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Attention-Deficit/Hyperactivity Disorder as a Predictor of Prolonged Functional Recovery From Sports-Related Concussion in High School Athletes

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Context: Attention-deficit/hyperactivity disorder (ADHD) has been speculated to prolong concussion recovery; however, the evidence regarding concussion recovery for individuals with ADHD is limited.

Objective: To examine the concussion recovery time based on ADHD status, sex, and age.

Design: Cross-sectional study.

Setting: High school.

Patients or Other Participants: Nine hundred and thirty-five (female: $n = 382$, 40.1%) concussions, including 78 (female: $n = 13$, 20.0%) self-identified ADHD data, were analyzed.

Main Outcome Measure(s): A Poisson regression was used to estimate the return-to-learn and return-to-sport recovery outcomes with 3 predicting variables: ADHD status, sex, and age.

Results: The mean return-to-learn days of the ADHD and non-ADHD groups were 12.86 ± 10.89 (median = 11.0; interquartile range [IQR] = 8.0; 7.0–15.25) and 1.43 ± 8.39 (median = 9.0; IQR = 9.0; 6.0–14.0), respectively. The mean return-to-sport days of the ADHD and non-ADHD groups were 20.82 ± 15.25 days (median = 17.0; IQR = 9.0; 12.0–21.0) and 18.03 ± 11.42 days (median = 15.0; IQR = 10.0; 11.0–21.0), respectively. For return-to-learn, ADHD status (risk ratio [RR] = 1.16; 95% confidence interval [95% CI]: 1.08, 1.24; $P < .001$) and female sex (RR = 1.13; 95% CI: 1.08, 1.17; $P < .001$) were significant variables for longer recovery, whereas age was not (RR = 0.995; 95% CI: 0.98, 1.01; $P = .056$). For return to sport, ADHD status (RR = 1.17; 95% CI: 1.12, 1.23; $P < .001$), female sex (RR = 1.07; 95% CI: 1.04, 1.11; $P < .001$), and younger age (RR = 0.98; 95% CI: 0.96, 0.99; $P < .001$) were all significant variables for longer recovery.

Conclusions: Health care providers must be aware of the elevated risk of prolonged concussion recovery among high school athletes with ADHD.

Key Words: functional concussion recovery, return-to-learn, return-to-sports, anticipatory guidance

Key Points

- Attention-deficit/hyperactivity disorder status, female sex, and younger age are potential risk factors for prolonged recovery from sport-related concussion.
- Athletic trainers and health care providers must consider these factors to provide anticipatory guidance and patient-centered care in the management of sport-related concussion.

The effect of attention deficit/hyperactivity disorder (ADHD) on concussion recovery has been debated extensively in the literature, yet there is no clear clinical consensus.[1] The inherent challenge is due to the fact that athletes with ADHD often present with multiple risk factors for prolonged concussion recovery, which makes it difficult to isolate the effect of ADHD. Studies have shown that concussion recovery is affected by previous concussion histories, higher initial symptom scores, delayed reporting, age, sex, and comorbidities such as depression, anxiety, and ADHD.[2,3] Athletes with ADHD are more susceptible to multiple concussions, exhibit more severe acute symptoms, and have at least 1 other coexisting condition.[4–7] An additional layer of challenge is obtaining a sufficient amount of concussion recovery data on athletes with ADHD, as the prevalence of ADHD in young athletes has been reported between 4.2% and 8.1%.[8] Although there are multiple factors possibly influencing concussion recovery of athletes with ADHD, small sample sizes create a limited ability to control for confounding factors.

Early investigations showed ADHD as a factor in prolonging recovery, but those studies were criticized for the very small ADHD sample size.[9] A study by Cook et al used the largest sample ($n = 90$) of athletes with ADHD that were aged 14 to 19 and reported no significant difference in recovery duration between the ADHD (17.5 ± 12.9 days) and control (19.9 ± 22.7 days) groups.[10] Conversely, Mautner et al reported, although it was not statistically significant ($P = .12$, $d = 0.25$), a "longer" recovery in high school athletes with ADHD when the duration to normalize the neurocognitive scores was analyzed (ADHD = 16.5 ± 14.4 days, control = 14.9 ± 8.7 days, $n = 70$ per group).[8,11] Studies analyzing data from concussion clinics have shown that ADHD is a significant predicting factor of prolonged recovery; however, patients who were referred to concussion clinics tend to have worse symptoms than in other medical settings.[9,10] Thus, it is unclear if these recovery data (ie, 68 days of symptom resolution) represent the typical concussion cases seen in high school athletic populations. These studies illustrate the inherent issues of large standard deviations of the recovery date and small sample sizes. Moreover, these studies did not consider age and sex effects, thus it is unclear if these results are solely due to the ADHD effect.

Interpreting these studies also requires caution as the definition of "recovery" varies, including the normalization of neurocognitive scores, symptom resolution, return to learn (RTL), and return to sport (RTS).[12–14] Such discrepancies in the outcome measures of "recovery" make direct comparisons difficult. Although the resolution of symptoms is an important clinical indicator of recovery, "functional recovery" is much more practical and meaningful to the athletes, coaches, and parents. In the most recent Consensus Statement of Concussion in Sports, RTL was defined as the "return to preinjury learning activities with no new academic support, including school accommodations or learning adjustments."[1] *RTS* is "the completion of the RTS strategy with no symptoms and no clinical findings associated with the current concussion at rest and with maximal physical exertion." These functional recovery definitions are commonly used in athletic training settings to monitor the gradual RTS strategy, and they may more accurately reflect the recovery timeline of concussed athletes to be able to participate in what matters to them.

Functional recovery timeline data of high school athletes have been established through a large sample ($n = 726$) study, with an average RTL of 13.6 ± 10.6 days and RTS of 20.2 ± 13.9 days.[15] The study has also indicated that younger age and female sex were factors associated with longer recovery; however, this study did not examine the effect of ADHD. To clarify how ADHD influences concussion recovery, there is a need for greater evidence focusing on functional recovery outcomes with a large sample size of athletes with ADHD. Therefore, the purpose of this study was to investigate whether ADHD was a potential modifying factor for prolonged recovery of returning to their preinjury functional level of academic and athletic performance, controlled for sex and age. We hypothesize that, in addition to sex and age, ADHD status will be a contributing factor for prolonged recovery from sport-related concussion (SRC) in high school athletes.

METHODS

Setting

This study analyzed the effect of self-reported ADHD status (ADHD, $n = 78$, control, $n = 857$) on the recovery outcomes of concussed high school athletes. Data were collected by full-time athletic trainers (ATs) at 60 local high schools in a single state between the 2010 and 2018 school years and were tracked and monitored by the state concussion management program (CMP). This study was approved by the university's Internal Review Board (CHS#18431).

Table 1. 7-Step Gradual Return-to-Play Protocol[a]

Onset			
Step 1	Cognitive rest/no school	Days to return to learn	
Step 2	Return to school full time		
Step 3	Light exercise[b]		Days to return to sport
Step 4	Running/sport-specific drills		
Step 5	Noncontact drills		
Step 6	Full contact practice		
Step 7	Return to game/competition[c]		

[a] The individual must be asymptomatic for 24 hours before progressing to the next step.
[b] Step 3 was initiated after the physician's clearance and with a normalized postinjury Immediate Post-Concussion Assessment and Cognitive Testing score.
[c] Step 7 was not included in the analysis because the game schedule affects the outcome.

Standardized Concussion Management Protocol

ATs at participating schools managed all reported concussions using a standardized concussion management protocol set forth by the state concussion management program. Before the 9th- and 11th-grade seasons, all participants were required to complete the baseline computerized neuropsychological test using the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT Applications, Inc). Once a concussion was diagnosed by a physician, the recovery process was monitored by the ATs using a 7-step graded return-to-play (return-to-play (RTP)) protocol mandated by the state concussion law.[16] The 7-step RTP protocol (Table 1) was a modified version of a 6-step protocol published in the 2014 National Athletic Trainers' Association Position Statement on the management of sports-related concussions, and it has an additional step (step 2) for RTL, which allows the concussed athletes to progressively adjust to the cognitive loads required in classroom activities.[17] Attainment of step 2, full RTL, was defined as a student fully participating in all classroom activities, except for physical education classes, without any academic accommodations. To ensure safe progression, a concussed athlete must also be cleared by a physician when symptom free and have postinjury ImPACT scores back to baseline, as determined by a designated neuropsychologist, before proceeding to step 3 (light exercise). The athletes progressed to each step of the RTP protocol if they were asymptomatic for 24 hours or regressed to the previous step if any postconcussion symptoms occurred. The ATs recorded the date when the concussed athlete completed each step in the Sports Injury Management System (FlanTech, Inc).

Data Screening

A total of 4646 concussion cases were reported to the state concussion management program during the 8-year data collection period. The data were further screened for completeness and were excluded if any of the following information

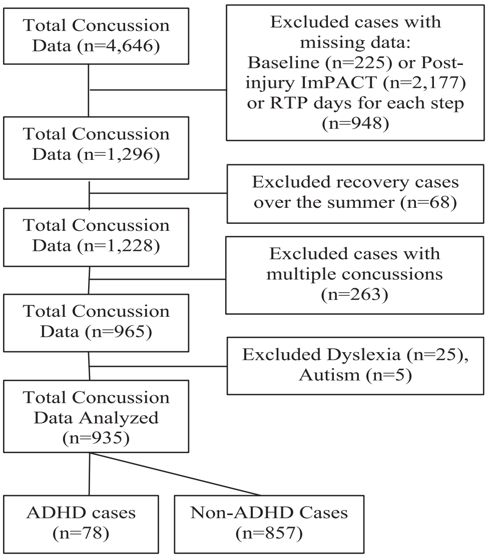

Figure. Data cleaning process and exclusion criteria.

was missing: baseline ImPACT within 2 years of injury (n = 225), postconcussion ImPACT data (n = 2177), and days spent for each RTP step (n = 948). Cases where recovery took place over summer break when ATs could not follow up with concussed athletes (n = 68) were also excluded. In addition, to eliminate the confounding effect of multiple concussions, athletes with 2 or more concussion histories were excluded (n = 263). To isolate the effect of ADHD on concussion recovery from other disabilities, athletes who reported having dyslexia (n = 25) and autism (n = 5) were excluded. In the end, a total of 935 cases were divided into an ADHD group (n = 78) and a non-ADHD group (n = 857) based on the demographic section of the ImPACT test where athletes identified themselves if they had ever been diagnosed with ADHD (Figure).

Outcome Measures

RTL was defined as days spent from injury onset to the completion of step 2, which is the full return to school without any accommodations. RTS was defined as the days spent from injury onset to the completion of step 6, which is full participation in contact practice drills. Step 7, return to game/competition, was not included in the analysis because this timeframe depended on the sports game schedule and did not reflect the true "recovery" timeframe.

Statistical Analysis

Descriptive statistics were used to characterize the demographic information of the participants. Normality testing indicated that the concussion recovery outcome variables were positively skewed. Thus, Poisson regression, a generalized regression model robust to the skewed data, was used to predict concussion recovery outcomes based on self-reported ADHD status, age at the time of injury, and sex. All statistical analyses were performed using Statistical Package for Social Sciences software version 25.0 (IBM). An α level of less than .05 was used for all tests of statistical significance in this study.

RESULTS

Of a total of 935 participants, 78 (8.3%) identified themselves as being diagnosed with ADHD, and 857 (91.7%) did not. Of the participants with ADHD, 13 (16.7%) were female, and 65 (83.3%) were male. Of all non-ADHD participants, 369 (43.1%) were female, and 488 (56.9%) were male. Other demographic information, such as the number of participants in each age group and participating sport, is described in Table 2.

RTL

Table 3 presents the means and standard deviations of both RTL and RTS outcomes of each group stratified by the following predictors: ADHD status, sex, and age. For RTL, ADHD status and sex were significant predictors for a prolonged recovery (both $P < .001$). The mean RTL days of the ADHD group was 12.86 ± 10.89 (median = 11.0; interquartile range [IQR] = 8.0; 7.0–15.25) and that of the non-ADHD group was 11.43 ± 8.39 (median = 9.0; IQR = 9.0; 6.0–14.0). Male participants took 11.04 ± 8.24 days (median = 9.0; IQR = 7.0; 6.0–13.0), whereas female participants took 12.28 ± 9.12 days (median = 10.0; IQR = 9.0; 6.0–15.0). According to the risk ratio (RR) calculations shown in Table 4, athletes with ADHD were estimated to take 1.16 times longer for RTL than the non-ADHD group (95% confidence interval [95% CI]: 1.08, 1.24; $P < .001$) while controlling for the effect of age and sex. Female participants also took 1.13 times longer for RTL than male participants (95% CI: 1.08, 1.17; $P < .001$), with other variables being constant. The RR for age was 0.995 and not significant (95% CI: 0.98, 1.01; $P = .056$). An equation was formulated using the general Poisson regression to predict RTL completion (days) using the predictor factors of ADHD status, sex, and age. Based on the test statistics listed in Table 3, a prediction equation was formulated to estimate RTL as follows:

$$\text{Estimated RTL (days)} = \exp\left(2.46 + 0.15 \times \text{ADHD} + 0.12 \times \text{Sex} - 0.005 \times \text{Age}\right)$$

RTS

The same procedure was repeated for the RTS data, and the results were presented in Table 3. The mean RTS days of the ADHD group and non-ADHD group were 20.82 ± 15.25 days (median = 17.0; IQR = 9.0; 12.0–21.0) and 18.03 ± 11.42 days (median = 15.0; IQR = 10.0; 11.0–21.0), respectively. Male participants took 17.81 ± 11.21 days (median = 15.0; IQR = 10.0; 11.0–21.0), whereas female participants took 18.91 ± 12.58 days (median = 15.0; IQR = 11.0; 11.0–22.0). For RTS, ADHD status, sex, and age were all significant predictors for a longer recovery (all $P < .001$). According to the RR calculations shown in Table 4, the ADHD group was estimated to take 1.17 times (95% CI: 1.12, 1.23; $P < .001$) longer for RTS than the non-ADHD group, with sex and age being constant. The RR of female participants was 1.07 (95% CI: 1.04, 1.11; $P < .001$), indicating a slightly longer recovery. Age and concussion recovery showed an inverse relationship, where an increase in age by 1 year decreased the recovery days by 0.98 (95% CI: 0.96, 0.99; $P < .001$). A prediction equation was formulated to estimate RTS as follows:

Table 2. **Participant Demographic Information**

	Total ($n = 935$) n (%)	ADHD ($n = 78$) n (%)	Non-ADHD ($n = 857$) n (%)
Sex			
Female	382 (40.1)	13 (20.0)	369 (43.1)
Male	553 (59.1)	65 (80.0)	488 (56.9)
Age, y			
14	154 (16.47)	18 (23.07)	136 (15.87)
15	285 (30.48)	21 (26.92)	264 (30.81)
16	246 (26.31)	19 (24.36)	227 (26.49)
17	190 (20.32)	14 (17.95)	176 (20.54)
18	60 (6.42)	6 (7.69)	54 (6.30)
Sports			
Football	391 (41.8)	54 (69.2)	337 (39.3)
Soccer	144 (15.4)	4 (5.1)	140 (16.3)
Basketball	88 (9.4)	4 (5.1)	84 (9.8)
Baseball/softball	74 (7.9)	5 (6.4)	69 (8.0)
Wrestling	59 (6.3)	8 (10.2)	51 (6.0)
Volleyball	59 (6.3)	0 (0.0)	59 (6.9)
Judo/martial arts	57 (6.1)	1 (1.3)	56 (6.5)
Cheerleading	55 (5.9)	2 (2.5)	53 (6.2)
Track and field/cross country	5 (0.5)	0 (0.0)	5 (0.6)
Water polo	2 (0.2)	0 (0.0)	2 (0.2)
Tennis	1 (0.1)	0 (0.0)	1 (0.1)

Abbreviation: ADHD, attention-deficit/hyperactivity disorder.

$$\text{Estimated RTS(days)} = \exp(3.21 + 0.16 \times \text{ADHD} + 0.07 \times \text{Sex} - 0.02 \times \text{Age})$$

DISCUSSION

Of 935 participants, 78 athletes (8.3%) identified themselves as being diagnosed with ADHD. Although our sample size of 78 participants with ADHD is not considerably large, our initial large data set allowed for exclusions of athletes with some confounding factors, such as multiple concussions and other disabilities, as well as cases that may not represent true recovery time, such as those spanning over summer break and nonadherence to the RTP protocol. Another strength of this study is the fact that all included data are "complete" recovery data from baseline to RTL to RTS monitored by the school's ATs under a standardized protocol. Our results indicate that ADHD is a significant modifying factor for prolonged recovery. Athletes with ADHD are predicted to take 1.16 times longer to complete the RTL process (RR = 1.16, 95% CI = 1.12, 1.23; $P < .001$) and 1.17 times longer to complete the RTS process (RR = 1.17, 95% CI = 1.12, 1.23; $P < .001$) than their non-ADHD counterparts.

The proportion of participants with ADHD in our sample (8.3%) is comparable to the previously reported prevalence of athletes with ADHD, which varied between 4.2% and 8.1%.[8] Of the 78 athletes with ADHD in our study, 13 (16.7%) identified themselves as female, and 65 (83.3%) identified themselves as male, with a female-to-male ratio of 1:4. The national female-to-male ratio drawn from children and adolescents with ADHD in the general population is between 1:1.88 and 1:2.32.[18] This discrepancy is speculated to be due to the lower participation rate of female athletes and underdiagnosis of female patients with ADHD. The percentage of females participating in state high school athletics ranged between 41.2% and 44.3% from 2010 to 2019, while the State Department of Education data suggest that 48% of their students are female.[19] Furthermore, females with ADHD are often underdiagnosed in childhood due to their difference in symptom presentation and social norms preventing them from exhibiting typical ADHD behavior. These factors might have contributed to the lower female proportions of athletes with ADHD in our samples.

Female sex was a significant predictor of prolonged RTL and RTS duration in our study. Female athletes completed the RTL and RTS process in 12.28 ± 9.12 days (median = 10.0; IQR = 9.0; 6.0–15.0) and 18.91 ± 12.58 days (median = 15.0; IQR = 11.0; 11.00–22.00), respectively. By contrast, male athletes took 11.04 ± 8.24 days (median = 9.0; IQR = 7.0; 6.0–13.0) and 17.81 ± 11.21 days (median = 15.0; IQR = 10.0; 11.00–21.00), respectively. This result is consistent with the literature on clinical recovery from concussion, in which the mean RTS duration for 13- to 18-year-old males was 15.7 (range, 13.2–18.2) days and for 13- to 18-year-old females was 18.3 (range, 13.6–23.0) days.[3] These findings are also supported by a 2023 study by Shepherd et al indicating that female athletes use more academic accommodations, such as modified attendance, rest breaks, and/or limited screen time, than their male counterparts.[20]

An athlete's age also plays a significant role in predicting the duration of concussion recovery. Our analysis indicated that the risk for longer RTS became higher as age decreased. This trend was observed only for RTS outcomes and not with RTL. Zuckerman et al found that younger (13- to 16-year-old) athletes took 2 to 3 days longer for normalization of neurocognitive and symptom scores than older (18- to 22-year-old) athletes.[21] It is important to consider how age and sex, specifically younger age and female sex, affect concussion recovery of athletes with ADHD.

A higher acute total symptom score, regardless of ADHD, is the primary predictor associated with a longer recovery time.[3,22] In our study, we were unable to include acute symptom scores in the analyses. This was due to the fact that ImPACT was not administered until the asymptomatic phase was established to minimize redundant testing and learning

Table 3. **Poisson Regression Results for RTL and RTS Outcomes**

Predictor Variables	Mean (Days) ± SD	Median (Days)	IQR (25–75)	Coefficient (β)	SE	Lower 95% CI	Upper 95% CI	*z*	*P* Value
RTL									
Intercept				2.46	0.13	2.20	2.72	18.56	<.001[a]
ADHD status				0.15	0.03	0.08	0.22	4.46	<.001[a]
ADHD	12.86 ± 10.89	11.0	8 (7.0–15.25)						
Non-ADHD	11.43 ± 8.39	9.0	7 (6.0–14.0)						
Sex				0.12	0.02	0.08	0.16	6.07	<.001[a]
Male	11.04 ± 8.24	9.0	7 (6.0–13.0)						
Female	12.28 ± 9.12	10.0	9 (6.0–15.0)						
Age				–0.005	0.01	–0.02	0.01	–0.56	<.056
14	10.55 ± 7.17	9.0	7 (6.0–13.0)						
15	12.18 ± 8.78	10.0	9 (6.0–15.0)						
16	11.91 ± 9.50	9.0	9 (6.0–15.0)						
17	11.64 ± 8.32	10.0	8 (6.0–14.0)						
18	9.36 ± 8.28	7.0	6.5 (4.75–11.25)						
Estimated RTL (days) = exp(2.46 + 0.15 × ADHD + 0.12 × sex – 0.005 × age)									
RTS									
Intercept				3.21	0.11	3.01	3.42	30.50	<.001[a]
ADHD status				0.16	0.03	0.11	0.21	6.09	<.001[a]
ADHD	20.82 ± 15.25	17.0	9 (12.0–21.0)						
Non-ADHD	18.03 ± 11.42	15.0	10 (11.0–21.0)						
Sex				0.07	0.02	0.04	0.10	4.63	<.001[a]
Male	17.81 ± 11.21	15.0	10 (11.0–21.0)						
Female	18.91 ± 12.58	15.0	11 (11.0–22.0)						
Age				–0.02	0.01	–0.04	–0.01	–3.37	<.001[a]
14	18.08 ± 11.01	15.0	8 (12.0–20.0)						
15	18.68 ± 10.81	16.0	11 (12.0–23.0)						
16	19.40 ± 14.15	15.0	11 (11.0–22.0)						
17	17.70 ± 10.99	15.0	11 (10.0–21.0)						
18	14.98 ± 9.74	12.5	9.25 (9.0–18.25)						
Estimated RTS (days) = exp(3.21 + 0.16 × ADHD + 0.07 × sex – 0.02 × age)									

Abbreviations: 95% CI, 95% confidence interval; ADHD, attention-deficit/hyperactivity disorder; IQR, interquartile range; RTL, return to learn; RTS, return to sport; SD, standard deviation; SE, standard error.

[a] Indicates statistical significance at the level of $\alpha < .001$.

Table 4. Risk Ratio of ADHD Status, Sex, and Age on RTL and RTS Outcomes

Predictor Variables	RTL			RTS		
	RR	95% CI	*P* Value	RR	95% CI	*P* Value
ADHD status						
Non-ADHD	1			1		
ADHD	1.16	1.08, 1.24	<.001[a]	1.17	1.12, 1.23	<.001[a]
Sex						
Male	1			1		
Female	1.13	1.08, 1.17	<.001[a]	1.07	1.04, 1.11	<.001[a]
Age	0.995	0.98, 1.01	.056	0.98	0.96, 0.99	<.001[a]

Abbreviations: 95% CI, 95% confidence interval; ADHD, attention-deficit/hyperactivity disorder; RTL, return to learn; RTS, return to sport.
[a] Indicates a significant result based on $P < .001$.

effects, which caused inconsistent reporting of acute symptoms scores. Iaccarino et al suggested that concussion total symptom scores of individuals with ADHD were higher than those of non-ADHD individuals.[5] However, Cook et al reported that baseline total symptom scores of individuals with ADHD were also higher than those of their non-ADHD counterparts.[23] Therefore, availability of the baseline score is crucial for ADHD patients to clinically determine the asymptomatic state. One of the strengths of this study is the availability of baseline data. Baseline testing is a part of the statewide concussion RTP protocol, and postconcussion symptom scores back to the baseline level was one of the criteria for return to light aerobic exercise based on the 2017 Concussion in Sport Group consensus statement.[24] Therefore, generally higher total symptom scores for ADHD student-athletes were accounted for in our recovery data. Meanwhile, our study did not account for acute symptom severity, which could influence the recovery timeline for both ADHD and non-ADHD groups, and readers are advised to take caution when interpreting our results.

With this said, using our equation model, the predicted RTL days for a 15-year-old male athlete without ADHD (ADHD = 0, male = 0, age = 15) is estimated to take 10.85 days. This is consistent with the Consensus Statement of Concussion in Sports, which indicated the typical length of RTL to be 10 days postinjury.[1] By contrast, for a 15-year-old male high school athlete with ADHD, the RTL is estimated to be 12.61 days, approximately 2 days longer than that of his non-ADHD counterparts. Comparing 2 extreme cases using our equation, the difference in the RTL timeline can be significant (for example, a 4 days variation), with a male 18-year-old high school athlete without ADHD would be estimated to take 10.70 days to recover, whereas a female 15-year-old high school athlete with ADHD would be estimated to improve in 14.22 days.

Clinical Implications

The timing of RTS carries important clinical relevance. The predicted RTS days for a non-ADHD 18-year-old male athlete is 17.29 days, whereas that for a 15-year-old female athlete with ADHD is 23.10 days. From the clinical perspective (ie, physician and other health care providers), this difference may not seem significant; however, from a coach's, parent's, or athlete's perspective, it may feel very important, as this recovery difference may result in missing an additional game, depending on the timing of injury incidence. For example, if the injury occurred during a competition on a weekend, an athlete with a typical 20 days RTS time will be able to return to the competition on the third week of recovery, resulting in missing 2 games on weekends. However, if the athlete takes 23 days to RTS, he/she will miss 3 games on weekends, as day 23 will be in the fourth week of recovery. Although it may seem like a small difference, this variation could result in a tangible impact on the athletes as well as coaches and the team. Clinicians should be aware of the possible longer recovery for athletes with ADHD, particularly younger female athletes, to provide anticipatory guidance and to address questions regarding the RTS recovery timeline following concussion.

Limitations

The major strength of this study is the fact that these data were collected from school settings by certified ATs under the standardized protocol, which reflects the realistic functional recovery timeline. Simultaneously, incomplete data and limited access to protected health information are major obstacles for field-based data. As we acknowledge the value of field-based clinical data, we emphasize the importance of accurate and precise documentation to further explore the relationship between athletes with ADHD and recovery from SRC. Thus, our study limitations include (1) lack of initial symptom scores, (2) lack of clinical diagnoses of ADHD and other psychiatric conditions, (3) lack of information regarding medication use, and (4) physician's schedule availability. First, our study did not control for the initial symptom severity due to the unavailability of such data. Therefore, we cannot conclude that ADHD is the sole factor of increased recovery time. Second, the diagnosis of ADHD was self-reported by high school athletes and was not confirmed by their medical records. Our study did exclude individuals with self-reported diagnoses of dyslexia and autism; however, we were unable to account for psychiatric conditions such as anxiety and depression due to a lack of data validity. Also, our study did not exclude athletes with ADHD who were taking stimulant medications. We made this decision because previous research has indicated that ADHD medication does not affect concussion recovery.[25] However, if medications were used inconsistently, especially between the baseline and postconcussion ImPACT testings, it may affect ImPACT outcomes and subsequently influence recovery time. Last, the schedule availability of high school athletes, as well as the accessibility of physician appointments and/or ImPACT tests, may have influenced the number of recovery days, particularly in the progression to step 3 (light exercise), which requires a physician's clearance. For example, athletes may have reached symptom-free status days before being cleared by a physician. For this reason, our recovery time frame could possibly be inflated relative to those who use less stringent RTP criteria.

CONCLUSIONS

RTL and RTS duration can have a significant impact on an athlete and/or their family as well as their coach and team. This study investigated the SRC recovery of high school athletes with ADHD ($n = 78$) compared with high school athletes without ADHD ($n = 857$) from a large clinical dataset ($n = 935$) collected through high school ATs under a standardized, statewide concussion RTP protocol. ADHD status, female sex, and younger age are potential risk factors for prolonged recovery from SRC. Clinicians and health care providers must consider these factors to provide anticipatory guidance and patient-centered care in the management of SRC.

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