

**Procedure**


- 3 stances (firm, foam)
  - Double leg
  - Single leg (non-dominant)
  - Tandem (non-dominant in back)
- 20 second holds
- Count the number of errors

**Errors**

- Opening eyes
- Removing hands from the iliac crest
- Stepping or falling out of position
- >30 degrees of hip abduction or flexion
- Lifting the forefoot or heel
- Remaining out of position > 5 seconds



(Riemann et al., 1999, Bell et al., 2011)




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- Low reliability
  - Finnoff et al., 2009
- Low sensitivity
  - McCrea et al., 2003, Oldham et al., 2018
- High MDC scores
  - Finnoff et al., 2009
- Practice effect
  - Valovich McLeod et al., 2003; Burk et al., 2013

## BESS Limitations

**Table 6.** Sensitivity (Sn) and specificity (Sp) for detecting impairment at postinjury time points

	Time of injury		Postgame		Day 1		Day 2		Day 3		Day 5		Day 7	
	Se	Sp	Se	Sp	Se	Sp	Se	Sp	Se	Sp	Se	Sp	Se	Sp
GSC	.89	1.00	.74	1.00	.53	1.00	.27	1.00	.20	1.00	.10	1.00	.04	1.00
BESS	.34	.91	.31	.96	.16	.93	.24	.91	.16	.91	.10	.93	.07	.95
SAC	.80	.91	.65	.93	.31	.95	.22	.89	.18	.93	.18	.93	.02	.98

(McCrea et al., 2003)




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## Post-Concussion Gait Assessment

- **Conservative gait strategy**

- Gait (Catena et al., 2007, 2009, 2011; Parker et al., 2005, 2006, 2007, 2008; Howell et al., 2014, 2015)
- Impairments persist up to **two months post-injury** (Howell et al., 2015)
- Transitional movements (Buckley et al., 2013; Oldham et al., 2016; Buckley et al., 2017)
- Concussion history (Martini et al., 2011; Buckley et al., 2016; Howell et al., 2016)

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## What is Tandem Gait?

- 3-meter line
- Clinically feasible assessment across athletic settings
  - Association between dual-task tandem and dual-task gait speed (Howell et al., 2015)
- <75% of HS athletes were unable to complete the 14 second cut (Santo et al., 2017)



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## Tandem Gait VS BESS

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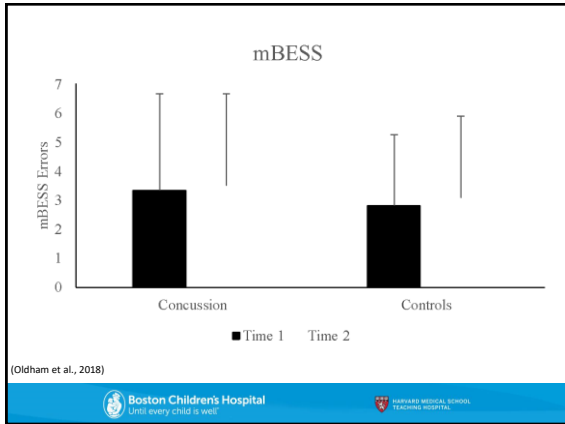
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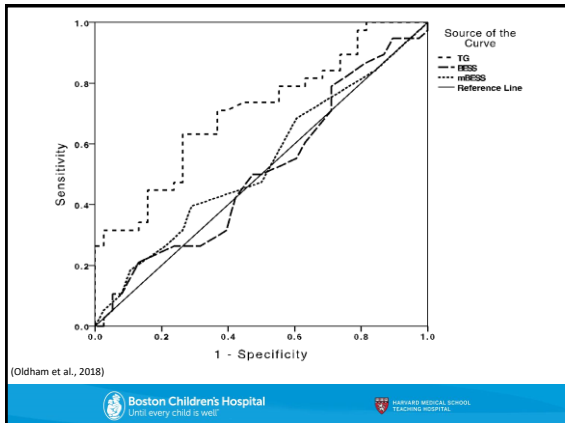
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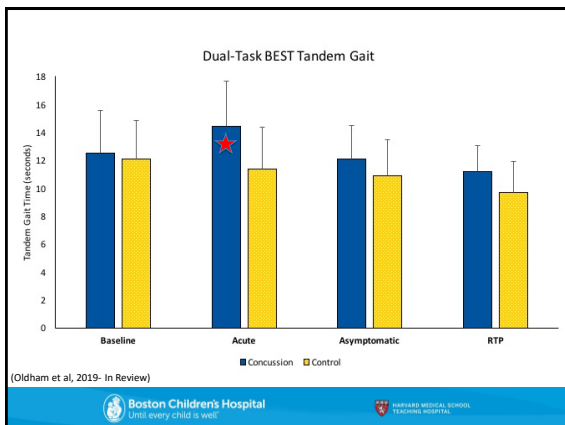
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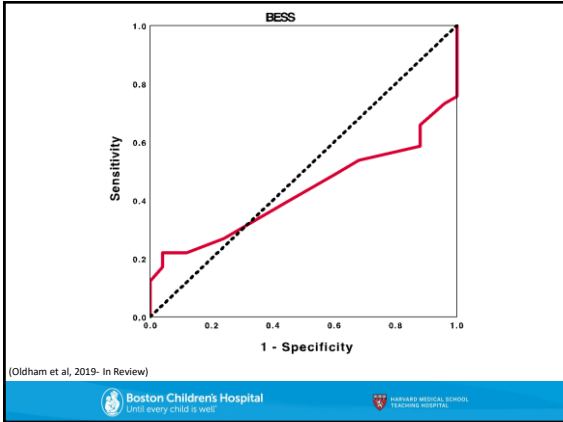
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### 4 Clinical Implications

#### 6 STEP 4: NEUROLOGICAL SCREEN

**Balance Examination**

Do one or both of the following tests. See the instruction sheet (page 7) for details of test administration and scoring of the tests.

**SCAT-3**

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

(SCAT-3, SCAT-5)

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### Clinical Implications

- Tandem gait > BESS (acutely)
- Neither are designed for recovery
- SCAT3 tandem gait protocol appears to be more suitable than SCAT5

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## Concussion Recovery: Rest vs Exercise




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### Trouble Falling Asleep After Concussion Is Associated With Higher Symptom Burden Among Children and Adolescents

David R. Howell, PhD, ATC<sup>1,2,3</sup>, Jessie R. Oldham, PhD<sup>3,4,5</sup>,  
Anna N. Brilliant, BS<sup>2,3</sup>, and William P. Meehan III, MD<sup>3,5,6</sup>

**Table 3.** Multivariable Independent Association of Clinical Predictor Variables and Trouble Falling Asleep After Concussion.

Variable	Odds ratio	Standard error	95% confidence interval	P value
Prior treatment for headache	3.89	2.73	0.984, 15.40	.05
Confusion*	1.64	0.41	1.015, 2.667	.04
2 d of school or more missed since injury*	4.65	2.24	1.807, 11.96	.001
Nervousness	1.34	0.26	0.929, 1.955	.12
Feeling like in a fog	1.39	0.30	0.913, 2.114	.13
Sensitivity to noise*	1.58	0.26	1.146, 2.166	.005
Don't feel right	0.66	0.16	0.416, 1.057	.08

\*Significantly associated with trouble falling asleep in the 24 hours prior to evaluation.




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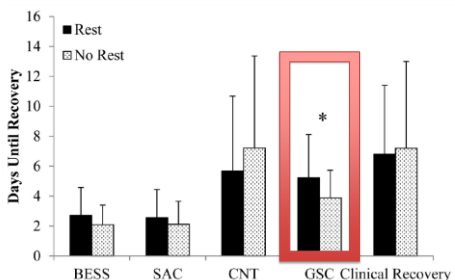
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### Acute Cognitive and Physical Rest May Not Improve Concussion Recovery Time

Thomas A. Buckley<sup>1</sup>, Barry A. Munkasy<sup>2</sup>, and Brandy P. Clouse<sup>3</sup>



Measure	Rest (Days)	No Rest (Days)
BESS	~3.5	~2.5
SAC	~3.0	~2.5
CNT	~6.5	~7.5
GSC	~6.5	~4.5
Clinical Recovery	~7.5	~7.5




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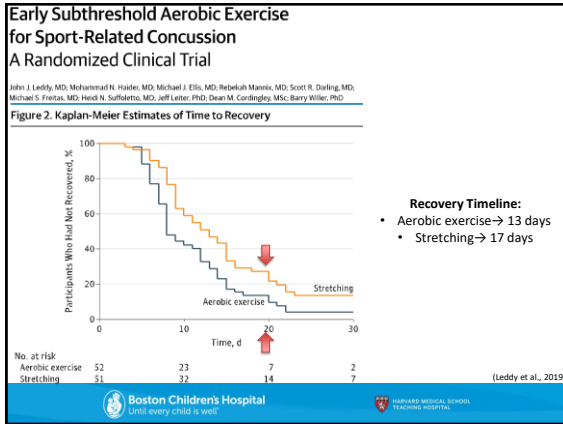
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Variable	Exercise group	No exercise group	P value	Cohen's d
<b>Gait evaluation</b>				
Single-task gait speed (m/s)	1.03 [0.99-1.14]	0.99 [0.92-1.13]	0.30	0.39
†Dual-task gait speed (m/s)*	0.91 (0.16)	0.78 (0.16)	0.02	0.82
<b>Cognitive evaluation</b>				
Single-task accuracy (% correct)	98 [97-98]%	98 [94-100]%	0.84	0.20
Dual-task accuracy (% correct)	100 [94-100]%	99 [95-100]%	0.89	0.19
<b>Modified BESS evaluation</b>				
Single leg stance errors	1.5 [0.5-6]	3 [1-6]	0.48	0.19
Tandem stance errors	1 [0-3]	1 [0-3]	0.77	0.14

(Howell et al., 2019- In Review)

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## Clinical Implications

- Sleep disturbances are associated with poor clinical outcomes.
- Strict rest is no longer appears to be the appropriate prescription.
- Aerobic exercise initiation earlier in recovery may help facilitate recovery.

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# Subsequent Injury following Return to Play




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## Acute Lower Extremity Musculoskeletal Injury Risk After Concussion in Adolescent Athletes

Robert C. Lynall, PhD, ATC<sup>1</sup>; Timothy C. Mauntel, PhD, ATC<sup>1</sup>; Ryan T. Pohlig, PhD<sup>2</sup>; Zachary Y. Kerr, PhD, MPH<sup>3</sup>; Thomas P. Dompier, PhD, ATC<sup>1</sup>; Eric E. Hall, PhD, FACSM<sup>4</sup>; Thomas A. Buckley, EdD, ATC<sup>5</sup>

1. Harvard Medical School, Harvard School of Public Health, Department of Sport Science, Boston Children's Hospital, Boston, MA; 2. Department of Human Movement Science, Department of Allied Health Professions, North Carolina State University, Raleigh, NC; 3. Sports Medicine Research Laboratory, Department of Exercise and Sport Sciences, North Carolina State University, Raleigh, NC; 4. Injury Prevention Research Center, University of North Carolina, Chapel Hill, NC; 5. Injury Prevention Research Center, University of North Carolina, Chapel Hill, NC

### DISCUSSION

The main finding of this study was that in high school athletes, concussion increased the risk of incurring a subsequent time-loss lower extremity injury but not a non-time-loss lower extremity injury. Previous studies have explored the association between acute lower extremity musculoskeletal injury after concussion of these findings represent the first prospective published association at the high school level. (Close to 8 million children play high school sports in the United States and 10% of those athletes sustain a lower extremity injury in this population compared with older cohorts. Thus, understanding the musculoskeletal injury risk after concussion in this age group is important.)




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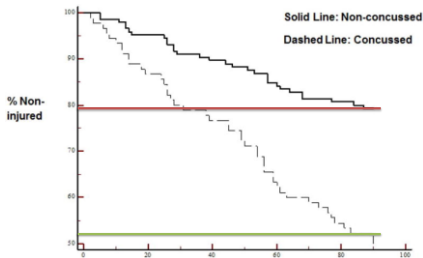
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## Concussion May Increase the Risk of Subsequent Lower Extremity Musculoskeletal Injury in Collegiate Athletes

Daniel Herman, MD, PhD<sup>1</sup>; Debi Jones, PT<sup>2</sup>; Ashley Harrison, DPT<sup>4</sup>; Michael Moser, MD<sup>1,2</sup>; Susan Tillman, PT<sup>3</sup>; Kevin Farmer, MD<sup>1,2</sup>; Anthony Pass, ATC<sup>5</sup>; Jay Clugston, MD, MS<sup>2,6</sup>; Jorge Hernandez, PhD<sup>7</sup>; and Terese Chmielewski, PT, PhD<sup>8</sup>

• 3.39x odds of sustaining MSK injury in concussed compared to non-concussed




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### Sports-related concussion increases the risk of subsequent injury by about 50% in elite male football players

Anna Nordström,<sup>1</sup> Peter Nordström,<sup>2</sup> Jan Ekstrand<sup>3</sup>

#### What are the new findings?

- ▶ There was an **increased risk of a subsequent injury** within the year following concussion in elite football players.
- ▶ Analysis of previous injury history revealed that those elite football players who subsequently sustained a concussion, had also suffered more injuries than their counterparts who did not suffer concussion (ie, concussion may be part of an 'injury prone' phenotype/behaviour).




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### Concussion Frequency Associates with Musculoskeletal Injury in Retired NFL Players

BRIAN PIETROSIMONE<sup>1,2,3</sup>, YVONNE M. GOLIGHTLY<sup>4,5,6</sup>, JASON P. MIHALIK<sup>1,6,7</sup>, and KEVIN M. GUSKIEWICZ<sup>1,2,9</sup>

#### DISCUSSION

Our study provides evidence of the association between self-reported concussions and musculoskeletal injuries sustained in the NFL. The overall odds of reporting a musculoskeletal injury increased when a greater frequency of concussions was also reported. Regardless of the reported concussion frequency, there was a notable increase in the odds of reporting a knee or ankle injury in former NFL players that reported any number of concussions. Associations were significantly higher for all musculoskeletal injury categories in players reporting three or more concussions. For all musculoskeletal injury categories, except for hamstring/quadiceps strains, there was a trend for increasing estimates as the number of reported concussions increased.




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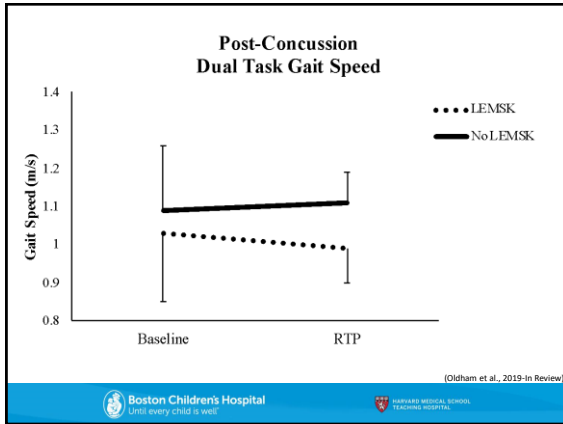
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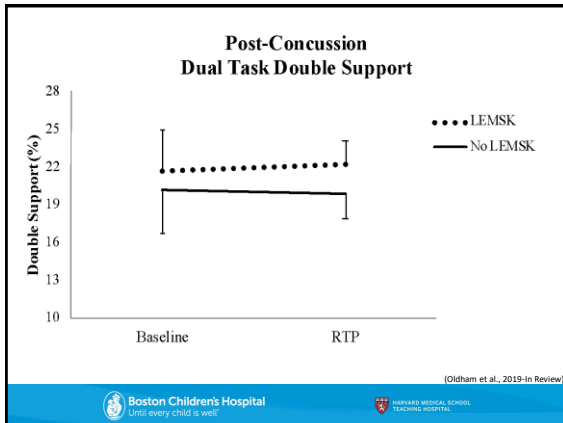
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## Clinical Implications

- Are certain individuals just injury prone?
  - Higher rates of injury pre-concussion (Lynall et al., 2015; Nordstrom et al., 2015; Burman et al., 2016)
- Should injury prevention programs be put in place?
- Dual task challenges appear exacerbate differences

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