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Delayed Recovery from Concussion Symptoms in Patients with ADHD

Dr. Satish Gaddam

Abstract: ***Concussions have been an increasing incidence and specifically pediatric sport-related concussions have become a public concern. As far as prolonged recovery from concussions of ADHD patients or severity of post concussion symptoms are concerned, some findings reveal a prolonged recovery from concussion in ADHD individuals; however, a further baseline characteristic of patients is needed to predict more accurately as to what type of patient exactly is at a higher risk of delayed concussion recovery. The very first thing required to be done is conducting large prospective cohort studies that will help in establishing associations and will confirm what kind of individuals are at more risks of delayed recovery or severity in post concussion symptoms [1]. Generally, a majority of pediatric patients of concussions recover fully in about three weeks time however the neuropsychological impact that the patients suffer from is not properly known [2]. This can be owed mainly to the fact that several factors affect the severity of concussions being experienced by the patients such as age, post concussion treatment and presence of co-morbidities [3]. The findings related to prolonged post concussion symptoms or severity in post concussion symptoms in patients suffering from ADHD offers somewhat mixed results, with some pieces of evidence that support the claims, while others questioning the validity of the findings of such types of researches.***

Keywords: Concussions Symptoms, ADHD, Concussion Recovery

1. Introduction

Concussions are defined as traumatic injury to the brain affecting its functioning [4]. Generally the effects of such an injury are temporary, however during recovery phase patients may experience a variety of different symptoms including loss of attention, headache, balance, and coordination issues, memory, etc [1]. Concussions are generally considered as a strong bow to the head, however violent shaking of the upper body or the head alone can also result in concussion. A concussion patient might lose conscious after a concussion, but this does not happen in all the cases. In medical literature, concussion has largely been studied with context to sport related concussion, as concussion is common in sports [5].

Concussions have large and varied adverse effects on the cognitive balance and functioning in the initial 24 hours after incurring of injury [6, 7]. Concussion symptoms can be diverse in nature being cognitive, physical and emotional following the first week of injury, and the more severe the symptoms or the greater the number of symptoms experienced after concussions, the slower the recovery from them [8, 9]. Concussions have been studied deeply in relation to sports related injury and an ample amount of research has been conducted on identifying factors that may possibly influence sport related concussion outcome [10].

As far as athletic related injuries are concerned cognitive balance [11], deficits [12] and symptoms [13] improve rapidly in the first two weeks time period following injury. Further, on the preinjury range of individual differences, acute clinical effects, initial severity of injury indicators, comorbidities or subacute clinical effects might have different outcomes or influences on patients of concussion[5]. Other factors that affect concussion symptoms include sex difference [14], genetics [15], young age [16], learning disability [17], neurodevelopmental factors such as Attention Deficit Hyperactivity Disorder (ADHD) [18], family [19] or personal[12] history, history of migraine [14], mental health problems [14].

Other factors that affect recovery from concussions include history of past concussions [20], and multiple past concussions are associated with patients suffering from more cognitive, physical and emotional symptoms [21] as compared to patients with no prior concussion history. There are some inconsistent findings related to specific concussion symptoms contributing to prolonged recovery in patients such as loss of consciousness [22], post traumatic amnesia, or retrograde amnesia [23] or prolonged recovery [24] from general symptoms.

Concussions and related symptoms differ in every patient and a lot of factors have been discussed in related literature; however, this study emphasizes specifically factors which may result in prolonged recovery from concussion symptoms in patients with ADHD. Since a majority of concussion related literature has been presented in the wake of sports related concussion and related symptoms, the same will be analyzed for ADHD patients.

2. ADHD - Brief Review

ADHD is a heritable disorder related to neurodevelopment. There is growing evidence in literature related to ADHD being a product of genetic components altering the synthesis, presynaptic release and uptake and postsynaptic reuptake of catecholamines in different networks and regions in an individual's brain [25, 26].

ADHD is generally characterized by issues in behavior such as impulsivity, hyperactivity, and/or in attentiveness. These factors persistently cause impairment in several areas of life and cannot be explained in any better manner in any other mental disorder [27].

Since concussion is mostly observed in studies related to sports injuries and athletes, there is otherwise very limited data related to any mental disorder in athletes. As far as ADHD is concerned, the data related to concussion is mostly based on car accidents [32, 33], instead of athlete specific

research and that too much is extracted from general ADHD literature [28].

Diagnosis of ADHD is very significant initially as individuals suffering from ADHD are prone to enhanced risk of comorbid psychiatric conditions and overall impact on the individual's functioning [25]. Individuals suffering from ADHD are proven of suffering from higher rates of anxiety disorders, depression, oppositional defiant and conduct disorders, bipolar disorder and language and learning developmental disorders [29, 30].

ADHD incidence on school age population is said to be at 3% to 10% [25], however further evidences suggest that the stated percentage could be much higher among school athletes [31, 24]. This is mainly owed to the positive influence athletics have on ADHD individuals [32]. Athletic participation serves as a consistent and dependable physical and emotional outlet that helps in coping with the symptoms [33]. Another reason why ADHD individuals are found more to be participating in sports is because involvement in athletics offers them the environment that gives them positive reinforcement and thus sometimes ADHD individuals excel naturally in their sport of interest owed to their inherent impulsivity that offers them an added advantage in making reactionary and quick decisions [24]. This has allowed study of athletes with ADHD a better area in discovering factors and reasons contributing towards delayed recovery from concussion symptoms in ADHD patients.

3. Review of General Predictors that Affect Recovery from Concussion Symptoms

Before going into details of predictors that have been to date studied as being indicators of delayed recovery or symptom severity in ADHD individuals, there is a need to review the general predictors that have been studied either solo or in multiple indicator studies that are suspected to affect recovery after concussion. A lot of literature in this regard is opposing to each other with a few studies validating one or more factors to affect post concussion symptom recovery, while others prove it wrong. There are only a few findings that have not been disputed to date. This review will offer the areas that should be considered as possible indicators for future reviewing with ADHD individuals. Almost all studies done in regard with assessing predictors or factors that might affect recovery after concussion, can be categorized broadly under 4 categories

1) Pre-injury characteristics that may affect recovery after concussion [10]

Terwilliger, et.al. [34] and Chermann, et.al. [35] found age to be a characteristic that affects post concussion recovery, whereas Lau [36] and Hang [37] among several others denied age as being a determining characteristics. Baker [38] and Berz [39] presented female gender as being a characteristic that affect post concussion recovery; however, Chermann[35] and Moor [40] deny this finding.

Vargas [41] and Kontos [42] studies race(white versus non white) as a characteristic in this regard, considering it a possibility, however McDevitt [43] and Asplund [44] deny it being a characteristic. McDevitt [43] in a prior study considered genetics in being a predictor, however in a later study, he himself denied his findings. Hang [37] and Nelson [45] found past concussion history as being a solid predictor, however studies such as Asken [47] and Moor [46] deny it. Miller [56] in his study held ADHD responsible of affecting recovery, whereas Asken [47] and Lau [48] denied the findings. Zemek [49] considered learning disability as an affecting factor, while Asken [47] and Lau [48] again denied it.

Similarly, studies both in favor and against of prior psychiatric history, migraine, headache history all surfaced fro time and again not offering any substantial evidence either in favor or against the claims. Family psychiatric history is the only factor which has two studies Morgan [50] and Ellis [51] in favor but none against the factor. This can; however; be because the factor is not well explored to date.

2) Severity of injury and its relationship with recovery after concussion [10]

Chermann[35] and Pellman [52] stated in their works that loss of consciousness affect recovery time in concussion patients, whereas Brown [53] and Guskiewicz [1] found otherwise. Benson [54] and Chrisman [55] found post traumatic amnesia as being an indicator of delayed recovery time, while Brown [53] and Guskiewicz [1] denied the finding in their study. Asplund [44] and McCrea [11] found retrograde amnesia as affecting recovery from concussion but Lau [36] and Merritt [15] found otherwise. Asken [47] and Terwilliger [34] found delayed removal from play or additional head trauma as affecting recovery from concussion.

3) Acute clinical characteristics that might affect recovery after concussion [10]

Chermann [35] & Brown [53] considered sub-acute or greater acute symptoms to affect recovery from concussion, whereas Barlow [56] and Moor [46] denied the statements. Asplund [44] and Kontos [42] defined acute headache as affecting recovery from concussion but Mihalik [57] and Chrisman [58] denied the findings. Lau [36] and Erlanger [59] found acute dizziness to be effective on concussion symptom recovery, but McDevitt[43] and Merritt[9] found otherwise. Iverson [60] and Erlanger [59] found Acute Neuropsychological deficits to affect recovery, while Barlow [72] and Hang [37] said it did not affect recovery.

4. Concussion and ADHD

The American Medical Society For Sports Medicine's 2013 position statement revealed that ADHD can complicate management and diagnosis of concussion, however still research has not included analyses of ADHD youth athletes in the manner as it should have [61]

According to estimation around 1.6 million to 3.8 million concussion cases are recorded annually with 9% related to sports injury, while the remaining occurs from different incidences [62, 63], mostly in adolescents and children [64]. Since earlier on very limited data related to ADHD and concussion was worked on, relating to mostly car accidents related concussion, it is only lately that ADHD has been

started to be explored with relations to concussion risk and recovery from sport-related injuries. Some recent researches have also emphasized the need to assess influence of ADHD on pre-injury baseline via neurocognitive profiles that are computerized, leading to facilitation of clinical decisions related to pediatric concussion management [65].

Diagnosis and management of concussion remains to be at the forefront and is continual evolving in sports medicine pathology by means of research. One focus related to these researches is the modifiers and risk factors that affect management of concussions and related clinical course. In this wake many consensus statements and societies have identified neuropsychiatric disorders, inclusive of ADHD as being significant concussion modifiers [66, 67].

Concussions and ADHD both involve many different neurocognitive domains such as concentration, attention, memory [37]. This has proven that ADHD is a direct influence in concussion evaluation inclusive of its clinical presentation, diagnosis of neurocognitive recovery and testing, and physical examination [36]. A study compared data compiled from 8056 schools and collegiate level athletes revealing that ADHD individuals had greater baseline fatigue rate, higher concentration difficulty, more trouble in sleeping and remembering, and severe balancing related problems. All of these were also found to be concussion symptoms as well [10].

Differences in processing speed, executive functioning, neurocognitive reaction time during pre and post testing of concussion was revealed as being lower in ADHD individuals compared to standard data [10]. The collective effects of ADHD and LD (Learning Disability) which are both comorbid developmental disorders were also found to have effects on the neurocognitive baseline performance [10]. Considerable low scores in memory, verbal, processing speed, visual and reaction time were evident in baseline testing with individuals with both developmental disorders [68]. ADHD individuals compared to their non ADHD peers present continual decline in testing scores of neurocognitive testing after concussion owed to worsening inattention which is a symptom of ADHD itself, rather than of concussion [38]. Factors as such make it harder to assess, evaluate and manage concussion in the ADHD patient population.

Another very important study discovered an altered trajectory of recovery in ADHD patients who have undergone concussion revealing a slower recovery of up to 3 days[15]. However still even after late recovery, there were no signs of any worsened chronic ADHD symptom after concussion. The mean time of return to play, learn is anticipated as being longer in ADHD individuals and there is no evidence of any faster recovery from concussion through treatment using stimulants.

It was found to be of vital importance that when approaching a concussion patient, awareness of ADHD should be a well aware factor to be considered as a prognostic marker and risk modifier [69]. Since ADHD individuals commonly have lower baseline performance and baseline concussion symptoms in their neurocognitive testing, baseline and pretesting evaluation is always helpful in the population [10].

Assessment of Concussion Risks in Young and Adolescent Athletes

ADHD individuals or athletes are more prone to sports-related injuries or concussions owed mainly to their poor fine and gross motor movements and their aggressive play style [31]. A large demonstration survey conducted in 2014 on a population of 6,529 student-athletes between 13 years of age to 19 years of age found that in terms of concussion history, a larger number was related to ADHD suffering athletes (26%) compared to non ADHD students (17%) in both boys and girls [70].

Another case-control study also conducted in 2014 considering athlete students aged 12 to 25 years revealed that in students who sustained a mild traumatic brain injury, the rate of ADHD individuals was higher compared to other non ADHD control subjects. It should be noted that ADHD was diagnosed prior to the concussion injury. The study revealed that students that suffered mild concussion and had ADHD underwent severe symptoms related to concussions as compared to those athletes that even though had a history of concussion however were non ADHD [39].

Another study on the topic conducted in 2016 considering 512 youth athletes, twice as many, almost 14% reported of sustaining a concussion prior to the study, compared to only 18% ion non ADHD athletes. Researchers [39] suggest that ADHD athletes are more vulnerable of suffering from concussion related injury. Another recent cross sectional study conducted over 8,000 college and high school athletes, mostly male football players revealed that multiple players with ADHD reported prevalent concussions [10].

Predictors of Prolonged or Severity of Symptoms after Concussions in ADHD Individuals

According to the preliminary study athletes with ADHD may suffer from a higher risk of developing anxiety and depression symptoms after undergoing a concussion. Investigating over 1,000 college athletes, the study found that Athletes with ADHD and prior concussion history scored higher anxiety and depression. Individuals with ADHD but no history of concussion scored better than athletes suffering both, while non ADHD athletes with no history of concussion scored highest [15].

Though several studies that have been conducted reveal somewhat results such as more severe symptoms or prolonged recovery from post concussion symptoms, however almost every study found limitations to the extent that the prolonged effects or severity of symptoms, specifically in ADHD individuals may have already been higher in the athletes before the head injury [71].

ADHD and concussion symptoms are mostly alike and thus it is important to have complete knowledge of whether ADHD makes an individual more vulnerable to symptoms of concussion. The immediate symptoms of concussion include dizziness, fatigue, headache, nausea and confusion. These symptoms generally disappear within a few days time, however for some people the symptoms may take weeks or

even months to recover from, and often these individuals are at a risk of developing emotional symptoms as well such as anxiety or depression [72].

Anew study conducted on evaluating the vulnerability of individuals with ADHD and past concussion history towards prolonged recovery and symptom severity, analyzed 979 athletes at a university, where they were divided into four groups. One group consisted of students that had both ADHD and a past history of concussion. The other group had ADHD but no past history of concussion, while the third group had a past concussion history, but no ADHD. The final fourth group had none of the two conditions [73].

The study presented its general findings as athletes with both the conditions (Group1) scoring higher when anxiety and depression symptoms were gauged with the group scoring 26 versus 16 in the other three groups on the scale of depression. On the scale of anxiety,the first group scored 42 against a score of 33 for the other three groups [46]. The results though did not reach the range where they can be diagnosed as being major depressive or suffering from clinical anxiety however they did reveal; that individuals or athletes with both the conditions were at a higher risk of developing these conditions [44].

Further exploration on why individuals with both conditions were more at risk of developing anxiety and depression, one reason presented was that Individuals with ADHD found it harder to deal with the stress of being sidelined during the time they were recovering from the concussion symptoms, related to falling behind in school work or in their play in their sports team. This was however rejected by the researchers of the study as all participants of the study were in good schoolwork and playing condition at the time of the study. Another finding of the study was that all groups fared same in terms of anxiety trait, indicating that all presented a natural tendency of getting anxious when any stressor was faced with[44]. Though this is not an indicator that patients with ADHD will sustain a prolonged depression or anxiety attack however, they do need to be carefully monitored during their recovery phase after concussion [74].

There have been some studies that indicate that gender may be a predictor in prolonged post concussion symptom recovery [50] however evidence on this is not sufficient or significant enough to prove anything and not much research had been done to prove a definite point in this regard.

Difference in Recovery Time in ADHD and Non ADHD Patients

Two different studies conducted in the past offered their findings that no relationship exists between ADHD and prolonged concussion recovery time; however, both studies were conducted on a very small scale considering a small population only. A very recent case-control study conducted over 70 high school athletes with subsequent concussion history with self-reported ADHD versus 70 high school athletes with no ADHD but the history of concussion revealed the mean recovery time-indexed via neurocognitive testing and scores of concussion symptoms was 16.5 days in ADHD group versus only 13.5 days in non ADHD group [15]. The three days difference in the outcome of the two groups recovery time though not significant statistically, maybe owed to a smaller sample size; however, reveals that recovery from a sports-related injury is slow in ADHD individuals compared to non ADHD individuals [15].

There have been reservations filed against the findings of the study as it was inferred that ADHD patients may have decreased cognitive reserve or in general may have a reduced capability of overcoming a concussion as swiftly as those who do not suffer from ADHD. Another reason for prolonged recovery in ADHD individuals from concussions can be owed to poor adherence to restrictions required being followed post concussion, resulting in which delayed recovery and prolonged symptoms were experienced in the ADHD affected group. Besides these factors, other factors considered as limitations of the study include self reporting of ADHD by patients, retrospective design and other issues related to methodology. Additionally since ADHD patients would have been using related medication which was not assessed and there is a possibility that the effects of those medicines may have tempered with the results of the neurocognitive testing [75]. The authors of the study suggested that clinicians should consider the status of medication when they interpret the profile scores of neurocognitive tests [76].

Another control case study conducted considering 300 pediatric patients investigating predictors of prolonged recovery such as recurring symptoms for more than 28 days. The findings showed increased protracted recoveryfrom sport related concussion with ADHD individual [77]. Researchers of the study suggested that clinicians need to specifically focus on the fact that people who suffer from concussions may also suffer from several risk factors that affect their time to recover from a concussion. This is one area that needs more research and extensive studies to be conducted before offering any conclusive statement about a finding.

Computerized Neurocognitive Profiles

Based on common consensus, using baseline testing in athletes to stress on whether ADHD in any way affects the neurocognitive performance score has been the underlying methodology in many studies conducted in exploring the area. One reason why this is important is because age specific normative data for ADHD population is almost extinct, and there is need for more evidence to define causes and reasons for delayed recovery in ADHD patients [31].

The researchers of the study emphasized that using baseline computerized assessment will help tremendously in assessing ADHD athletes offering a complete understanding of their situation via a unique profile based on neurocognitive findings. This will allow accurate diagnostics and informed decisions to be taken for an athlete with ADHD, especially in case if such an athlete sustains a concussion, full knowledge of his or her disorders will be available and treatment can be made more efficient[31]. Present findings reveal that athletes with ADHD display a lower score of baseline performance, compared to their non ADHD peers measured by neurocognitive testing.

5. Conclusion

Concussion recovery is an individualized experience and differs for every individual or student. Studies pertaining to different factor based study that would affect or result in delayed recovery from concussion symptoms, specifically in ADHD patients; it was found that factors such as gender, migraine history, ADHD, ADD and similar histories did have a delaying effect on recovery from concussions. There is however a need to conduct further research on that topic as evidence present currently is not sufficient to present a significant result to determine these findings. It was found that ADHD individuals require more careful analysis and attention post concussion as they may experience more severe symptoms, which might be similar to some of their similar symptoms, worsening them, thus resulting in a delayed recovery. Resorting to available literature the strongest or the most consistent predictor of severity in post concussion symptoms was found to be linked with sub acute and acute symptoms of a person suffering from concussion.

Other findings suggest that if An ADHD patient suffering concussion is less likely to take more than 28 days to recover from it and the greater risks of having concussion and severe symptoms and prolonged delay in recovery are associated to the teenage years of ADHD individuals. Also, some studies found girls to be more vulnerable than boys in ADHD population.

It was also found that stimulant medications can serve as base for successful treatment of ADHD population and there is a need to analyze the possibilities of its use in treating ADHD individual suffering from concussions. When stimulant medication initiation is considered there is also a need to examine a through cardiovascular history.

ADHD affects not just the recovery from concussion but also the diagnosis of symptoms as most symptoms of ADHD and concussion are similar, demanding a more deep investigation paired with past medical history, so that concussion can be better managed, diagnosed and treated in ADHD patients. Owed to similar symptoms, prolonged recovery from concussion symptoms can also be wrongly assessed, since ADHD patients on a regular basis go through certain symptoms prior to concussion as well.

The study has presented the various works of researchers in different areas, where the oldest literature considered car accidents as base for ADHD concussion symptom recovery based studies; however, more recently sports-related concussion have been largely studied. There is a need to study ADHD related concussion even more deeply and apply study on a wider scale to derive significant statistical results related to findings.

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