Factors associated with delayed recovery in athletes with concussion treated at a pediatric neurology concussion clinic

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Abstract

Purpose With the increase in knowledge and management of sport-related concussion over the last 15 years, there has been a shift from a grading scale approach to an individualized management approach. As a result, there is an increased need to better understand the factors involved in delayed recovery of concussion. The purpose of this retrospective study was to examine factors that may be associated with recovery from sport-related concussion in student athletes aged 11 to 18 years old.

Methods Of the 366 patients who met the inclusion criteria, 361 were included in our analysis. The primary dependent variable included days until athlete was able to return to play (RTP). Independent variables of interest included age, gender, academic performance, comorbid factors, sports, on-field markers, days until initial neurological evaluation, Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT®) scores, acute headache rescue medications, chronic headache medication, sleep medication, and referral to concussion rehabilitation program.

Results Variables associated with longer median RTP were being female (35 days), having a referral to concussion rehabilitation program (53 days), being prescribed acute headache rescue therapy (34 days), and having chronic headache treatment (53 days) (all $p<0.05$). Variables associated with shorter RTP were on-field marker of headache (23 days) and evaluation within 1 week of concussion by a concussion specialist (16 days) (Both $p<0.05$).

Conclusion This study supports the need for a concussed athlete to have access to a provider trained in concussion management in a timely fashion in order to prevent delayed recovery and return to play.

Keywords Pediatric · Concussion · Recovery · Factors

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Introduction

The number of sport-related concussions reported to the CDC has dramatically increased, with the current estimate being 1.6 to 3.8 million occurring each year in the USA [1]. In a recent Canadian study, the annual prevalence of concussion was estimated to be 110/100,000 with 54 % rate reported to be sport related [2]. As a result, there is increasing attention on understanding the factors influencing the management of sport-related concussions.

A concussion is a temporary disturbance of brain function from a direct hit to the head, face, or neck or an indirect hit elsewhere on the body where the force is transmitted to the

head [3]. Evaluation of the concussed athlete in the past relied primarily on concussion grading scales based on reported symptoms [4]. Over time, grading scales were found to overemphasize loss of consciousness by allowing athletes to return to play the same day as their injury [5]. In a landmark paper by Lovell et al., American Academy of Neurology (AAN) grade 1 players, who normally would be placed back into play the same day, were instead pulled out of play and underwent neuropsychological testing. It was found that AAN grade I injured athletes had a delay of cognitive recovery beyond the first day following injury [5].

An improved understanding of the physiology of concussion along with better tools to assist in diagnosis has led to a more individualized management approach for the concussed athlete. Even though most concussions heal within a 7–10-day period, roughly 10 % of athletes take longer to recover [6, 7]. The purpose of this study was to review factors associated with delayed return to play (RTP) after a sport-related concussion in student athletes.

Methods

This was an IRB-approved retrospective study that included patients treated at a Pediatric Neurology Concussion Clinic in South Central Pennsylvania from January 2008 to December 2010. This was a subspecialty practice, and at this time, most patients did see a primary care provider or emergency room before being referred to the clinic. An exception to this pattern was ice hockey players who, in 2008, were part of a PA state grant for Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT®) and, as a result, were directly referred to the Pediatric Neurology Concussion Clinic prior to seeing their primary provider. Inclusion criteria were patients aged 11–18 years diagnosed with a sport-related concussion (ICD9 codes 850.0, 850.1, 850.11, 850.12, 850.3, 850.4, 850.5, 850.9, and 310.2). Exclusion criteria were patients younger than 11 years old, lost to follow-up, diagnosed with concussion from a non-sport-related injury, or with an incomplete medical history.

The primary dependent variable was time until RTP as an indirect marker of recovery time. RTP was calculated by determining the days between date of injury and date of clearance to full exertion and contact sports by a clinic provider trained in concussion management. For the purposes of this paper, the term *evaluation* includes a history, physical exam, and ImPACT®. ImPACT® includes composite scores in visual memory, verbal memory, visual motor speed, and reaction time. A total symptom score is also provided from a seven-point Likert scale symptom inventory (SI) (https://www.impacttest.com/about/?The-ImPACT-Test-4). If there was a significant change from pre-concussion to post-concussion composite scores and/or SI on ImPACT®, it was recorded.

Patients were referred to concussion rehabilitation if the athlete had persistent symptoms and/or a significant difference on ImPACT® scores from their pre-concussive baseline at 4 weeks from their initial evaluation. Concussion rehabilitation consisted of providers with specific training in concussion management from the disciplines of physical, speech, and occupational therapy.

Independent variables of interest included gender, academic performance (above average, average, and below average, as reported by the patient/family), comorbid factors (ADD, ADHD, headache/migraine, mood disorder, learning disability, substance abuse, mental retardation, and *other*), sports (football, wrestling, lacrosse, basketball, soccer, ice hockey, volleyball, field hockey, cheerleading, and *other*), on-field markers (loss of consciousness, amnesia, headache, confusion, and *other*), and days until initial neurological evaluation. The latter was calculated as the number of days between date of injury and date of evaluation. This was then categorized into evaluation *within the first week* or at *more than 1 week*. Other variables included referral to post-concussive rehab; acute headache rescue (AHR) medication which included non-steroidal anti-inflammatory drugs (NSAIDS), dihydroergotamine (DHE), steroid pulse (SP), nasal spray (NS) such as Migranal, and triptans; chronic headache medication (CHM) which included amitriptyline, beta-blocker, and valproic acid; sleep medication (melatonin); physical symptoms (headache, dizziness, nausea, balance problems, changes in vision, fatigue, vomiting, photosensitivity, and phonosensitivity); cognitive symptoms (fogginess, decreased concentration, and slowed down); emotional symptoms (irritable, sad, and anxious); and sleep symptoms (sleeping more and sleeping less).

Low frequency of categories within variables (e.g., sports, comorbid factors, on-field markers) was categorized as other. For example, other sports included activities such as bicycling ($N=8$), water polo ($N=4$), dirt biking ($N=4$), and baseball ($N=3$).

Data was analyzed using IBM SPSS Statistics (version 21; SPSS). Statistics used were descriptive, Mann–Whitney U nonparametric t test, and Kruskal–Wallis nonparametric ANOVA.

Results

A total of 366 patients met the inclusion criteria. The dependent variable, RTP, ranged from 2 to 362 days. However, preanalysis data screening and stem-and-leaf plots identified five outliers greater than 254 days. After removing these outliers, which were felt to contain variation outside the normal population parameter, 361 patients were included for analysis with the RTP ranging from 2 to 188 days. The mean and median RTP was identified as 38.7 and 27.0 days, respectively. In addition, the analysis showed that 109 patients (34.7 %) had

a longer RTP than the mean of 38.7 days. Since the dependent variable, RTP, is positively skewed, this paper will primarily use and present median values.

The median age of eligible participants was 15 years old. Males comprised 65.9 % of the patients, and 57.6 % of all the participants were rated as being above average academic performers. Football was the most common sport, accounting for 33.0 %. Only 17.7 % of the patients had a comorbid factor of headache, while 70.9 % reported headache as a primary on-field symptom. 62.9 % had AHR treatment, 27.1 % received CHM, and 1 % received medication for sleep. In addition, 62.3 % of the patients waited longer than a week to receive a neurological evaluation from a health-care provider trained in concussion management and 6.6 % were referred to concussion rehabilitation. Of the 361 patients, 206 people had baseline ImPACT® scores; of these, 68 % were classified as *significant* for the ImPACT® total symptom score.

Table 1 presents variables demonstrating statistical significance with respect to median RTP days. Factors associated with longer RTP were female gender, referral for a concussion rehabilitation program, acute headache rescue medication, and chronic headache medication. Females had a median RTP of 35 days, and males had 22 days, $p<0.001$. Patients who were referred to the concussion rehabilitation program had a longer RTP (53 days) than did patients who were not given a referral (25 days). There was also a delay in RTP in patients who

received medicine for their concussion. Patients who were prescribed AHR medication had a longer RTP (34 days) than did patients who did not receive AHR medication (22 days). Likewise, patients who were prescribed CHM were out of their sport longer (53 days) than patients who did not need CHM (22 days).

Factors associated with shorter RTP were the on-field marker of headache (reported headache on the field at the time of injury) and the time to initial neurological evaluation. Those who had an on-field marker of headache had shorter RTP (23 days) than those who did not have an on-field marker of headache (33 days), $p<0.001$. A Spearman's rho indicated nearly a 60 % (0.591) relationship between time to initial evaluation and return to play, $p<0.001$. Those who had an evaluation within the first week of their concussion had significantly shorter RTP (16 days) than those who did not (36 days), $p<0.001$. Of the 136 people who were evaluated within 1 week, 77.2 % of them had an on-field marker of headache, $p=0.014$.

Additional analysis indicated that females had significantly longer median time to a neurological evaluation (14 days) than did males (9 days). In addition, females presented with higher median total physical symptom scores (3) compared to their male cohorts (2), both $p<0.001$. There were no significant RTP gender differences for cognitive, emotional, and sleep symptoms.

Academic performance, comorbid conditions, and on-field markers such as loss of consciousness, amnesia, and confusion showed no significant associations with RTP, all $p>0.05$.

ImPACT® scores were also associated with RTP days (Table 2). Two hundred and six patients (57 %) had an ImPACT® pre-concussion score, and a Mann–Whitney U test

Table 1 Significant variables determining RTP

	Median RTP in days	Minimum	Maximum	Significance
Factors associated with longer RTP				
Gender				
Female	35	3	188	<0.001
Male	22	2	183	
Referral for concussion rehabilitation program				
Yes	53	15	162	0.001
No	25	2	188	
Acute headache rescue				
Yes	34	7	188	<0.001
No	22	2	169	
Chronic headache medication				
Yes	53	6	188	<0.001
No	22	2	179	
Factors associated with shorter RTP				
On-field markers				
Headache				
Yes	23	2	179	<0.001
No	33	3	188	
Time to initial neurological evaluation				
Evaluated in 1st week	16	2	119	<0.001
More than 1 week	36	8	188	

Table 2 Median RTP for ImPACT composite and total symptom score

	Median RTP	Minimum	Maximum	Significance
Had pre-concussion ImPACT				
Yes	25.5	2.00	188.00	0.033
No	28.5	6.00	179.00	
Impact verbal memory				
Significant	31.0	6.00	183.00	0.001
Not significant	18.0	2.00	188.00	
Impact visual memory				
Significant	32.5	7.00	183.00	<.001
Not significant	17.0	2.00	188.00	
Impact visual processing speed				
Significant	32.0	6.00	125.00	0.008
Not significant	19.0	2.00	188.00	
Impact reaction time				
Significant	32.0	7.00	188.00	0.001
Not significant	19.0	2.00	131.00	
Impact total symptom score				
Significant	28.0	3.00	188.00	0.009
Not significant	18.5	2.00	112.00	

revealed a significant difference between ImPACT® baseline testing and RTP. The median RTP was 25.5 days for those patients having an ImPACT® baseline test and 28.5 days for those without ImPACT® baseline testing, $p=0.033$. Furthermore, the RTP was longer if patients had a significant ImPACT® score: verbal memory score (31 days), $p=0.001$; visual memory score (32.5 days), $p<0.001$; visual processing speed score (32 days), $p=0.008$; reaction time score (32 days), $p=0.001$; and total symptom score (28 days), $p=0.009$.

Using a nonparametric ANOVA (Kruskal–Wallis), it was revealed that all the athletes across all sports who had a neurological evaluation within the first week of their concussion had a significant decrease in RTP days (16) compared to those who had an evaluation beyond 1 week (36), $p<0.001$. This was most evident with hockey players who were participating in the state grant for ImPACT® testing of which 78.9 % received a neurological evaluation within the first week of their concussion compared to 17 % of field hockey who had an evaluation within the first week, $p=0.0001$. Figure 1 illustrates that individuals for those sports, where the majority of their team were evaluated within the first week, had a shorter RTP.

Discussion

The present retrospective study assessed factors associated with delayed symptom recovery as marked by prolonged RTP in concussed pediatric athletes. Our data suggests that patients who had an evaluation within 1 week of injury by a concussion specialist, regardless of sport, had a quicker recovery back to play (16 vs. 36 days). One potential reason is that concussion specialists are more likely to use updated concussion guidelines to drive care. McCarthy and O'Hara found that 59 % of family practice physicians in Connecticut were using concussion grading scales instead of individually determining injury severity and using return-to-play decisions as outlined in the Vienna protocol [8, 9]. In a more recent survey by Carl and Kinsella, of 158 general pediatrician members of the Illinois Chapter of the American Academy of Pediatrics, only

26.6 % reported being familiar with the Illinois Concussion Legislation and only 14.6 % were *very familiar* with the Consensus Statement on Concussion in Sport (2009 Zurich Guidelines) [10]. Concussion guidelines, although in continuous evolution, inform the concussion provider of the updated recommendations for the treatment and management of this injury [3]. Therefore, these guidelines are an important resource for any provider working with athletes. In addition, it can be proposed that concussion specialists will recognize subtle signs and symptoms related to concussion and employ tools such as ImPACT® to help with diagnosis. As a result, the specialist may have an increase in diagnostic accuracy that can lead to the ability to tailor the treatment for a given athlete [11].

This study also found that athletes with an on-field marker of headache also had shorter RTP. The reason for this is unclear but may represent early reporting by the athlete. Underreporting of symptoms is well known in the athletic population, and therefore, one could conjecture that reporting headaches early may lead to earlier treatment in these athletes [12]. Future studies are needed to clarify this finding.

Our study showed that females were out of their sport longer than male athletes. However, our data also found that females waited longer to receive a neurological evaluation from a health-care provider trained in concussion management which may have led to longer RTP in our population. In addition, female patients had significantly higher self-reported physical symptom scores during their initial neurological evaluation, with the top three symptoms being headache (78.9 %), photosensitivity (52.8 %), and decreased concentration (46.3 %). This is similar to the findings of Broshek et al., who found that females were more likely to report more symptoms than their male counterparts [13]. However, unlike Broshek et al., our findings only had a significant difference in physical symptoms between females (3) and males (2) and no significant difference in cognitive, emotional, or sleep symptoms. Other factors in explaining the longer RTP in female athletes may be the difference between male and female neck size and strength or possibly gender-specific differences in brain physiology [14, 15].

Fig. 1 Percent of athletes seen within 1 week vs. RTP
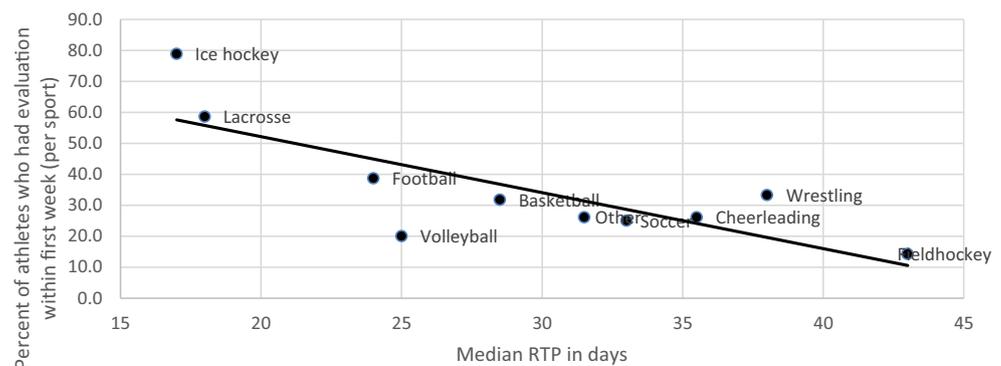
Headaches occur in approximately 85 % of patients with a sport-related concussion [16]. However, there is a paucity of evidence to direct pharmacological treatments [17]. In a survey of traumatic brain injury psychiatrists, Francisco et al. found that there was no uniformity in drug choice among psychiatrists in treating various symptoms arising from concussions [18]. Kinnaman et al. reported that medication choice was based on the number of years managing concussion patients. For example, pediatricians with over 16 years of experience were more likely to use prescription medications compared to the NSAIDs prescribed by less-experienced doctors [19]. As a result, it was not surprising that patients in our study who received AHR medication had a significantly longer RTP of 35 days compared to 22 days for those who were not prescribed medicine. Likewise, patients who received CHM had an even longer RTP of 53 days. This may be due to a number of factors that confound concussion headache management such as severity of injury, over-reporting of symptoms, mechanism of injury, pre-morbid history, or even rebound headaches from medication overuse which cannot be verified by this study alone [17]. However, it does support the need for any concussion provider to evaluate all potential contributors to an athlete's headache and realize that pharmacological treatment alone may not lead to headache resolution.

Other findings from this study included the fact that athletes with abnormal ImPACT® symptom scores as well as composite testing scores had longer RTP and this may be consistent with possible lingering cognitive issues delaying recovery [20, 21]. Concussion rehabilitation referral patients also had a significantly longer RTP than did patients who were not referred to rehabilitation (53 vs. 25 days). This is not surprising, considering that the small sample size of only 24 out of 361 patients met the criteria for rehabilitation and these patients were sick for at least 4 weeks.

This study has several limitations that make further generalizations difficult and is mostly confirmatory. This is a retrospective study that includes data from 2008 when concussion guidelines were different from today's standards. For instance, ocular motility disorders were not diagnosed and not included in this database. This is just one factor unaccounted for that may have played a role in delayed recovery. As already mentioned, this is a subspecialty clinic for which many of the patients were referred from their primary providers due to having persistent symptoms beyond 1 week and, therefore, recovery times are certainly longer than expected for routine concussions. Nonetheless, our data strongly suggests that early evaluation by a concussion specialist is an important factor influencing length of recovery and shortened RTP. With a minimum of 3.8 million sports and recreational concussions per year, it may be beneficial to have a network of providers with expertise in concussion management that would allow athletes' access to concussion specialists in a timely fashion.

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