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Effects of Multiple Concussions on Collegiate Football Players' Motor Behavior

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by

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EFFECTS OF MULTIPLE CONCUSSIONS ON COLLEGIATE FOOTBALL PLAYERS' MOTOR BEHAVIOR

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Deborah Storm

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CHAPTER 1

INTRODUCTION

Recently, there has been a great deal of media attention and research into the incidents and severity of concussions and their long term effects. One of the biggest problems with concussions is that they are not always reported. Llewellyn, Burdette, Joyner, and Buckley (2014) found that many athletes at the collegiate level were not reporting their concussions, and a large percentage of those athletes did not fully understand the definition of a concussion. Robbins, Daneshvar, Picano, Gavett, Baugh, Riley, Nowinski, McKee, Cantu, and Stern (2014) asked athletes how many concussions they had suffered throughout their career, then gave them the definition of a concussion. Once the athletes were provided the definition of a concussion, there was a significant increase in the number of concussions reported compared to their original reporting. When athletes do not report their concussions, they put themselves at a greater risk for long-term effects and the possibility of further, more serious brain injury.

Common causes of concussions are head-to-head or head-to-player contact, head-to-equipment contact, whiplash, or head contact with a wall or a group of people. The most common cause of a concussion in football is due to how a player makes contact with another athlete or the ground. Physiologically, when a person is concussed, the neurovascular components of the brain become torn due to the whiplash acceleration-deceleration of the head. This can cause the nerves in the brain to depolarize resulting in a loss of communication between the neural signals (Harper, 2013). If concussions are not reported, the athletes will likely continue to play, increasing the risk of subsequent concussions and brain damage.

Edwards and Bodle (2014) reported that athletes who suffer multiple concussions have a much higher risk of early onset cognitive decline and psychiatric instabilities. It is believed that

they are having difficulties due to the multiple concussions they suffered throughout their careers. Dean and Sterr (2013) found that previously concussed participants showed a delay in their information processing speed and greater difficulty with working memory compared to controls. Additionally, Mangels, Craik, Levine, Schwartz, and Struss (2002) discovered that putting their participants with brain injury into a dual-task paradigm using everyday situations resulted in cognitive and motor ability impairments.

Caron, Bloom, Johnson, and Sabiston (2013) performed a qualitative study on retired professional hockey players who had suffered multiple concussions, and retired due to the severity and multiple accounts of injury. During their study they interviewed the retired athletes and found that the concussions had significantly affected their daily living. Not only did these athletes have continuous concussion symptoms, but their emotional and mental states were affected negatively as well. McAllister and colleagues (2001) found that participants that had suffered a mild traumatic brain injury showed more difficulty with working memory. They believed this to be because there was a reduction in information processing capability compared to individuals without a traumatic brain injury.

Little has been done to investigate the effects of multiple concussions on an individual's ability to perform specific motor tasks. To date, the impact of two or more concussions on a motor task has not been explicitly evaluated, therefore, the purpose of this study was to determine if collegiate football players that have suffered two or more concussions throughout their career, had difficulty completing a novel visuomotor tracking task compared to non-concussed football players. Given the decreases in processing speed that has been previously observed (Dean & Sterr, 2013), it was hypothesize that collegiate football players that have

suffered multiple concussions would have a lower time on target while performing a pursuit rotary tracking task compared to non-concussed football players.

CHAPTER 2

METHOD

Participants

A cover letter, informed consent, and a "Rivermead Post-Concussion Symptoms" questionnaire was distributed to the entire Southern Illinois University (SIU) 2014-2015 football team during a team meeting. Those athletes that reported having no concussions, and those athletes reporting two or more concussions were included in the study. The athletes voluntarily signed an informed consent approved by the SIU Human Subjects Committee. The control group consisted of 14 athletes with no self-reported concussions, and 16 athletes that reported having experienced two or more concussions throughout their football career. To be qualified as a part of the control group, a Physician or Athletic Trainer must have never diagnosed them with a concussion in their football career. Qualifications to be in the experimental group included having suffered at least two diagnosed concussions throughout their entire football career. Permission to access the athletes' medical files, if needed, was granted by the head football Athletic Trainer and the athletes by signing the informed consent.

Apparatus and Task

The participants used a Lafayette Instrument Rotary Pursuit Tracker, model 30014A to measure visuomotor ability. The Rotary Pursuit Tracker was used at 25 revolutions per minute (RPM). The participants used a hand-held stylus that contained a light-sensitive photocell to follow a rotating fluorescent light around a predictable, clockwise, circular path of 2.54 cm by 2.54 cm for five trials that were 20 seconds in duration. The Rotary Pursuit Tracker measured how long the stylus stayed in contact with the light (i.e., time on target) during each trial. The

amount of time each participant was able to keep the stylus on the light served as the dependent variable.

Procedures

Each participant completed a "Rivermead Post-Concussion symptoms Questionnaire" (RPQ) reporting how many concussions they have suffered, as well as reporting any challenges of daily living post-concussion (King, Crawford, Wenden, Moss & Wade, 1995). The athletes that reported zero concussions on the questionnaire were placed in the control group. Those that reported two or more concussions were placed in the experimental group. The amount of concussions were verified by the documentation from the football team's head Athletic Trainer. The athletes that completed the questionnaire but had suffered only one concussion were not included in the study.

Once the participants completed the questionnaire, they were assigned into one of the two groups, the control and experimental depending on their answers to the questionnaire and self-reported concussions. Each participant reported to the Motor Behavior laboratory one time for approximately ten minutes for testing. Each participant was sent an email the day before to remind him of his scheduled testing time. When the athlete reported on his testing day, he was instructed to stand in a comfortable position in front of the table supporting the Rotary Pursuit Tracker, and hold the stylus with his dominant hand, and place it on the orange piece of tape located in the center of the Rotary Pursuit Tracker. Participants were then instructed that once the light began to move, to transfer the stylus from the tape to the light and do his best to keep the tip of the stylus in contact with the light throughout the trial. After each trial, time on target was recorded, and the participant returned the stylus back to the starting position on the orange tape. The data collection consisted of five, 20-second trials at 25 revolutions per minute.

Analysis

The settings for the task were as follows: test time= 20 seconds, rest time= zero seconds, number of test cycles= one, stimulus sensitivity= seven, direction= clockwise, and revolutions per minute= 25. The task included one day of testing, lasting approximately two minutes. Each football player completed five trials at 25 RPMs. Each trial's time on target was recorded and each trial lasted 20 seconds. The Rotary Pursuit Tracker reported time on target and it was be documented on an excel spreadsheet. After each trial the time on target was reset to zero. Time on target data were averaged across the 5 trials.

Differences between the concussed and non-concussed groups were analyzed using IBM SPSS Statistics for Windows Version 22.0 (Armonk, NY, USA). The mean time on target results were analyzed by using a One-Way ANOVA to evaluate significant differences between the two groups. Alpha was set as $p = .05$.

CHAPTER 3

RESULTS

Participant Characteristics

A total of 30 Southern Illinois Football players participated in this study. The results of the participant survey indicated that the 14 players that constituted the control group represented nine different positions, with defensive ends making up the largest group within the condition. Their ages ranged from 19-23 years old, with the average of 20 years old and a standard deviation of 1.14 years. The experimental group consisted of 16 football players. Eight positions were represented in this group, with wide receivers being the largest portion of the sample. The ages ranged from 18-25 years old, with an average of 20 years old and a standard deviation of 1.59 years. The amount of concussions each athlete had varied between two and five, averaging 2.75 with a standard deviation of 1.06 concussions. Of these 16 athletes who had experienced multiple concussions, 13 still had post-concussion symptoms according to "The Rivermead Post-Concussion Symptoms Questionnaire". The results of this experiment support the hypothesis that multiple concussions impair motor task ability.

Time on Target

The five trials completed by each participant were averaged for the analysis. The results of the ANOVA indicated that the non-concussed group had a significantly greater time on target compared to the concussed athletes (p=0.03). The average time on target for both conditions is displayed below in Figure 1.

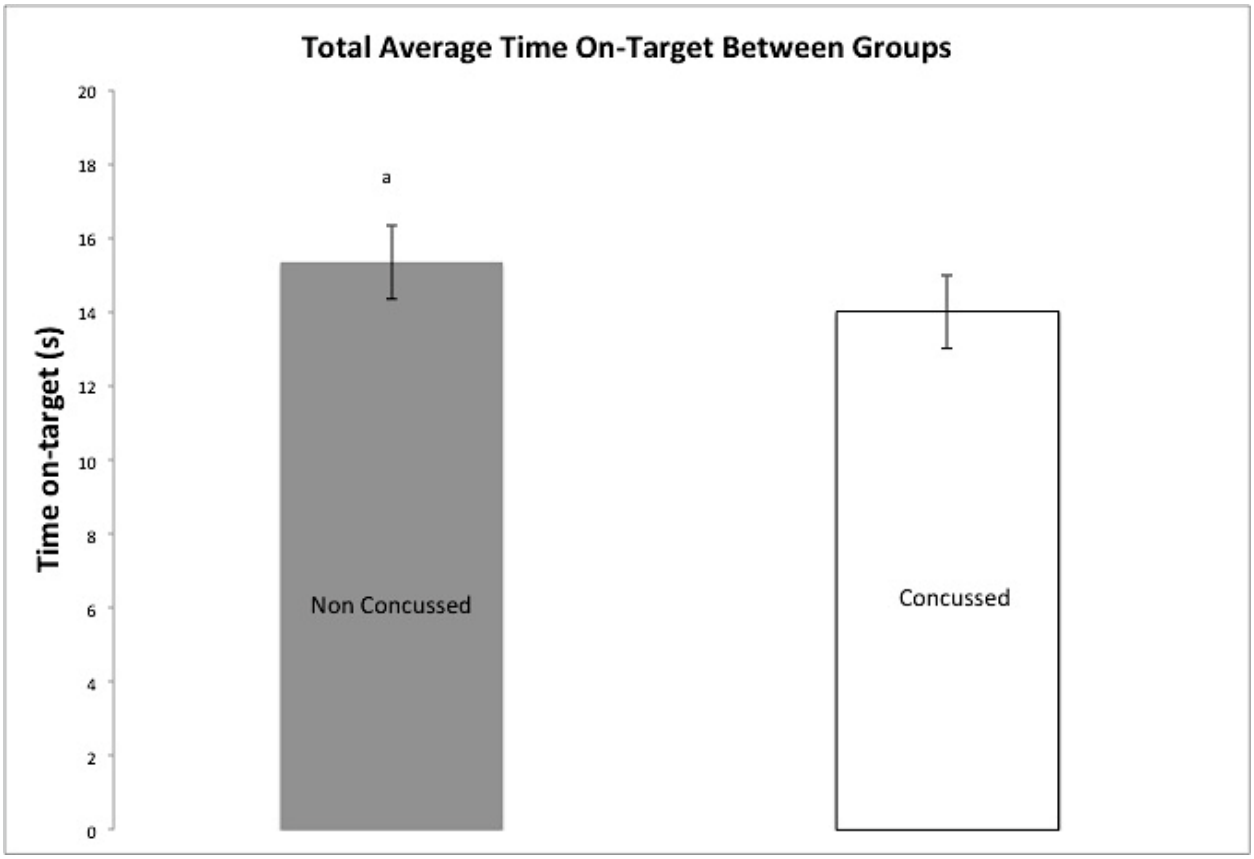

Figure 1. Average time on target for both groups. Errors bars represent standard deviations. (a) signifies significant differences between groups.

In an attempt to determine if there was a practice effect difference of the PRT, we analyzed group by trial differences with a follow up 2 (condition) X 5 (trial) ANOVA with repeated measures on the second factor. Interestingly, the first trial showed no significant difference between the control and experiment group. In trials two and three, the control group had a significant greater time on-target than the experiment group. By the fourth and fifth trials, while the non-concussed group tended to be on target longer than the concussed group, there was not a significant difference between the two groups. These results suggest that the concussed

group was delayed in parameterizing the visuomotor task relative to the non-concussed group.

The time on target across the trials within each condition are displayed below in Figure 2.

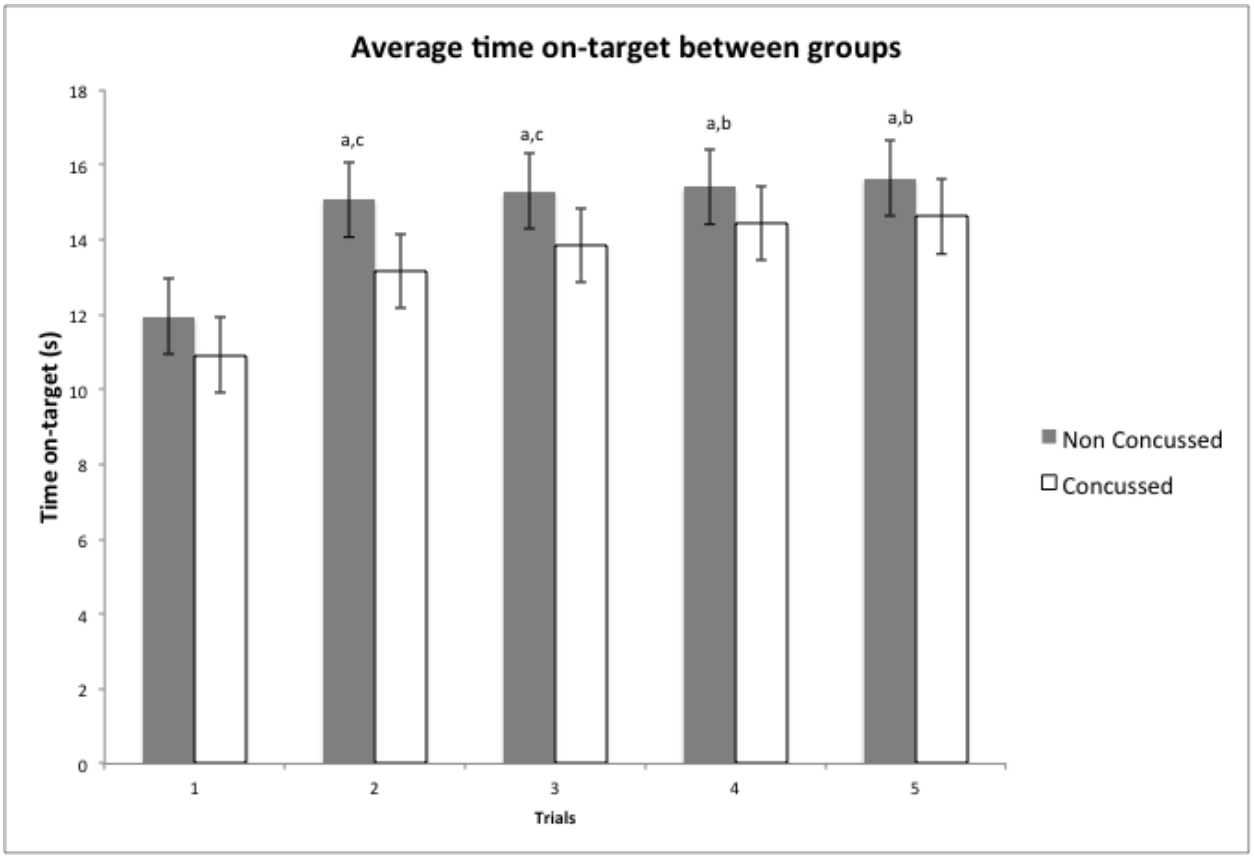

Figure 2. Average time on target across trials for each condition. Time was measured in seconds. This graph displays a comparison of average total time on target. (a) signifies the non-concussed are significantly different than trial 1, (b) signifies that the concussed are significantly different than trial 1, and (c) signifies that two groups are significantly different from each other in that trial.

CHAPTER 4

DISCUSSION

The results of this study show that individuals who have experienced multiple concussions have impaired performances on a visuomotor task compared to individuals who have not experienced a concussion. This extends the findings of De Beaumont and colleagues (2013) who tested motor learning of former collegiate athletes that were middle aged and older. They used a computer test to measure reaction time and found that the experimental (i.e., concussed) group, took longer to learn the task compared to the control (i.e., non-concussed) group. Similarly, O'neil, Skeel, and Ustinova (2013), used a virtual reality game with participants with brain injuries to determine deficits in motor ability. That study did not only focus on athletes, it assessed the performance on non-athletes as well. The results of that study were consistent with the results of the present study. Specifically, O'Neil et al. (2013) found that both the control (i.e., no traumatic brain injury) and experimental (i.e., traumatic brain injury) groups improved with each trial, it took the experimental group longer to show greater improvements, whereas the control group showed significant improvement right away.

The cortical mechanisms of neuroplasticity are negatively affected from a concussion, this can cause difficulty with motor performance and learning. Levac, Missiuna, Wishart, DeMatteo, and Wright (2011) developed a method of measuring motor development and learning in children with a brain injury. It is believed that with early intervention and therapy, a child can regain motor skills that have been lost, and continue to learn new ones at developmentally appropriate levels. Research has shown that for recovery within the brain after a brain injury, plastic reorganization has to occur within the affected neurons (Plautz & Nudo, 2005). Motor deficits can be regionally restored by selective inactivation of plastic regions

within damaged cortical areas. Recovery of the damaged tissue can be restored and functionality can be regained after injury. However, recent studies have shown that the tissue will not heal on it's own, and requires extensive therapy to manage and possibly reverse the damage.

Limitations and Future Direction

Limitations of this study would include self-reported concussions. Due to not having access to records prior to college, it is not known if any of the athletes had concussions before college. This study also relied on the athletes admitting to having concussions, some of the athletes had fear that they would be penalized for not reporting concussions during season to participate in the study. In addition, this study also used a relatively small sample size and was only limited to football players.

Another study that could be interesting would be to follow these collegiate athletes that participated in this investigation to see how they progress or digress throughout the next 15 years. For a future study, former collegiate football players could follow the same testing protocol and see if the results have increased, decreased, or remained the same. A future study could use athletes that have been out of collegiate athletics for several years.

CHAPTER 5

CONCLUSION

The purpose of this study was to determine if collegiate football players that had suffered two or more concussions throughout their career, had greater difficulty performing a novel motor skill compared to collegiate football players that self-reported that they had never had a concussion. The results of this study supported the hypothesis that the concussed participants would not perform as well as the non-concussed participants. The results of the study further revealed that the rate of motor skill improvement was faster for the non-concussed group compared to the concussed individuals.

The inability to optimally perform a motor skill like the one utilized in this study could have implications for activities of daily living and even greater implications for subsequent athletic performance. What can be taken away from this study is the importance of educating athletes on the severity of concussions and the importance of reporting them. It is also important for athletes to be taught at a young age how to hit properly to prevent head injuries. There are many new safety regulations regarding hitting to help prevent concussions and it is important for coaches to enforce these. By playing safer, it can help protect the athletes from life-long complications due to head injuries.

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APPENDICES

APPENDIX 1

Review of Literature

Introduction

The severity of concussions is gaining a lot of ground as more research is being completed. Researchers are finding more long-term effects of concussions than just the short-term symptoms. Gait and motor skills can be effected by a concussion and remain effected even after the other symptoms subside. When a concussion occurs, tearing of the neurovascular components happen because of the rapid whiplash-like acceleration, deceleration movement. Because of this, nerves in the brain can become depolarized and negatively affects the neural communication signals (Harper, 2013). Due to neural imbalance, potassium rushes to the newly created empty spaces, creating a release of the excitatory amino acid glutamate. This is a risk because it can potentially cause an influx of potassium (Halstead & Walker, 2010). There is not a lot of research on the physiology of a human brain following a concussion, most of the theories are referring to lab animals.

Concussion Diagnosis

When an athlete appears to be concussed or has had some type of blow to the head, someone on the sports medicine team will perform a cognitive and coordination test on the sidelines. College and professional athletes who are involved in contact or high-risk head injury sports usually take a baseline test before they begin participation. By taking a baseline exam, this gives the sports medicine team something to compare the results of this exam post concussion. A common test used is Immediate Postconcussion Assessment and Cognitive Testing (ImPACT), it is a computer based exam. Typically an athlete will not take the ImPACT test until it is believed that

he/she no longer has a concussion because it is a time consuming test. On the sidelines, the athlete is asked cognitive questions that are basic and easy to answer like name, age, date, where he/she is, etc. to discover a possible concussion. They are also asked to perform balancing tests. Some balancing tests are Rhomberg and Balance Error Scoring System (BESS). The BESS test begins with the athlete standing two feet on the ground and eyes closed for twenty seconds. While performing this test, the Athletic Trainer counts how many errors they have. "A balance error is operationally defined as opening the eyes, hands coming off the hips, taking a step, moving the hips into 30 degrees or more abduction, lifting the forefoot or heel, or remaining out of testing position for more than 5 seconds" (Oliaro et al., 2001). The next step is single leg stance for each leg. Once those three tests are completed, they are repeated on an unstable surface. The athlete will also take a Standardized Assessment of Concussion (SAC) test. The SAC test is used for neuropsychological testing for memory cognition (Oliaro, Anderson, & Hooker 2001).

Short Term Effects

When an athlete has the initial concussion injury, he/she tends to have a variety of signs and symptoms. Some athletes will experience a loss of consciousness. Other signs and symptoms of a concussion are headaches, difficulty with balance, dizziness, nausea, confusion, anxiety, noise and light sensitivity, and lack of concentration. An athlete can also experience retrograde amnesia, which is not remembering what happened before the injury, or anterograde amnesia, not being able to remember what happened after the injury. Sometimes the signs and symptoms of a concussion do not occur until several minutes to the next day after the injury to surface. The sports medicine team has to be extremely cautious when allowing athletes to return to play. It is

not uncommon for athletes to not even report their symptoms. If athletes do not report symptoms or return to play before all the symptoms have subsided, they run the risk of second impact syndrome. Second impact syndrome is when the athlete has not fully healed from one head trauma, and receives a second head trauma. The second trauma usually will not lead to loss of consciousness instantly, it is a more delayed reaction. Along with this loss of consciousness, the athlete can experience rapid increase of size of the pupils, lack of eye movement, and respiratory failure. This second impact can also create excessive swelling in the brain and create intracranial pressure. If the athlete does not receive medical attention immediately after, second impact syndrome can result in death (Cantu & Gean, 2010).

Long Term Effects

Researchers are discovering more about the long-term effects of a concussion. Many professional athletes, later on in their lives, are experiencing difficulties in their day-to-day activities because of suffering from concussions. The types of things they are suffering with include depression, lack of desire or drive, lack of concentration, irritability, anxiety, uncontrollable emotions, and memory impairment. Many athletes try to hide their symptoms so they can continue playing. This is more common in male athletes than female athletes. By continuing to play, the athletes put themselves in further danger of possibly experiencing second impact syndrome. Many times athletes would also start playing again before they were fully healed from their concussion. If they return to play before they are healed, they run the risk of having more long-term effects of a concussion (Caron, Bloom, Johnston, Sabiston, 2013).

Motor Skill Impairments

Motor skills and gait function are another negative impairment of concussions. Athletes that have suffered many concussions will some times experience difficulty with standing or sitting upright for long periods of time. Other former athletes could not hold a normal job because their bodies would need more rest and more breaks to be able to make it through each day (Caron et al., 2013). In a study monitoring motor decline in former athletes that had suffered concussions, they found that the athletes that had suffered concussions in their past, had difficulty with a repeated motor sequencing (De Beaumont, Tremblay, Henry, Poirier, Lassonde, & Theoret, 2013). O'Neil, Skeel, and Ustinova, 2013, performed a virtual reality game to measure the motor learning of subjects with mild traumatic brain injury. Interestingly, they did not find a difference in those that had been recently concussed to those that had been concussed many years ago. The control group's learning rate increased significantly in the first few stages of the study, however both groups showed improvement throughout the study. This study has shown that the participants with mild traumatic brain injury improved in their motor learning skills, but that they took longer than the control group.

Gait Impairments

A majority of the current studies on gait and concussions are not performed over a long period of time. Because of this, most of the research that has been found usually only goes up until a month after the initial concussion injury. Studies have found that even after six years post concussion, people still have an altered gait pattern due to their injury (Martini, Sabin, DePesa, Leal, Negrete, Sosnoff, & Broglio, 2011). In the Martini et al. (2011) study, they discovered that the participants that had suffered a concussion had a slower walking velocity, and spent more

time in the double-leg stance support than the single-leg stance support. They believe this is due to the fact that they decrease their time in a less stable position. Concussed individuals sometimes end up developing a medial-lateral sway in their gait. By having a greater medial-lateral motion it is showing that they have a decrease in their stability, this was noticed up to at least two weeks post concussion (Chou, Kaufman, Walker-Rabatin, Brey, & Basford, 2004). In the Catena et al (2011) study, the researchers had the participants perform an auditory Stroop Task while walking. The Stroop task is from a computer where it says words in a high or low pitch, the participants were supposed to state if the word was in a high or low pitch, without saying the word. During this experiment, they determined that the concussed individuals had a delayed reaction time. Like the other researchers, it was also discovered that the concussed participants slowed their gait speed even more when they were performing a dual task.

Conclusion

There is still a significant amount about concussions that researchers have not yet discovered. The brain is difficult to study, and not much physiological research has been performed on humans who have suffered concussions. Even though there is not a lot of research, the knowledge of the short and long term effects is greater now than it ever has been. Researchers are working hard to discover more about concussions and how to prevent them. The sports medicine field is making advances in protective equipment to keep contact sport athletes safer. In the past, it was believed that an athlete that suffered a concussion would heal just like any other injury. Within the last few years, many former professional athletes have discussed their post career lives. Many of them are significantly affected from their concussions and are trying to cope mentally and physically. Some things that are not always noticed are the gait and motor

skills. After an athlete suffers a concussion, they have a decrease in their stride length, more difficulty balancing, and even an increase in difficulty in multitasking. Most of the time, these difficulties disappear as the other symptoms begin to subside. It is still possible for athletes to continue to suffer from these motor skill deficiencies later on in life. It is important for the sports medicine team members to be continuing their education in concussions for the safety of the athletes. In the past many athletes were cleared to return to play before they were fully healed, this is extremely dangerous because the athlete could end up suffering a second concussion; which could lead to second impact syndrome. With the advances in medical research, hopefully in the near future there will be better ways to protect an athlete from suffering from a concussion or recovering from a concussion without the lifelong affects it can leave.

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