

Associations among Concussion History, Psycho-Affective Status, and Cognitive-Motor Performance in College Students

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Disclaimer

- We have nothing to disclose.

Background

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- ❑ Microstructural brain damage can increase risk for subsequent injury¹
 - ❑ Athletes often fail to report concussion occurrence²
 - ❑ Repetitive head impacts can have similar effects as concussion³
- ❑ Subtle impairment of brain processing efficiency difficult to detect⁴
 - ❑ Compensatory increase in activation of brain resources can mask problem⁵
 - ❑ Dual-task testing can overwhelm cognitive reserve to reveal deficiency⁶

Background

- ❑ Concussion is associated with a variety of post-acute symptoms, which appear to worsen with repetitive concussion occurrences⁷
 - ❑ Sleep-related problems
(trouble falling asleep, sleeping less, fatigue/drowsiness)
 - ❑ Mood related problems
(nervousness/anxiety, sadness/depression, irritability/stress)
 - ❑ Behavioral problems
(substance abuse, suicidality)
 - ❑ Cognitive impairment
(poor academic performance, aging-related cognitive decline)

Purpose

- To identify potential associations between lifetime concussion history, psycho-affective status, and dual cognitive-motor task performance in healthy college students.

Methods

- Participants recruited from the Health & Human Performance program (N=38)
 - Age: 22.0 ± 1.2 years
 - Height: 173.8 ± 9.9 cm
 - Weight: 73.8 ± 14.0 kg
 - Median time since last concussion (n=11): 4.2 years (range: 1.8-11.1 years)
- Participants completed an electronic survey and cognitive-motor assessments
 - Surveys
 - Global well-being Index (GWBI)
 - Depression Anxiety Stress Scale (DASS)
 - Pittsburgh Sleep Quality Index (PSQI)
 - Cognitive and Motor Tasks (performed separately and simultaneously)
 - Tandem Gait
 - Serial-7 Subtractions
 - Smartphone Flanker Task

Global Well-Being Index

Check (✓) each of the problems listed below that have affected your ability to function or derive maximum enjoyment of life activities in the past couple of years.

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1. General Pain or Discomfort

Headaches/Pressure in Head Neck Pain Non-Specific Body Discomfort

2. Sleep-Related Problems

Trouble Falling Asleep Sleeping Less Fatigue/Drowsiness

3. Mood-Related Problems

Nervousness/Anxiety Sadness/Depression Irritability/Stress

4. Musculoskeletal Problems (During Activities of Daily Living)

Aching Discomfort Joint Stiffness Muscle Spasms/Tightness

5. High-Intensity Performance Limitations

Running Speed Limitation Explosive Power Limitation Endurance Limitation

Follow-up questions appear if at least 1 problem selected within a given category:

How frequently has the worst problem been experienced over the past couple of years?

0 1 2 3
None – Not at all Rare to Occasional Occasional to Frequent Frequent to Persistent

When was the most recent occurrence of the worst problem among those that were selected?

1 2 3 4
> 1 Year Ago > 6 Months Ago > 1 Week Ago Current Week

Estimate the severity of the worst problem at any point over the past couple of years?

1 2 3
Mild to Moderate Moderate to Severe Severe

Single-Task Tandem Gait

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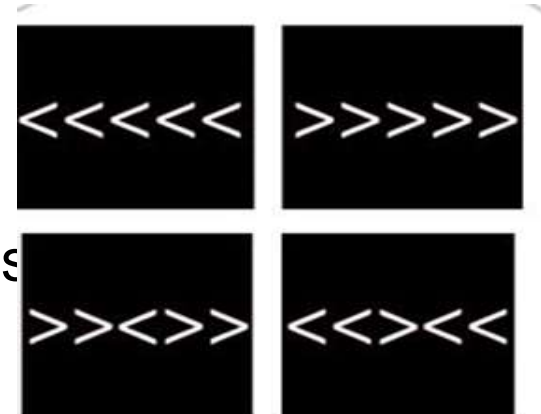
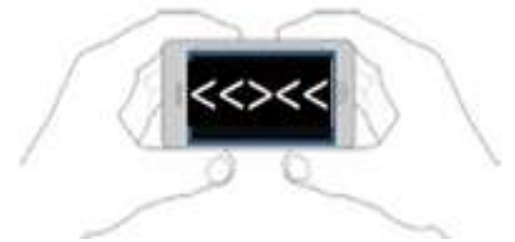


“For this test, when I say go, I want you to walk in a forward direction as quickly and accurately as you can using a heel-to-toe gait. Go to the end of the line, turn around and return to the starting point using the same gait. Do your best to keep your feet on the line and to always touch your heel to toe for each step. If you mess up, get back on the line and keep going.”

Single-Task Flanker Test

- ❑ Smartphone application quantified reaction time and accuracy
 - ❑ 20 sets of arrows; each presented for 250 ms
 - ❑ Congruent: all arrows point in same direction
 - ❑ Incongruent: middle arrow points opposite direction of flanking arrows
- ❑ Participants instructed to tilt phone in direction center arrow points
- ❑ Practice trial completed prior to test trial

Erikson Flanker Test



Single-Task Serial 7 Subtractions

Say "Now, while you are walking heel-to-toe, I will ask you to count backwards out loud by 7s. For example, if we started at 100, you would say 100, 93, 86, 79. Let's practise counting. Starting with 93, count backward by sevens until I say "stop". Note that this practice only involves counting backwards.

Dual Task Practice: Circle correct responses; record number of subtraction counting errors.

Task								Errors	Time
Practice	93	86	72	65	58	51	44	37	

Participants limited to amount of time required to complete single-task tandem gait
 Outcome: Total number of correct subtractions made

Score as follows:

93, 86, 79, 72, 65	5 points
✓ ✓ ✓ ✓ ✓	(all correct)
93, 88, 81, 74, 67	4 points
✓ X ✓ ✓ ✓	(4 correct, 1 wrong)
92, 85, 78, 71, 64	4 points
X ✓ ✓ ✓ ✓	(4 correct, 1 wrong)
93, 87, 80, 73, 64	3 points
✓ X ✓ ✓ X	(3 correct, 2 wrong)
92, 85, 78, 71, 63	3 points
X ✓ ✓ ✓ X	(3 correct, 2 wrong)
93, 87, 80, 75, 67	2 points
✓ X ✓ X X	(2 correct, 3 wrong)
93, 87, 81, 75, 69	1 point
✓ X X X X	(1 correct, 4 wrong)

Dual-Task Conditions

- Participants completed tandem gait motor task while simultaneously performing Serial 7 Subtractions and Flanker Task
- Dual Task Cost (%) calculated for both motor and cognitive outcomes⁸

$$\frac{\text{Dual Task} - \text{Single Task}}{\text{Single Task}} \times 100$$



Statistical Analysis

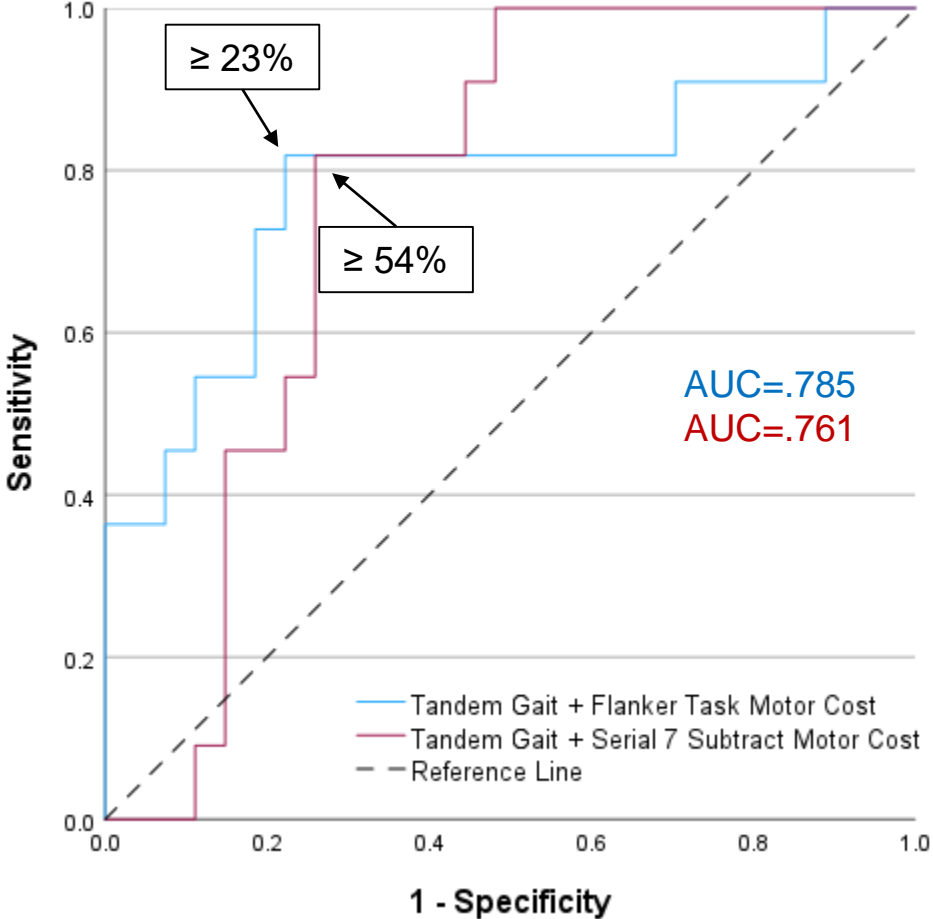
- Receiver Operating Characteristic Analysis
 - Area Under Curve (AUC) criterion for moderate association $\geq .600$
 - Youden's Index used to identify optimal cut point
 - Binary classification – History of Concussion (+) versus No History (-)

- Chi-Square Analysis of each potential predictor
 - Fisher's Exact One-Sided P-Value
 - Univariable Odds Ratio (OR) with 95% Confidence Interval

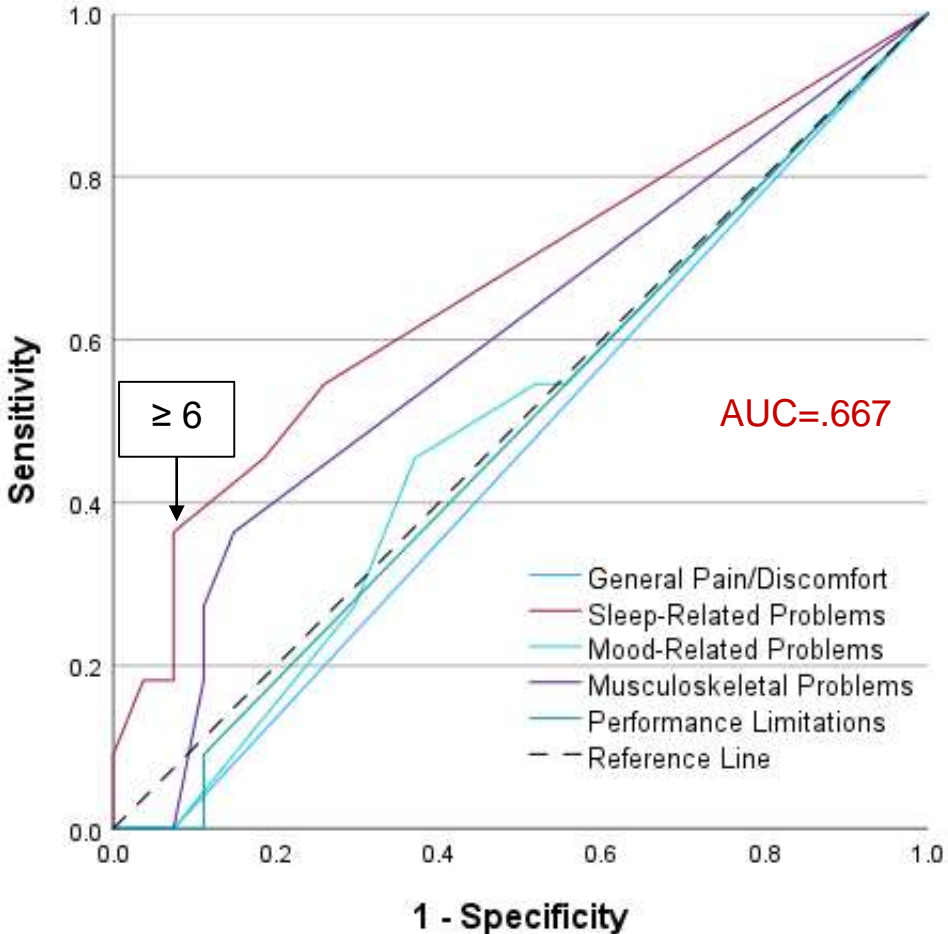
Discrimination Between Concussion Hx versus No Hx

29% (11/38) Reported Concussion Hx

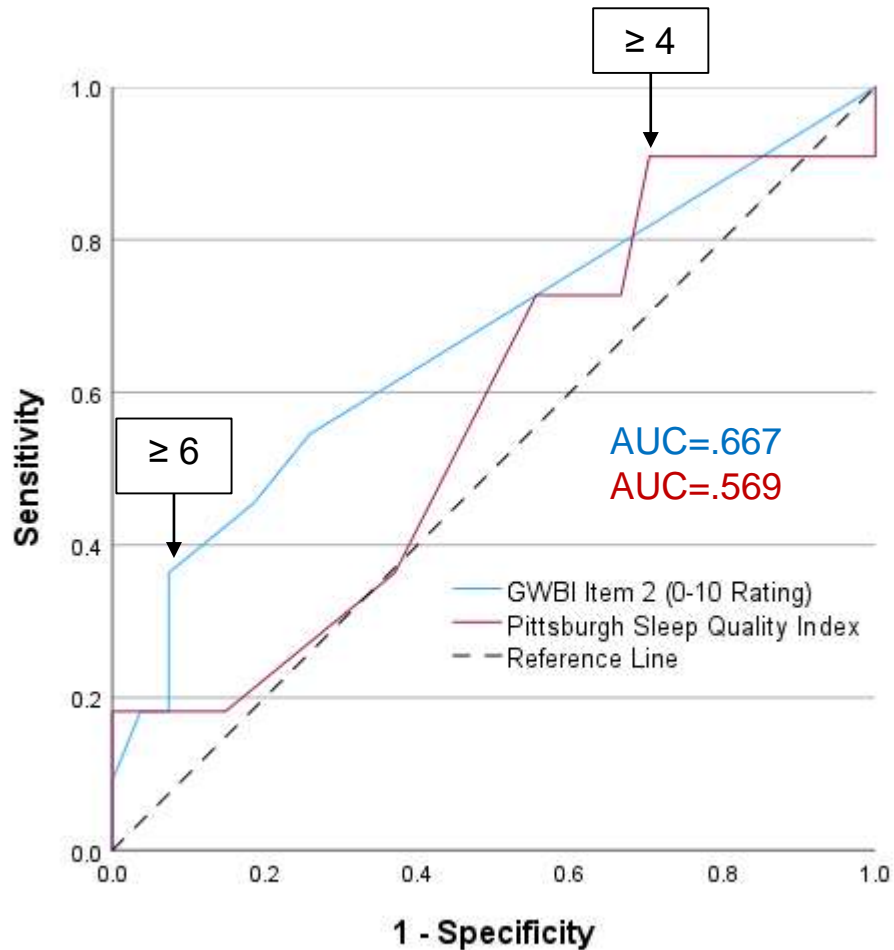
Dual-Task Motor Cost (Percentage)



Global Well-Being Index Items (0-10 Rating)



Sleep-Related Problems: Association with Concussion Hx



		Concussion History		Prevalence
		Yes	No	
Sleep-Related Problems GWBI (0-10)	≥ 6	4	2	67%
	< 6	7	25	22%
Total		11	27	

PPV: 67%

NPV: 78%

Sensitivity: 36%

Specificity: 93%

Accuracy: 76%

$$\chi^2(1) = 4.93$$

1-Sided $P = .047$

OR = 7.14

95% CI: 1.08; 47.42

		Concussion History		Prevalence
		Yes	No	
PSQI (0-21)	$\geq 4\%$	10	19	34%
	$< 4\%$	1	8	11%
Total		11	27	

PPV: 34%

NPV: 89%

Sensitivity: 91%

Specificity: 30%

Accuracy: 50%

$$\chi^2(1) = 1.82$$

1-Sided $P = .179$

OR = 4.21

95% CI: 0.46; 38.59

2 X 2 Cross-Tabulation Classification Accuracy

		Concussion History		Prevalence
		Yes	No	
Tandem Gait Serial 7 Subtract Motor Cost (%)	≥ 54%	9	7	56%
	< 54%	2	20	9%
Total		11	27	

Positive Predictive Value: 56%

Negative Predictive Value: 91%

Sensitivity: 82% Specificity: 74%

Accuracy: 76%

$$\chi^2(1)=10.02$$

1-Sided $P=.002$

OR=12.86

95% CI: 2.22, 74.54

		Concussion History		Prevalence
		Yes	No	
Tandem Gait Flanker Task Motor Cost (%)	≥ 23 %	9	6	60%
	<23 %	2	21	9%
Total		11	27	

Positive Predictive Value: 60%

Negative Predictive Value: 91%

Sensitivity: 82% Specificity: 78%

Accuracy: 79%

$$\chi^2(1)=11.62$$

1-Sided $P=.001$

OR=15.75

95% CI: 2.65; 93.46

Healthy College Students n=38
Self-Report of Concussion History
11/38 = 29% Prevalence

n=16

n=22

Tandem Gait + Serial 7
Motor Cost \geq 54%
9/16 = 56% Prevalence

Tandem Gait + Serial 7
Motor Cost $<$ 54%
2/22 = 9% Prevalence

n=5

n=11

n=1

n=21

Sleep-Related Problems
GWBI (0-10) \geq 6
3/5 = 60% Prevalence

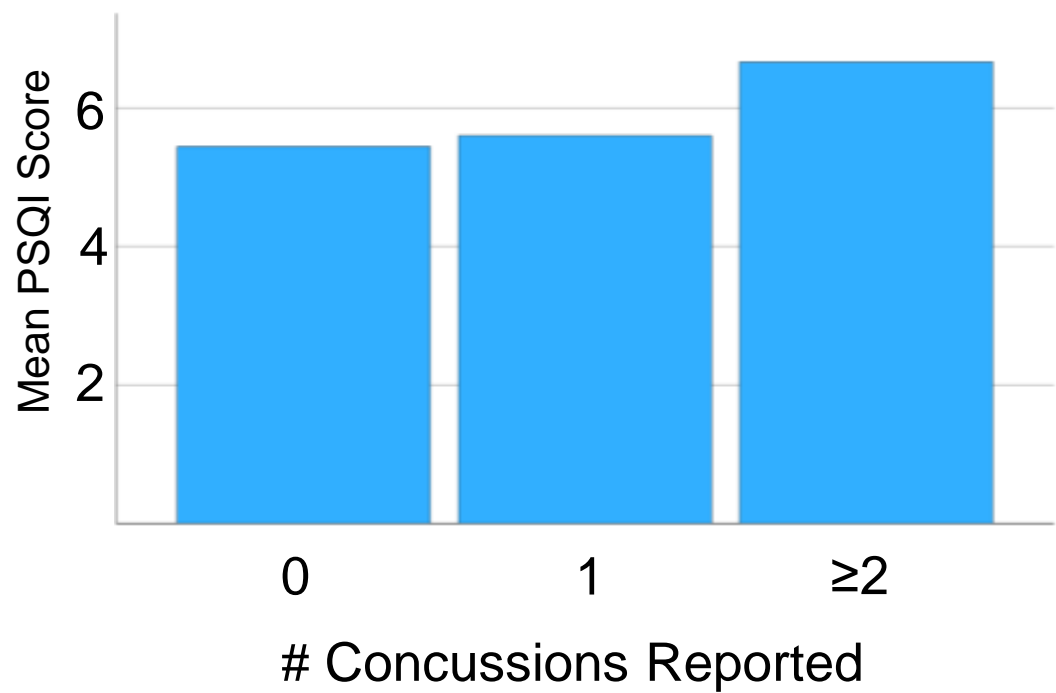
Sleep-Related Problems
GWBI (0-10) $<$ 6
6/11 = 55% Prevalence

Sleep-Related Problems
GWBI (0-10) \geq 6
1/1 = 100% Prevalence

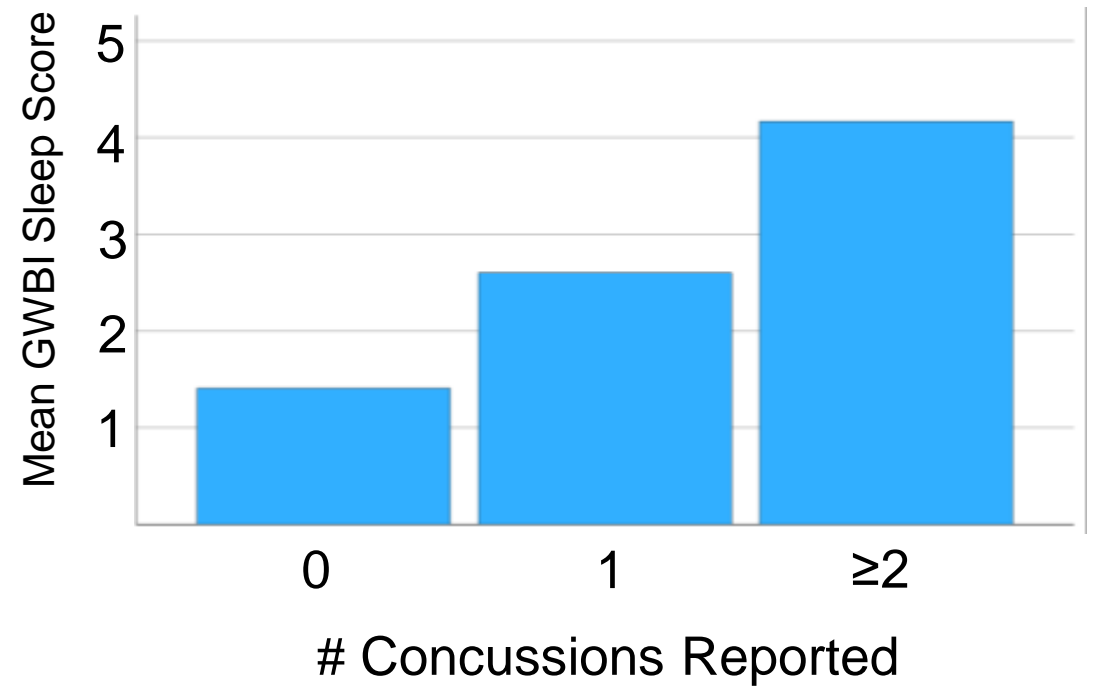
Sleep-Related Problems
GWBI (0-10) $<$ 6
1/21 = 5% Prevalence

Influence of Multiple Concussions

PSQI Score



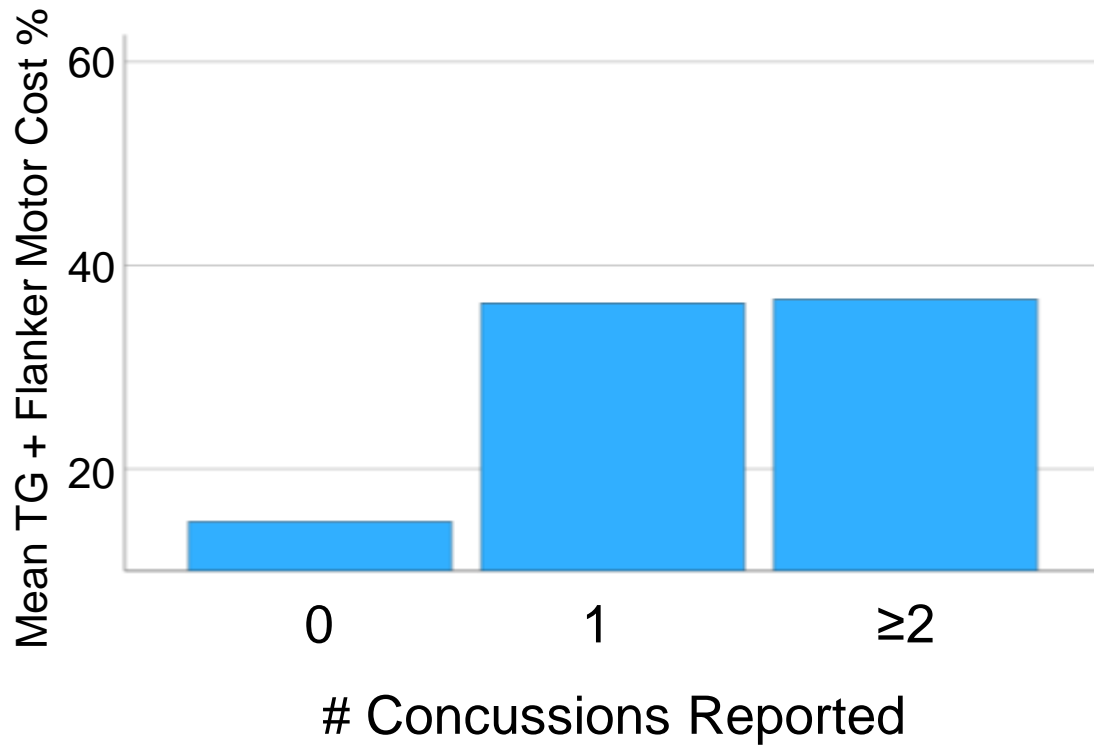
GWBI Sleep Score



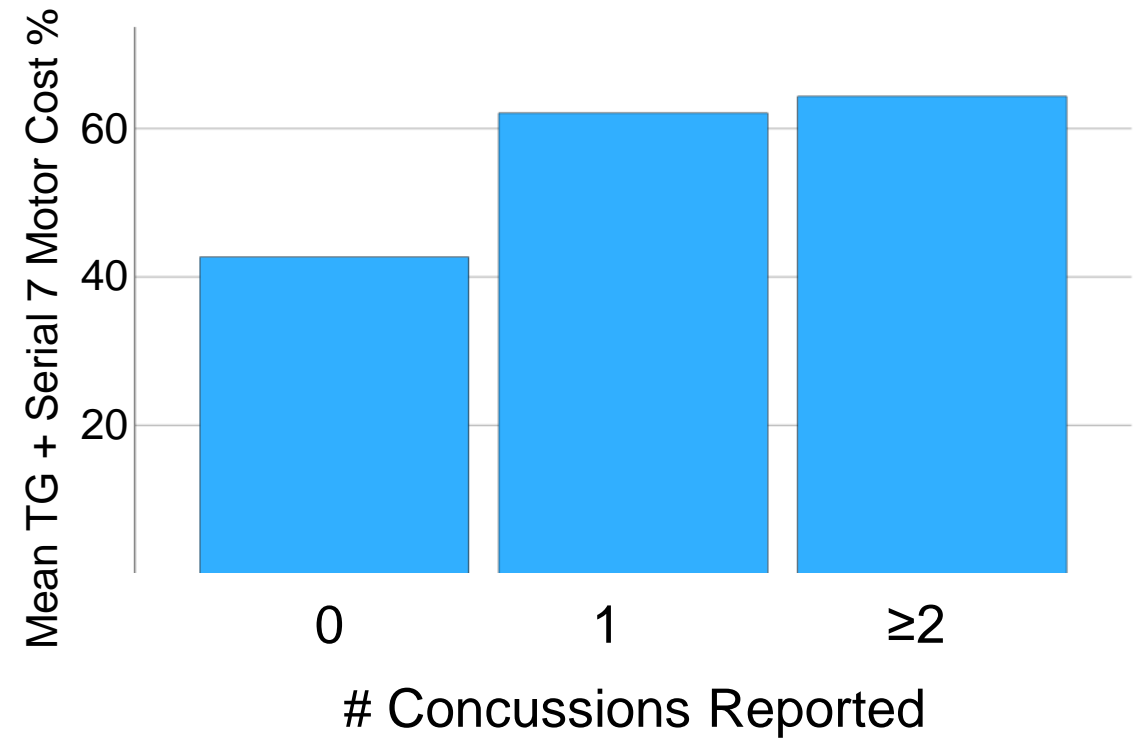
Influence of Multiple Concussions

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TG + Flanker



TG + Serial 7



Clinical Relevance

- Dual-Task Serial 7 Subtractions has comparable discriminatory ability to Dual-Task Flanker Task for identifying those with a history of concussion
 - No special phone app necessary
- GWBI Sleep item better for identification of concussion history and easier to score than “gold standard” PSQI
 - Also provided better discrimination among those with 0, 1, and 2+ concussions

Clinical Relevance

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- ❑ Risk for concussion recurrence and/or other injury is often unknown
 - ❑ Post-concussion elevation of injury risk may persist for months or years¹
 - ❑ Athletes often fail to report concussion symptoms at time of occurrence²
 - ❑ Repetitive head impacts can have similar effects as concussion³
- ❑ Dual-task testing and self-reported well-being can identify high-risk status
 - ❑ Tandem Gait + Serial 7 Subtractions does not impose any cost
 - ❑ Electronic administration of GWBI survey can be completed very quickly

Clinical Relevance

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- ❑ Identification of individual athletes with greatest injury risk allows time and resources to be focused on those likely to derive greatest benefit
 - ❑ Permits individualized prevention plan, rather than one-size-fits-all approach
 - ❑ Training designed to improve cognitive-motor integration
 - ❑ Interventions to promote increased sleep duration and improved quality

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