

Learning Objectives

1. Describe the prevalence of SRC, attention deficit hyperactivity disorder, and stimulant use in the young athlete (< 21 years) population and their potential as modifiers in the assessment and management of SRC
2. Identify the importance of accurate NP assessment in return to play decision-making and how specific co-morbidities (i.e., ADHD) can affect the neuropsychological performance of patient populations
3. Recognize the need for further investigation into the effects of ADHD on recovery from sport-related concussion

Introduction

Sport-related concussions (SRC) are a significant cause of morbidity in athletes in the US.¹ Attention deficit hyperactivity disorder (ADHD) is common in the pediatric population^{2,3} with stimulant prescriptions in this population dramatically increasing.⁴ For return-to-play decision making after SRC, accurate interpretation of the Immediate Post-Concussion Assessment and Cognitive Test (ImPACT) battery is important.^{1,5} ADHD and stimulants have been shown to affect baseline ImPACT scores.⁶⁻⁸ The purpose of this study is to assess if a self-reported diagnosis of ADHD and stimulant use was associated with post-concussion differences in ImPACT scores.

Methods

- From January 2013 – February 2014, 7704 amateur athletes from across the United States, ages 13-21 underwent baseline and post-concussion ImPACT testing. Retrospectively, following application of inclusion/exclusion criteria, self-reported histories were reviewed and athletes were classified based on self-reported 1) history of ADHD and 2) stimulant use (yes or no)
- Classification yielded 4 groups: 1. All Patients with ADHD, 2. Stimulant Treated ADHD, 3. Untreated ADHD, 4. Controls (no history of ADHD and no stimulant use)
- Three matching processes were undertaken in which Groups 1-3 were matched on sex, age, body mass index (BMI), education level, concussion history, and time elapsed (days) from concussion to post-concussion ImPACT test to controls
- Each group’s baseline + post-concussion ImPACT scores were compared to the appropriate matched controls utilizing non-parametric statistical analysis. A fourth, final comparison of Groups 2+3 was performed.

Results

Compared to controls, a history of ADHD was associated with

- Worse ImPACT composite scores in all categories at both baseline and post-concussion
- More total symptoms at baseline; Similar total symptoms post-concussion

Compared to controls, a history of untreated ADHD was associated with

- Worse ImPACT composite scores in all categories at both baseline and post-concussion.
- More total symptoms at baseline; Similar total symptoms post-concussion

Compared to controls, a history of stimulant-treated ADHD was associated with

- Worse verbal memory and visual memory composite scores at baseline and post-concussion
- More total symptoms at baseline and post-concussion.

Compared to those with a history of untreated ADHD, those with a history of stimulant-treated ADHD

- Had higher visual motor composite scores but reported more total symptoms at baseline
- No differences between the two groups were noted post-concussion

References: **1.** Harmon, K.G., et al., American Medical Society for Sports Medicine position statement: concussion in sport. British journal of sports medicine, 2013. 47: p. 15-26. **2.** Kessler, R.C., et al., The prevalence and correlates of adult ADHD in the United States: results from the National Comorbidity Survey Replication. Am J Psychiatry, 2006. 163(4): p. 716-23. **3.** Thomas, R., et al., Prevalence of attention-deficit/hyperactivity disorder: a systematic review and meta-analysis. Pediatrics, 2015. 135(4): p. e994-1001. **4.** Olfson, M., et al., National trends in the mental health care of children, adolescents, and adults by office-based physicians. JAMA psychiatry, 2014. 71: p. 81-90. **5.** McCrory, P., et al., Consensus Statement on Concussion in Sport: The 4th International Conference on Concussion in Sport Held in Zurich, November 2012. British Journal of Sports Medicine, 2012. 47: p. 9. **6.** Elbin, R.J., et al., Individual and combined effects of LD and ADHD on computerized neurocognitive concussion test performance: Evidence for separate norms. Archives of Clinical Neuropsychology, 2013. 28: p. 476-484. **7.** Zuckerman, S.L., et al., Baseline neurocognitive scores in athletes with attention deficit-spectrum disorders and/or learning disability. J Neurosurg Pediatr, 2013. 12(2): p. 103-9. **8.** Yengo-Kahn, A.M. and G. Solomon, Are psychotropic medications associated with differences in baseline neurocognitive assessment scores for young athletes? A pilot study. Phys Sportsmed, 2015. 43(3): p. 227-35.

ImPACT Composite Scores: All Groups and Controls						
ImPACT Composite Score	All Patients with ADHD	Controls for All ADHD	Untreated ADHD	Controls for Untreated	Treated ADHD	Controls for Treated
Baseline Verbal Memory	82.0±10.90	84.6±9.9	82.1±10.67	84.4±9.75	81.6±11.64	84.8±10.2
Baseline Visual Memory	71.1±13.0	76.1±12.6	70.9±13.04	76.1±12.63	71.9±12.75	76.2±12.22
Baseline Visual Motor	34.7±7.38	37.1±7.02	34.1±7.46	37.1±6.97	36.6±6.85	37.0±7.10
Baseline Reaction Time	0.63±0.09	0.61±0.09	0.64±0.10	0.61±0.08	0.62±0.09	0.61±0.09
Baseline Total Symptom Score	5.66±8.41	3.31±6.23	5.07±8.37	3.31±6.23	7.43±8.37	3.26±6.18
Post-Concussion Verbal Memory	82.8±12.80	86.9±10.66	82.7±12.57	86.7±10.82	83.3±13.58	87.6±10.40
Post-Concussion Visual Memory	73.0±14.17	77.8±12.76	73.2±13.86	77.4±12.91	72.4±15.17	78.3±12.43
Post-Concussion Visual Motor	36.0±7.28	38.5±7.07	35.6±7.02	38.4±7.10	37.1±7.95	38.6±7.00
Post-Concussion Reaction Time	0.63±0.10	0.60±0.10	0.63±0.10	0.61±0.11	0.62±.13	0.60±.10
Post-Concussion Total Symptom Score	7.91±14.45	5.60±10.58	6.89±12.89	5.82±10.52	11.0±18.14	5.09±10.57

Summary of Comparisons of ImPACT Composite Scores Between Groups Pre + Post Concussion					
	Verbal Memory	Visual Memory	Visual Motor	Reaction Time	Total Symptom Score
Baseline: All Patients with ADHD vs. Matched Controls	↓	↓	↓	↑	↑
Post-Concussion: All Patients with ADHD vs. Matched Controls	↓	↓	↓	↑	↔
Baseline: Untreated ADHD vs. Matched Controls	↓	↓	↓	↑	↑
Post-Concussion: Untreated ADHD vs. Matched Controls	↓	↓	↓	↑	↔
Baseline: Stimulant-Treated ADHD vs. Matched Controls	↓	↓	↔	↔	↑
Post-Concussion Stimulant-Treated ADHD vs. Matched Controls	↓	↓	↔	↔	↑
Baseline: Stimulant-Treated ADHD vs. Untreated ADHD	↔	↔	↑	↔	↑
Post-Concussion: Stimulant-Treated ADHD vs. Untreated ADHD	↔	↔	↔	↔	↔

Comparison of ImPACT Composite Scores Between Groups													
ImPACT Composite Score	All ADHD vs. Controls	p Value*	Effect Size (r)**	Untreated vs. Controls	p Value*	Effect Size (r)**	Treated vs. Controls	p Value*	Effect Size (r)**	Treated vs. Untreated	p Value*	Effect Size (r)**	
Baseline Verbal Memory	Worse	0.001	-0.101	Worse	0.012	-0.088	Worse	0.047	-0.108	No Difference	0.885		
Baseline Visual Memory	Worse	0.000	-0.166	Worse	0.000	-0.176	Worse	0.013	-0.134	No Difference	0.608		
Baseline Visual Motor	Worse	0.000	-0.139	Worse	0.000	-0.175	No Difference	0.496		Better	0.025	-0.134	
Baseline Reaction Time	Worse	0.001	0.100	Worse	0.000	-0.125	No Difference	0.717		No Difference	0.143		
Baseline Total Symptom Score	Worse	0.000	-0.156	Worse	0.000	-0.124	Worse	0.000	-0.234	Worse	0.037	-0.125	
Post-Concussion Verbal Memory	Worse	0.000	-0.143	Worse	0.000	-0.144	Worse	0.023	-0.124	No Difference	0.541		
Post-Concussion Visual Memory	Worse	0.000	-0.148	Worse	0.000	-0.133	Worse	0.003	-0.162	No Difference	0.990		
Post-Concussion Visual Motor	Worse	0.000	-0.147	Worse	0.000	-0.174	No Difference	0.285		No Difference	0.085		
Post-Concussion Reaction Time	Worse	0.000	-0.113	Worse	0.000	-0.143	No Difference	0.631		No Difference	0.071		
Post-Concussion Total Symptom Score	No Difference	0.050		No Difference	0.689		Worse	0.001	-0.177	No Difference	0.059		

*According to Mann-Whitney U-test; Bolded values indicate significant differences (p < 0.05)

**Effect Size Estimate for Mann-Whitney U Comparisons

Discussion

Baseline Results:

- Agree with previous studies
- Stimulants may aid visual performance and reaction time
- Further describe normative baseline data set of NP scores in patients with ADHD
- Medication status may be important consideration

Post-Concussion Results:

- Novel data
- Stimulant-treated ADHD patients report greater symptoms than controls
- Same differences observed post-concussion as at baseline
- Continuation of baseline deficits vs. ADHD prolonging recovery from SRC?

Conclusions

- ADHD associated with worse neurocognitive performance in all ImPACT domains at baseline and post-concussion
- Stimulants may help improve visual motor composite scores and reaction time in patients with ADHD
- These baseline and post-concussion neurocognitive test performance data can be considered when evaluating scores in athletes with ADHD, especially when interpreting post-concussion performances that appear to be abnormal and making RTP decisions in those without a baseline test
- Further assessment is needed to determine the effect of ADHD on post-concussion recovery