OXFORD UNIVERSITY PRESS

Archives of Clinical Neuropsychology 37 (2022) 633–640

Archives of CLINICAL NEUROPSYCHOLOGY

Impact of Psychiatric Illnesses and Selective Serotonin Reuptake Inhibitor Medications on Baseline Neurocognitive Testing

Zerubabbel K. Asfaw[1,*], Theodore C. Hannah[1], Muhammad Ali[1], Adam Y. Li[1], Zachary Spiera[1], Naoum Fares Marayati[1], Roshini Kalagara[1], Nickolas Dreher[1], Alexander J. Schupper[1], Alex Gometz[2], Mark R. Lovell[3], Tanvir Choudhri[1]

[1]*Department of Neurosurgery, Icahn School of Medicine at Mount Sinai, New York, NY, USA*
[2]*Concussion Management of New York, NY, USA*
[3]*Department of Neurological Surgery, University of Pittsburgh Medical Center, Pittsburgh, PA, USA*

*Corresponding Author at: Department of Neurosurgery, Icahn School of Medicine at Mount Sinai, 1468 Madison Avenue, Annenberg Building, 8th Floor, Room 88, New York, NY 10029, USA. Tel: 508-505-8402. *E-mail address*: zerubabbel.asfaw@icahn.mssm.edu (Z. K. Asfaw)

Accepted 27 September 2021

Abstract

Introduction: Neurocognitive tests are an integral component of sport-related concussion (SRC) workup. A history of psychiatric illness (HPI) is common among young athletes. Investigations of factors that influence athletes' baseline neurocognitive function are crucial for an accurate assessment of SRC.
Objective: In this study, we aim to elucidate the effect of HPI and selective-serotonin reuptake inhibitor (SSRI) medication use on baseline neurocognitive performance in young athletes.
Methods: We conducted a retrospective cross-sectional study of Immediate Post-Concussion Assessment and Cognitive Testing assessments. A total of 268 athletes with HPI and a control group of 6,364 athletes were included. The outcomes were total symptom score based on post-concussion symptom scale, verbal memory, visual memory, visual motor, reaction time, and impulse control scores with self-reported HPI status and SSRI use.
Results: Athletes with HPI had an elevated symptom score in both univariate analysis ($p < .0001$) and multivariate analysis ($p < .0001$). HPI influence on visual memory score was not robust to multivariate analysis ($p = .24$). Athletes with HPI who reported SSRI medication use had the same baseline neurocognitive performance as other athletes with HPI. HPI influences athletes' baseline neurocognitive performance by elevating symptom scores. HPI does not alter any of the objective neurocognitive composite scores in contrast to previous work.
Conclusions: Clinicians should consider the impact of HPI on baseline neurocognitive performance during the assessment of a suspected SRC. Additional research is required to bolster our findings on SSRI use and ascertain the effects of other drug classes on baseline neurocognitive performance.

Keywords: sport-related concussion; history of psychiatric illness; SSRI medications; ImPACT; baseline neurocognitive testing

Introduction

Sport-related concussion (SRC), a subset of mild traumatic brain injury (mTBI), affects nearly 3.8 million people annually (Langlois, Rutland-Brown, & Wald, 2006). Eclipsed only by motor accidents, sports-related injuries are the second most frequent cause of traumatic brain injury among individuals aged 15–24 years (Gessel, Fields, Collins, Dick, & Comstock, 2007). Because SRC is a multifaceted pathology, its assessment and management are multifactorial and often necessitate the utilization of neurocognitive testing and vestibular evaluation in addition to clinical evaluation (McCrory et al., 2017). Among current

https://doi.org/10.1093/arclin/acab087 Advance Access publication 19 October 2021

neurocognitive tests, Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) remains widely employed in the field of sports medicine. ImPACT is a Food and Drug Administration-approved computerized neurocognitive test battery that quantifies six composite scores to assess athletes' attention and processing speed (Iverson, Lovell, & Collins, 2005).

Neurocognitive assessment of a suspected concussion can occur either via a repeated-measure design or between-subjects design. ImPACT uses a repeated measures design, comparing an athlete's assessment following a suspected concussion with their baseline score. Barth et al. (1989) reported that a repeated-measure design is more sensitive in detecting neurocognitive changes after a concussion relative to a between-subjects design. However, studies have reported that age, sex, history of attention deficit hyperactivity disorder (ADHD), and history of anxiety and depression can affect athletes' baseline scores (Cottle, Hall, Patel, Barnes, & Ketcham, 2017; Covassin et al., 2006; Covassin, Elbin 3rd, Larson, & Kontos, 2012; Harmon et al., 2013; Solomon, Kuhn, & Zuckerman, 2016). Although previous literature indicates that a history of psychiatric illness (HPI) is associated with an elevated post-concussion symptom score (PCSS), there are conflicting reports regarding other ImPACT composite scores (Bailey, Samples, Broshek, Freeman, & Barth, 2010; Cottle et al., 2017; Covassin et al., 2012; Solomon et al., 2016). Although some studies reported that a HPIs worsened an athlete's baseline verbal memory and visual memory, others have indicated the effect is limited to just visual-motor speed or reaction time. Here, we aimed to elucidate the independent effect of HPI on ImPACT baseline composite scores—using a larger sample and controlling for relevant confounders.

Psychotropic medications are often prescribed for adolescents to treat psychiatric disorders such as ADHD, anxiety, autism spectrum disorder, depression, conduct disorder, and obsessive–compulsive disorder (Yengo-Kahn & Solomon, 2015). In the USA, 7% of all adolescents take at least one psychotropic medication a year, whereas 4.7% of these adolescents had psychotropic polypharmacy prescriptions in 2015 (Girand, Litkowiec, & Sohn, 2020; Olfson, He, & Merikangas, 2013; Yengo-Kahn & Solomon, 2015). Although psychotropics exert mild to impairing effects on healthy patients' cognitive performance, the literature demonstrates that some psychotropics could improve multiple cognitive domains in patients with depression (Amado-Boccara, Gougoulis, Poirier Littre, Galinowski, & Loo, 1995; Baune & Renger, 2014; Herrera-Guzman et al., 2009; Katona, Hansen, & Olsen, 2012; Levkovitz, Caftori, Avital, & Richter-Levin, 2002). Selective-serotonin reuptake inhibitors (SSRIs)—a subclass of psychotropics—may have varying effects on neurocognitive performance, which has been previously described in healthy and depressed patients (Amado-Boccara et al., 1995; Baune & Renger, 2014). The prevalence of SRC, psychiatric illness, and SSRI use among young athletes highlight the need to investigate the effect of SSRIs on baseline neurocognitive performance. Thus, the secondary objective of this study was to ascertain whether SSRI use altered baseline neurocognitive performance among young athletes with HPI.

Materials and Methods

Data Collection

Data from 11,563 baseline ImPACT tests from 7453 individual student-athletes taken between 2009 and 2019 were queried for HPI. Only the first baseline for each athlete was included in the analyses, and additional exclusions were made for any baseline that left the HPI question blank. HPI status was determined by each athlete's response to the question of whether they have been treated for a psychiatric condition. Institutional review board approval was granted, and this study was exempt from informed consent because the data were de-identified before the acquisition.

ImPACT Assessment

ImPACT tests neurocognitive function using a range of tasks over a 20-minute computerized testing session (Iverson et al., 2005). Demographic data collection and administration of the post-concussion symptom scale (PCSS) are performed at the outset of the examination. Reporting of symptoms is used to calculate the Symptom composite score. Next, the examinee undergoes a battery of neurocognitive tasks, including word recall, design recall, the X's and O's test, symbol matching, 3-letter recall, and a color match test. Scores on these tasks are used to generate the Verbal Memory, Visual Memory, Visual Motor, Reaction Time, and Impulse Control composite scores.

Medications

The collection of demographic information included a section where examinees are asked to report their current medications. This information was used to determine whether patients were taking stimulants or SSRI medications. Stimulant medications reported in the dataset included methylphenidate, dexmethylphenidate, lisdexamfetamine, atomoxetine, amphetamine, and amphetamine/dextroamphetamine. SSRIs included sertraline, citalopram, escitalopram, and fluoxetine.

Table 1. Demographics and baseline ImPACT scores of the study cohorts—history of psychiatric illness (HPI), diagnosed with a learning disability (DLD), and diagnosed with attention deficit and hyperactivity disorder (ADHD)

	CTRL ($n = 6364$) n (%)	HPI ($n = 268$) n (%)	p-value
Age (mean, SD)	14.95 (1.58)	15.31 (1.67)	.0003
Sex: female	2153 (33.8%)	141 (52.6%)	<.0001
Sport: football	2645 (49.5%)	82 (30.6%)	<.0001
DLD	165 (2.59%)	23 (8.58%)	<.0001
ADHD	263 (4.13%)	51 (19.0%)	<.0001
History of concussion (2 or more)	407 (6.40%)	33 (12.3%)	.0001
Headache/Migraine	799 (12.5%)	89 (33.2%)	<.0001
SSRI use	4 (0.06%)	33 (12.3%)	<.0001
Stimulant use	102 (1.60%)	22 (8.21%)	<.0001

ImPACT, Immediate Post-Concussion Assessment and Cognitive Testing; CTRL, control group; SSRI, selective-serotonin reuptake inhibitor.

Statistical Analysis

Chi-squared and *t*-tests were used to compare demographic differences between cohorts. Univariate and multivariate linear regression analyses were used to evaluate ImPACT composite score differences between cohorts at baseline. Similar regression analyses were used to evaluate SSRI medication's independent effect on ImPACT performance in patients with HPI. Multivariate regression analysis included various covariates that were observed to differ significantly between cohorts and known to correlate with both concussion incidence and psychiatric illness which could result in an omitted variable bias if excluded from the model (Bergman-Bock, 2018; Karic et al., 2019; McLean, Asnaani, Litz, & Hofmann, 2011). These covariates included age, sex, and binary indicators for diagnosed learning disability (DLD), ADHD, a history of two or more prior concussions, a history of migraines or headaches, sport played (football or other), current use of SSRI medications, and current use of stimulants.

Results

There were 268 subjects in the HPI cohort and 6,364 subjects in the control group (CTRL). On average, subjects in the CTRL cohort were younger than subjects with HPI (14.95 vs. 15.31, $p = .0003$). The percentage of females in the CTRL group was less than that of the HPI cohort (33.8% vs. 52.6%, $p < .0001$). More subjects in the CTRL cohort played football than in the HPI cohort (49.5% vs. 30.6%, $p < .0001$). The percentage of subjects with ADHD (4.13% vs. 19.0%, $p < .0001$), diagnosed learning disabilities (2.59% vs. 8.58%, $p < .0001$), history of two or more concussions (6.40% vs. 12.3%, $p = .0001$), history of treatment for headache or migraine (12.5% vs. 33.2%, $p < .0001$), SSRI use (0.06% vs. 12.3%, $p < .0001$), and stimulant use (1.60% vs. 8.21%, $p < .0001$) was lower in the CTRL group (Table 1).

Univariate analysis yielded statistically significant increases in the PCSS ($\beta = 9.33$, 95% CI: 8.11–10.54, $p < .0001$) and decreases visual memory scores ($\beta = -1.65$, 95% CI: −3.28 to −0.01, $p = .049$), for the HPI cohort. There was no statistically significant difference in verbal memory ($\beta = 0.20$, 95% CI: −1.08 to 1.47, $p = .30$), visual motor ($\beta = 0.61$, 95% CI: −0.26 to 1.46, $p = .17$), reaction time score ($\beta = -0.006$, 95% CI: −0.019 to 0.006, $p = .34$), and impulse control ($\beta = 0.04$, 95% CI: −0.56 to 0.65, $p = .89$). Upon multivariate analysis the difference in PCSS was preserved ($\beta = 7.29$, 95% CI: 5.94–8.65, $p < .0001$), whereas the difference in visual memory score was lost ($\beta = -1.11$, 95% CI: −2.97 to 0.76, $p = .24$). Differences in the verbal memory ($\beta = 0.06$, 95% CI: −1.39 to 1.51, $p = .49$), visual motor ($\beta = -0.20$, 95% CI: −1.13 to 0.73, $p = .68$), reaction time ($\beta = 0.000$, 95% CI: −0.014 to 0.014, $p = .96$), or impulse control ($\beta = 0.21$, 95% CI: −0.47 to 0.90, $p = .61$) composite scores were not statistically significant in the multivariate analysis (Fig. 1; Table 2).

Univariate analysis evaluating the effect of SSRI medications on baseline ImPACT within the HPI cohort demonstrated a no significant effect on PCSS ($\beta = 2.33$, 95% CI: −3.64 to 8.29, $p = .44$), verbal memory ($\beta = -0.89$, 95% CI: −4.84 to 3.05, $p = .66$), visual memory ($\beta = -2.90$, 95% CI: −7.59 to 1.79, $p = .22$), visual motor scores ($\beta = 2.13$, 95% CI: −0.53-4.80, $p = .12$), reaction time ($\beta = -0.009$, 95% CI: −0.046 to 0.028, $p = .62$), impulse control ($\beta = 0.51$, 95% CI: −1.10 to 2.13, $p = .53$). Similarly, multivariate analysis showed no significant effect of SSRI medication use on PCSS ($\beta = 3.11$, 95% CI: −4.07 to 10.3, $p = .39$), verbal memory ($\beta = -1.52$, 95% CI: −5.77 to 2.72, $p = .48$), visual memory ($\beta = -0.87$, 95% CI: −5.94 to 4.20, $p = .74$), visual motor ($\beta = 2.05$, 95% CI: −0.54 to 4.63, $p = .12$), reaction time ($\beta = -0.018$, 95% CI: −0.058 to 0.020, $p = .34$), or impulse control ($\beta = 0.10$, 95% CI: −1.62 to 1.81, $p = .91$) scores (Table 3).

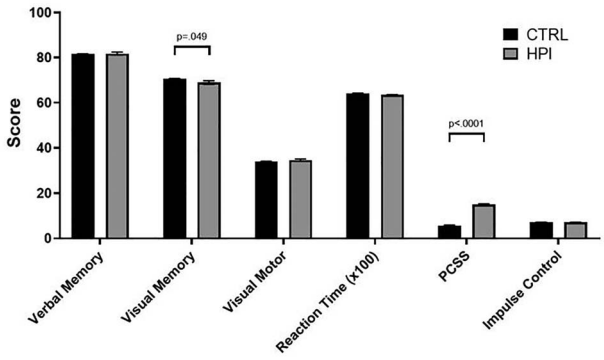

Fig. 1. Univariate analysis of history of psychiatric illness (HPI) influence on ImPACT baseline composite scores of athletes with HPI and control group (CTRL). HPI was associated with an elevated post-concussion symptom scale (PCSS) score ($p < .0001$) and a lower visual memory score ($p = .049$). ImPACT, Immediate Post-Concussion Assessment and Cognitive Testing.

Table 2. Linear regression analysis of the effect of history of psychiatric illness on the ImPACT baseline composite scores of subjects

Univariate analysis			
Composite score	Estimate	95% CI	*p*-value
Post-concussion symptom scale	$\beta = 9.33$	8.11 to 10.54	<.0001
Verbal memory	$\beta = 0.20$	−1.08 to 1.47	.30
Visual memory	$\beta = -1.65$	−3.28 to −0.010	.049
Visual motor	$\beta = 0.61$	−0.26 to 1.46	.17
Reaction time	$\beta = -0.006$	−0.019 to 0.006	.34
Impulse control	$\beta = 0.04$	−0.56 to 0.65	.89
Multivariate analysis			
Composite score	Estimate	95% CI	*p*-value
Post-concussion symptom scale	$\beta = 7.29$	5.94 to 8.65	<.0001
Verbal memory	$\beta = 0.06$	−1.39 to −1.51	.49
Visual memory	$\beta = -1.11$	−2.97 to 0.76	.24
Visual motor	$\beta = -0.20$	−1.13 to 0.73	.68
Reaction time	$\beta = 0.000$	−0.014 to 0.014	.96
Impulse control	$\beta = 0.21$	−0.47 to 0.90	.61

ImPACT, Immediate Post-Concussion Assessment and Cognitive Testing.

Discussion

The current study examined the influence of HPI on adolescent athletes' baseline scores and found that although HPI is associated with an elevated PCSS score, it did not affect the other baseline composite scores in a large cohort of adolescent athletes. Conflicting reports in the literature have suggested HPI influences athletes' verbal memory and visual memory scores or visual-motor speed and reaction time (Covassin et al., 2012; Wallace et al., 2020; Weber et al., 2018; Yang, Peek-Asa, Covassin, & Torner, 2015). However, our results suggest that such conflicting reports may be due to limited sample sizes or inadequate control of confounders. Based on a review of the current literature, the present study is one of the few that explored the association between SSRI medications and baseline cognitive test scores (Bailey et al., 2010; Covassin et al., 2012; Iverson, 2006; Yengo-Kahn & Solomon, 2015). The results indicated that SSRI use did not have a significant influence on any ImPACT composite score.

Post-Concussion Symptom Scale

In the present study, HPI subjects reported significantly higher PCSS scores than controls at baseline. These results align with previous reports that HPI influences PCSS score during baseline testing and demonstrate that the study was adequately powered to find a difference in ImPACT scores. Moreover, the results highlight the importance of recognizing baseline psychiatric illness in order to assess an athletes' baseline neurocognitive performance accurately (Cottle et al., 2017; Covassin et al., 2012; Morgan

Table 3. Linear regression analysis of the effect of taking SSRI on the ImPACT baseline composite scores of subjects with a history of psychiatric illness

Univariate analysis			
Composite score	Estimate	95% CI	*p*-value
Post-concussion symptom scale	$\beta = 2.33$	−3.64 to 8.29	.44
Verbal memory	$\beta = -0.89$	−4.84 to 3.05	.66
Visual memory	$\beta = -2.90$	−7.59 to 1.79	.22
Visual motor	$\beta = 2.13$	−0.53 to 4.80	.12
Reaction time	$\beta = -0.009$	−0.046 to 0.028	.62
Impulse control	$\beta = 0.51$	−1.10 to 2.13	.53
Multivariate analysis			
Composite score	Estimate	95% CI	*p*-value
Post-concussion symptom scale	$\beta = 3.11$	4.07 to 10.3	.39
Verbal memory	$\beta = -1.52$	−5.77 to 2.72	.48
Visual memory	$\beta = -0.87$	−5.94 to 4.20	.74
Visual motor	$\beta = 2.05$	−0.54 to 4.63	.12
Reaction time	$\beta = -0.018$	−0.058 to 0.020	.34
Impulse control	$\beta = 0.10$	−1.62 to 1.81	.91

ImPACT, Immediate Post-Concussion Assessment and Cognitive Testing.

et al., 2015; Wallace et al., 2020; Yengo-Kahn & Solomon, 2015). Because ImPACT relies on changes from baseline scores to assess neurocognitive dysfunction when a concussion is suspected, having higher symptom scores at baseline could make it more difficult to demonstrate significant change after a head injury. For example, Gaudet et al. found that verbal memory and visual memory scores may suffer from significant ceiling effects in a test–retest ImPACT paradigm. Although they did not evaluate symptom scores or post-concussion testing, a ceiling effect may result in an underestimation of concussion severity in athletes with HPI (Gaudet, Konin, & Faust, 2020), despite prior studies demonstrating that HPI—such as premorbid and concurrent anxiety—is actually associated with extended recovery from concussion (Broshek, De Marco, & Freeman, 2015; Ponsford et al., 2012). Conversely, clinicians who are unaware of a subject's HPI may be prone to over-diagnosing concussion when evaluating a patient with HPI because their symptom burden is likely to be much higher than the control population. Our result could have significant implications for post-concussion assessment and treatment because HPI can misrepresent an athlete's memory and processing capacity (Bailey et al., 2010).

It is critical to note that previous work has shown many potential confounders when comparing neurocognitive function between subjects with HPI and controls. It has been reported that both age and sex influence neurocognitive test performance (Cottle et al., 2017; Covassin et al., 2006; Covassin et al., 2012). In our dataset, the CTRL cohort was younger and had a lesser percentage of female subjects than the HPI cohort. Morgan et al. (2015) also reported that a history of concussion coupled with mood disorders influenced PCSS, and the HPI cohort in this study had a higher percentage of subjects reporting two or more prior concussions. The cohorts were significantly different in every demographic variable tested. It is therefore essential to adequately control for demographic differences in all studies analyzing differences between subjects with HPI and those without HPI. The validity of results in studies without such measures may be significantly compromised.

The effects of HPI on PCSS are also not limited to baseline performance (Bailey et al., 2010; Yang et al., 2015). Yang et al. found that athletes who reported HPI at baseline were 4.59 times more likely to suffer from depression and 3.40 times more likely to experience anxiety after sustaining a concussion. Consequently, baseline depression scores were significant predictors of post-concussion anxiety and depression (Yang et al., 2015). Equally important, understanding the influence of an increased symptom burden on baseline ImPACT scores can help physicians distinguish the level of symptoms reported post-injury from those reported at baseline before organizing a treatment plan (Wallace et al., 2020).

Objective Neurocognitive Composite Scores

This study indicates that HPI does not influence ImPACT baseline composite scores in young athletes—other than PCSS. Previous reports limited by sex, sport type, age, number of centers, and sample size reported divergent results regarding HPI influence on objective neurocognitive composite scores. Wallace et al. reported that a history of anxiety or depression was associated with a lower visual motor score among athletes (Wallace et al., 2020). Regarding visual memory score, Covassin et al. (2012) mentioned that athletes with a history of depression had a worse baseline visual memory score, whereas Yengo-Kahn

and Solomon (2015) found a similar result for those with untreated anxiety and depression). Discrepancies also extended to reaction time scores, with Bailey et al. (2010) reporting a slower baseline reaction time for athletes with a history of depression, anxiety, and other psychiatric problems. Although Bailey et al. used a different neurocognitive test—Concussion Resolution Index (CRI)—other studies that utilize baseline ImPACT tests have not replicated the influence of HPI on reaction time (Cottle et al., 2017; Covassin et al., 2012; Wallace et al., 2020; Weber et al., 2018).

In addition to being one of the ImPACT composite scores, increased PCSS can influence neurocognitive performance (Cottle et al., 2017; Wallace et al., 2020; Weber et al., 2018; Yang et al., 2015). However, studies, including the present report, that analyze the influence of HPI on baseline ImPACT scores do not account for the confounding role of PCSS on neurocognitive scores (Bailey et al., 2010; Brooks, Iverson, Sherman, & Roberge, 2010; Covassin et al., 2012; Wallace et al., 2020; Weber et al., 2018). This is likely because psychiatric illnesses cause, and are often defined by, significant somatic symptoms. It is thus difficult to delineate between the effect of HPI and the effect of extraneous symptom burden. Nevertheless, there are multiple symptoms in the PCSS that are unlikely to be directly attributable to psychiatric illness but may influence neurocognitive function. This factor may also help explain the divergent results in objective ImPACT composite scores.

There are additional rationales for the dissimilar results in this study compared with prior work. Similar studies in the past have evaluated either college-aged or high school-aged subjects, and some have exclusively examined football players, which limits the generalizability of the findings (Bailey et al., 2010; Brooks et al., 2010; Cottle et al., 2017; Yang et al., 2015). Additionally, many studies have had low sample sizes that could have inflated the effect sizes of the results (Bailey et al., 2010; Brooks et al., 2010; Cottle et al., 2017; Covassin et al., 2012; Wallace et al., 2020; Yang et al., 2015). The cohort examined in this study included subjects playing different sports, across the entire adolescent age range, from multiple centers in the USA. Consequently, relative to previous research, this study likely has enhanced generalizability. Furthermore, this study accounted for SSRI and stimulant medication use within the study population, thereby eliminating another common limitation observed in previous studies (Bailey et al., 2010; Brooks et al., 2010; Cottle et al., 2017; Covassin et al., 2012; Wallace et al., 2020; Weber et al., 2018).

SSRI Use

The use of SSRI medications had no effect on any ImPACT composite score in patients reporting HPI. With over 51 million adults with mental illnesses, SSRI use is prevalent in the USA (Health; Olfson et al., 2013). Nevertheless, there is a paucity of evidence on SSRI medications' effect on baseline neurocognitive performance despite the high incidence of SRC in adolescent student-athletes and the possibility of increased risk of post-concussion syndrome in athletes with HPI (Evered, Ruff, Baldo, & Isomura, 2003; Jotwani & Harmon, 2010). Yengo-Kahn et al. found that athletes on antidepressants had a faster reaction time, and those with HPI who have not received psychotropic medications had an elevated symptom score and a lower visual memory score (Yengo-Kahn & Solomon, 2015). Here, the univariate and multivariate analyses demonstrated that SSRI use had no influence on any baseline neurocognitive composite scores among subjects with HPI. Thus, there was no significant change in reaction time due to SSRI use in contrast to the results reported by Yengo-Kahn et al. Importantly, the authors of that study acknowledged the effect size of psychotropic medications on reaction times was relatively small (Yengo-Kahn & Solomon, 2015). Differences in sample size and lack of data stratification based on antidepressant type—SSRIs, tricyclic antidepressants, and bupropion—may have contributed to discrepancies in our results with Yengo-Kahn and Solomon (2015). Future studies are needed to assess the effects of different psychotropic medications based on the mechanism of action that was not assessed in either of these studies due to low numbers (Amado-Boccara et al., 1995; Baune & Renger, 2014).

Limitations

As a retrospective cross-sectional investigation, there are several limitations of this study. First, all the data pertinent to HPI, ADHD, DLD, history of concussion, and medication use was self-reported. As a result, the study is limited by the inherent inaccuracy of self-reported data (Gonyea, 2005). ImPACT composite scores are not a completely comprehensive neuropsychological evaluation. Therefore, different assessments, such as the CRI and Personality Assessment Inventory, could yield different results in the same population. The current study also did not incorporate independent validity or effort indicators beyond those provided by ImPACT. Equally important, even though the study is limited to only the first baseline test in the dataset for each subject, patients may have previously taken the test before joining the organizations involved in this study. Thus, some participants could have taken multiple baseline tests to improve neurocognitive performance due to practice effects, although ImPACT has shown resilience to such effects (Elbin et al., 2019). In contrast to Covassin et al. (2012), the HPI cohort was not stratified based on the severity of psychiatric illness. This study did not account for the influence of ethnicity and socioeconomic status of athletes on baseline IMPACT scores due to the absence of these variables in the database utilized for this research. Finally, this study provides only a snapshot of neurocognitive function at a single time point for each individual.

Longitudinal research designs, coupled with clinical evaluations, would be needed to track baseline neurocognitive performance over time to validate any persistent cognitive effects.

Conclusion

In a multivariate analysis, HPI was associated with an elevated PCSS score but not with verbal memory, visual memory, visual motor, reaction time, and impulse control scores. SSRI medications did not have a significant influence on any ImPACT composite score within the HPI cohort. In light of the prevalence of mental illnesses in the country, this report elucidates the effect of HPI on baseline neurocognitive performance and highlights the need for further research into any link between psychotropic medications and neurocognitive performance.

Acknowledgments

None.

Funding

No funding and financial support was received to support this work.

Conflict of Interest

Dr. Mark Lovell developed the technology for ImPACT, and he was a cofounder of ImPACT Applications Inc. All other authors report no conflicts of interest.

References

Amado-Boccara, I., Gougoulis, N., Poirier Littre, M. F., Galinowski, A., & Loo, H. (1995). Effects of antidepressants on cognitive functions: A review. *Neuroscience and Biobehavioral Reviews*, *19*(*3*), 479–493 https://doi.org/10.1016/0149-7634(94)00068-c.

Bailey, C. M., Samples, H. L., Broshek, D. K., Freeman, J. R., & Barth, J. T. (2010). The relationship between psychological distress and baseline sports-related concussion testing. *Clinical Journal of Sport Medicine*, *20*(*4*), 272–277 https://doi.org/10.1097/JSM.0b013e3181e8f8d8.

Barth, J. T., Alves, W. M., Ryan, T. V., Macciocchi, S. N., Rimel, R. W., Jane, J. A., & Nelson, W. E. (1989). Mild head injury in sports: Neuropsychological sequelae and recovery of function. In H. S. Levin, H. M. Eisenberg, & A. L. Benton (Eds.), *Mild Head Injury*. pp. 257–275. Oxford University Press.

Baune, B. T., & Renger, L. (2014). Pharmacological and non-pharmacological interventions to improve cognitive dysfunction and functional ability in clinical depression–a systematic review. *Psychiatry Research*, *219*(*1*), 25–50 https://doi.org/10.1016/j.psychres.2014.05.013.

Bergman-Bock, S. (2018). Associations between migraine and the most common psychiatric co-morbidities. *Headache*, *58*(*2*), 346–353 https://doi.org/10.1111/head.13146.

Brooks, B. L., Iverson, G. L., Sherman, E. M., & Roberge, M. C. (2010). Identifying cognitive problems in children and adolescents with depression using computerized neuropsychological testing. *Applied Neuropsychology*, *17*(*1*), 37–43 https://doi.org/10.1080/09084280903526083.

Broshek, D. K., De Marco, A. P., & Freeman, J. R. (2015). A review of post-concussion syndrome and psychological factors associated with concussion. *Brain Injury*, *29*(*2*), 228–237 https://doi.org/10.3109/02699052.2014.974674.

Cottle, J. E., Hall, E. E., Patel, K., Barnes, K. P., & Ketcham, C. J. (2017). Concussion baseline testing: Preexisting factors, symptoms, and neurocognitive performance. *Journal of Athletic Training*, *52*(2), 77–81 https://doi.org/10.4085/1062-6050-51.12.21.

Covassin, T., Elbin, R. J., 3rd, Larson, E., & Kontos, A. P. (2012). Sex and age differences in depression and baseline sport-related concussion neurocognitive performance and symptoms. *Clinical Journal of Sport Medicine*, *22*(*2*), 98–104 https://doi.org/10.1097/JSM.0b013e31823403d2.

Covassin, T., Swanik, C. B., Sachs, M., Kendrick, Z., Schatz, P., Zillmer, E. et al. (2006). Sex differences in baseline neuropsychological function and concussion symptoms of collegiate athletes. *British Journal of Sports Medicine*, *40*(*11*), 923–927discussion 927 https://doi.org/10.1136/bjsm.2006.029496.

Elbin, R. J., Fazio-Sumrok, V., Anderson, M. N., D'Amico, N. R., Said, A., Grossel, A. et al. (2019). Evaluating the suitability of the immediate post-concussion assessment and cognitive testing (ImPACT) computerized neurocognitive battery for short-term, serial assessment of neurocognitive functioning. *Journal of Clinical Neuroscience*, *62*, 138–141 https://doi.org/10.1016/j.jocn.2018.11.041.

Evered, L., Ruff, R., Baldo, J., & Isomura, A. (2003). Emotional risk factors and postconcussional disorder. *Assessment*, *10*(*4*), 420–427 https://doi.org/10.1177/1073191103259539.

Gaudet, C. E., Konin, J., & Faust, D. (2020). Immediate post-concussion and cognitive testing: Ceiling effects, reliability, and implications for interpretation. *Archives of Clinical Neuropsychology*. https://doi.org/10.1093/arclin/acaa074.

Gessel, L. M., Fields, S. K., Collins, C. L., Dick, R. W., & Comstock, R. D. (2007). Concussions among United States high school and collegiate athletes. *Journal of Athletic Training*, *42*(*4*), 495–503 https://www.ncbi.nlm.nih.gov/pubmed/18174937.

Girand, H. L., Litkowiec, S., & Sohn, M. (2020). Attention-deficit/hyperactivity disorder and psychotropic polypharmacy prescribing trends. *Pediatrics*, *146*(*1*), https://doi.org/10.1542/peds.2019-2832.

Gonyea, R. M. (2005). Self-reported data in institutional research: Review and recommendations. *New Directions for Institutional Research*, *2005*(*127*), 73–89 https://doi.org/https://doi.org/10.1002/ir.156.

Harmon, K. G., Drezner, J. A., Gammons, M., Guskiewicz, K. M., Halstead, M., Herring, S. A. et al. (2013). American medical Society for Sports Medicine position statement: Concussion in sport. *British Journal of Sports Medicine*, *47*(*1*), 15–26 https://doi.org/10.1136/bjsports-2012-091941.

Health, N. I. o. M. *Mental illness*. Retrieved November 1 from https://www.nimh.nih.gov/health/statistics/mental-illness.shtml.

Herrera-Guzman, I., Gudayol-Ferre, E., Herrera-Guzman, D., Guardia-Olmos, J., Hinojosa-Calvo, E., & Herrera-Abarca, J. E. (2009). Effects of selective serotonin reuptake and dual serotonergic-noradrenergic reuptake treatments on memory and mental processing speed in patients with major depressive disorder. *Journal of Psychiatric Research*, *43*(*9*), 855–863 https://doi.org/10.1016/j.jpsychires.2008.10.015.

Iverson, G. L. (2006). Sensitivity of computerized neuropsychological screening in depressed university students. *The Clinical Neuropsychologist*, *20*(*4*), 695–701 https://doi.org/10.1080/138540491005857.

Iverson, G. L., Lovell, M. R., & Collins, M. W. (2005). Validity of ImPACT for measuring processing speed following sports-related concussion. *Journal of Clinical and Experimental Neuropsychology*, *27*(*6*), 683–689 https://doi.org/10.1081/13803390490918435.

Jotwani, V., & Harmon, K. G. (2010). Postconcussion syndrome in athletes. *Current Sports Medicine Reports*, *9*(*1*), 21–26 https://doi.org/10.1249/JSR.0b013e3181ccb55e.

Karic, S., DesRosiers, M., Mizrahi, B., Zevallos, J., Rodriguez, P., & Barengo, N. C. (2019). The association between attention deficit hyperactivity disorder severity and risk of mTBI in children with attention deficit hyperactivity disorder in the United States of America: A cross-sectional study of data from the National Survey of Children with Special Health Care Needs. *Child: Care, Health and Development*, *45*(*5*), 688–693 https://doi.org/10.1111/cch.12684.

Katona, C., Hansen, T., & Olsen, C. K. (2012). A randomized, double-blind, placebo-controlled, duloxetine-referenced, fixed-dose study comparing the efficacy and safety of Lu AA21004 in elderly patients with major depressive disorder. *International Clinical Psychopharmacology*, *27*(*4*), 215–223 https://doi.org/10.1097/YIC.0b013e3283542457.

Langlois, J. A., Rutland-Brown, W., & Wald, M. M. (2006). The epidemiology and impact of traumatic brain injury: A brief overview. *The Journal of Head Trauma Rehabilitation*, *21*(*5*), 375–378 https://doi.org/10.1097/00001199-200609000-00001.

Levkovitz, Y., Caftori, R., Avital, A., & Richter-Levin, G. (2002). The SSRIs drug fluoxetine, but not the noradrenergic tricyclic drug Desipramine, improves memory performance during acute major depression. *Brain Research Bulletin*, *58*(*4*), 345–350 https://doi.org/10.1016/s0361-9230(01)00780-8.

McCrory, P., Meeuwisse, W., Dvorak, J., Aubry, M., Bailes, J., Broglio, S. et al. (2017). Consensus statement on concussion in sport-the 5(th) international conference on concussion in sport held in Berlin, October 2016. *British Journal of Sports Medicine*, *51*(*11*), 838–847 https://doi.org/10.1136/bjsports-2017-097699.

McLean, C. P., Asnaani, A., Litz, B. T., & Hofmann, S. G. (2011). Gender differences in anxiety disorders: Prevalence, course of illness, comorbidity and burden of illness. *Journal of Psychiatric Research*, *45*(*8*), 1027–1035 https://doi.org/10.1016/j.jpsychires.2011.03.006.

Morgan, C. D., Zuckerman, S. L., Lee, Y. M., King, L., Beaird, S., Sills, A. K. et al. (2015). Predictors of postconcussion syndrome after sports-related concussion in young athletes: A matched case-control study. *Journal of Neurosurgery. Pediatrics*, *15*(*6*), 589–598 https://doi.org/10.3171/2014.10.PEDS14356.

Olfson, M., He, J. P., & Merikangas, K. R. (2013). Psychotropic medication treatment of adolescents: Results from the National Comorbidity Survey-Adolescent Supplement. *Journal of the American Academy of Child and Adolescent Psychiatry*, *52*(*4*), 378–388 https://doi.org/10.1016/j.jaac.2012.12.006.

Ponsford, J., Cameron, P., Fitzgerald, M., Grant, M., Mikocka-Walus, A., & Schonberger, M. (2012). Predictors of postconcussive symptoms 3 months after mild traumatic brain injury. *Neuropsychology*, *26*(*3*), 304–313 https://doi.org/10.1037/a0027888.

Solomon, G. S., Kuhn, A. W., & Zuckerman, S. L. (2016). Depression as a modifying factor in sport-related concussion: A critical review of the literature. *The Physician and Sportsmedicine*, *44*(*1*), 14–19 https://doi.org/10.1080/00913847.2016.1121091.

Wallace, J., Learman, K., Moran, R., Covassin, T., Deitrick, J. M., Delfin, D. et al. (2020). Premorbid anxiety and depression and baseline neurocognitive, ocular-motor and vestibular performance: A retrospective cohort study. *Journal of the Neurological Sciences*, *418*, 117110 https://doi.org/10.1016/j.jns.2020.117110.

Weber, M. L., Dean, J. L., Hoffman, N. L., Broglio, S. P., McCrea, M., McAllister, T. W. et al. (2018). Influences of mental illness, current psychological state, and concussion history on baseline concussion assessment performance. *The American Journal of Sports Medicine*, *46*(*7*), 1742–1751 https://doi.org/10.1177/0363546518765145.

Yang, J., Peek-Asa, C., Covassin, T., & Torner, J. C. (2015). Post-concussion symptoms of depression and anxiety in division I collegiate athletes. *Developmental Neuropsychology*, *40*(*1*), 18–23 https://doi.org/10.1080/87565641.2014.973499.

Yengo-Kahn, A. M., & Solomon, G. (2015). Are psychotropic medications associated with differences in baseline neurocognitive assessment scores for young athletes? A pilot study. *The Physician and Sportsmedicine*, *43*(*3*), 227–235 https://doi.org/10.1080/00913847.2015.1071638.