# THE COGNITIVE AND PHYSICAL EFFECTS OF CONCUSSION ON YOUTH ATHLETES

By

JENNIFER SUZANNE ADLER

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A Thesis Submitted to The Honors College

In Partial Fulfillment of the Bachelor degree
With Honors in

Psychology

THE UNIVERSITY OF ARIZONA

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Approved by:

Elizabeth Glisky

Dr. Elizabeth Glisky
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**Abstract**

Concussion and sports are at the peak of attention recently, due to the thousands of athletes who suffer from the detrimental effects of the sports-related head injury. This study explores the short-term cognitive and physical effects that result from a sustained concussion in youth football athletes. The short-term cognitive and physical symptoms at pre-season and post-season are elucidated to determine the developmental risks and consequences of sustaining a concussion as a youth athlete. 213 football players aged 10-12 completed the Child-SCAT3 Symptom Evaluation prior to full contact practice to establish a true baseline for each athlete and determine the normal range of baseline symptoms and symptom frequencies. A subgroup of 51 youth football players aged 10-12 underwent a more comprehensive assessment using the complete Child-SCAT3 at pre-season and post-season, to pinpoint the cognitive impairments of sustained concussion. Background questionnaires were utilized to obtain a concussion history of individual athletes and length of time in which full recovery is obtained. A slight decline in cognitive functioning was found, although the effects were very small. A baseline symptom rating of 0 at pre-season is not typical.

The Cognitive and Physical Effects of Concussion on Youth Athletes

Over the past few years, sports-related head injury has received significantly more attention. It is estimated that sports-related concussion accounts for 170,000 emergency department visits annually (Prevention, 2011). While adults are susceptible to the effects of concussion, children and adolescents are particularly vulnerable to the consequences of concussion and have a heightened risk for longer-term sequelae (Buzzini, 2006). A concussion is commonly defined as a traumatic brain injury that alters the way in which the brain functions. In sports, the most common causes of concussion are due to bumps, jolts, or blows to the head, in which the individual does not experience a loss of consciousness, yet still is put at risk of change in the way the brain normally works. However, concussions do not require direct impact to the head but can also occur from a blow to the body that causes the head to move rapidly back and forth (NCIPC, 2013).

Up to 90% of concussed athletes present with oculomotor dysfunction, which relates to the movement and condition of the eyes (Ciuffreda, 2007). Deficits in the oculomotor system include difficulty with saccadic eye movements, accommodation, smooth pursuit (tracking), fixation, and difficulty reading (Kapoor, 2002).

A great deal of information is available as to the common signs and reported symptoms of concussion. While it is a common misunderstanding of the athlete that being knocked unconscious is the main sign of concussion, research has shown that appearing dazed or confused, forgetting plays, clumsy movements, slow response time to answering questions, behavior or personality changes, retrograde amnesia, and anterograde amnesia are all common sign of concussion (*Concussions*, 2014). Athletes have frequently reported headache, confusion, nausea, difficulty with memory and attention, balance problems, dizziness, irritability, heightened emotions, feelings of sluggishness and fatigue, slowed reaction time, sleep problems, double or blurry vision, and sensitivity to light and noise as the most common symptoms of concussion, especially in the short-term (NCIPC, 2013).

Due to the short- and long-term severity of concussions in the realm of athletics, professional athletic associations have reinforced the implementation of preseason baseline testing and neuropsychological evaluation to aid in return-to-play decision-making as well as for assessing the possible cognitive sequelae of concussive head injuries (Lovell, 1999). In addition to implementation in the professional sports realm, such comprehensive programs have begun to penetrate college athletics (Lovell & Collins, 1998) and have infiltrated the world of high school athletics (Echemendia, 1999), proving the keen concern and increasing attention surrounding the severity of concussive head injuries in contact sports.

Several studies (Barth, 1998; Barth et al., 1989; McCrea, 2003; Collins, 1999) have been conducted on collegiate athletes in terms of the neuropsychological performance effects of concussion in the short- and long-term, the recovery process and duration, and the overall cognitive effects of mild head injury in which loss of consciousness does not occur. Barth (Barth, 1998 and Barth et al., 1989) discovered that recently concussed athletes demonstrated significant increases in headaches, dizziness, attention issues, lack of problem solving abilities, and memory difficulties post-concussion. In his study that gathered data at three post-concussion time intervals, Barth found that the average time in which full recovery was achieved was within 5-10 days after injury, noting that concussed athletes returned to their preseason baseline abilities within this time frame. The immediate effect and course of recovery in relation to symptoms, cognitive functioning, and physical stability post-concussion were further scrutinized by McCrea (McCrea, 2003) and it was concluded that a collegiate athlete who experiences a concussion exhibited more severe symptoms, cognitive impairment, and balance problems immediately after injury, requiring an average of 5-7 days to return to baseline levels. In terms of learning disabilities in relation to concussion history in college athletes, Collins (Collins, 1999), found a correlation between the number of previous concussions and learning disabilities to suggest that neuropsychological assessment is not only a useful indicator of cognitive functioning in athletes, but further that multiple concussion history and learning disabilities are associated with reduced cognitive performance.

Many studies have also been conducted on high school athletes in terms of symptoms, cumulative effects, and cognitive functioning. Moser (2005) identified the prolonged neuropsychological effect of concussion in 223 high school athletes who underwent baseline neuropsychological evaluations and then post-concussion evaluations. Moser found that athletes with recent concussion performed significantly worse on attention and concentration measures in comparison to athletes with no concussion history. He further noted a significant decrease in grade-point-averages from youth athletes with two or more previous concussions as well as for athletes who experienced recent concussions. In Lovell (2003), memory dysfunction and self-reporting of symptoms were scrutinized in a group of high school athletes who had suffered mild concussion. Lovell concluded that a significant decline in memory processes relative to a non-injured control group was present in concussed athletes as well as neurologic self-reported symptoms of headaches, dizziness, nausea, and retrograde amnesia, suggesting that causing should be exercised when returning high school athletes to the playing field post-concussion.

Although several studies have examined the common symptoms of immediate concussion, the course of recovery, neuropsychological functioning, and cognitive impairment post-injury, very few studies have examined these facets of concussion on athletes below the high-school age population. While the studies evaluating pre- to post-season cognitive changes in collegiate and high school athletes have produced varying results, there has only been one small pilot study conducted in a true youth population, in which the effects of football participation on selected clinical measures of neurologic function were explored in 10 youth football players who were assessed at pre- and post-season and found that a 12-week season of youth football did not impair the postural stability, neurocognitive function, or oculomotor performance measure of the players (Munce, 2013). Further, an even greater gap in the research resides in the specific tests that are utilized post-injury and in the sheer importance of obtaining a baseline value for the individual athletes at pre-season. The importance of a true and accurate baseline value has yet to be identified in past research on youth athletes below the collegiate age. How can one determine whether an athlete is fully recovered if a standard baseline value is not accurate for that specific athlete? It is this crucial gap in youth research that leaves room for a great deal of error in terms of the course of full recovery and return to play, both of which could have detrimental effects on an athlete's cognitive abilities both short- and long-term.

The purpose of this study was to determine the cognitive and physical effects of concussions in youth athletes. Further, this study sought to determine the proper length of time in which full recovery from sustained concussion is achieved in this specific age group. Finally, the study used youth athlete symptom ratings to determine the normal range of baseline symptoms and evaluate the concurrence between youth athlete and parent symptom ratings. The frequencies of individual symptoms at baseline were scrutinized to determine the most common symptoms present in this youth population prior to regular-season play. It was hypothesized that cognitive functioning would be impaired if a concussion occurred, causing short-term neurologic changes in addition to the presence of heightened physical symptoms. It was expected that concussed youth athletes would take at least 10 days to fully recover and return to baseline. It was further hypothesized that youth athletes would have some symptoms at baseline and would not have a baseline symptom rating of 0 pre-season. Finally, it was predicted that the athlete symptom ratings at baseline would correlate with the parent symptoms rating of the youth athlete at baseline.

## Methods

### Participants

216 youth football players aged 10-12 years old who were enrolled in an organized youth football program, not part of their school, participated in the study. The athlete participants were recruited from the Rochester Youth Football Association (RYFA) in Rochester, MN and from the Arizona Pop Warner in Phoenix, AZ, both of which are youth tackle football leagues. All of the participants were English-speaking males who were able to speak and read English in a fluent manner. Athletes were excluded if they reported a neurological diagnosis other than concussion or migraine headaches, or they reported having sustained a concussion within the last 6 months. They were also excluded if they did

not have access to a computer with an internet connection. Participants were excluded if they were unable to complete the baseline assessment prior to their first full-contact practice. Athletes with a history of prior concussion (greater than 6 months prior to enrollment), learning disability, attention deficit hyperactivity disorder, mood or other psychiatric disorder were eligible to participate in the study. Written informed consent, approved by the Mayo Clinic Institutional Review Board, was obtained from parents or legal guardians prior to pre-season testing.

A subgroup of 51 youth athletes aged 10-12 years old were recruited from the Rochester Youth Football Association and Arizona Pop Warner tackle football leagues. All enrolled participants were required to meet the same inclusion and exclusion criteria as stated above, and were required to give written informed consent to participate in the more comprehensive assessment.

**Design**

All athletes in the RYFA and Arizona Pop Warner Football League meeting inclusion and exclusion criteria were invited to participate in the study. All received a packet that included a description of the purpose and design of the study, an informed consent sheet, and a brief overview of all tests being utilized. The study was conducted in a pre/post design, in which all participating athletes were evaluated at pre-season, prior to first full-contact practice, and post-season, within two weeks of the conclusion of the football season. If a concussion was suspected during the season on the field, the athlete was immediately removed from play and evaluated by the athletic trainer or coach who determined whether a concussion was sustained using the King-Devick (K-D) Test and the Child Sport Concussion Assessment Tool 3 (Child- SCAT3). If the athlete was determined to have sustained a concussion, he was not allowed to return to play until medical clearance and return to pre-season baseline were achieved. If a concussion was sustained during the season, the athletic trainer or coach was asked to report the concussion and the concussed athlete was asked to complete the Child-SCAT3 Symptom Evaluation online every 2-3 days post-concussion until full recovery was achieved. All participants were instructed to complete a background questionnaire, the Child-SCAT3 Symptom Evaluation, and the K-D Test. Parents or legal guardians of the child athlete were also instructed to complete a symptom evaluation of the child.

In addition, a subgroup of 51 participants meeting all inclusion and exclusion criteria underwent more comprehensive pre- and post-season evaluations. The pre-season testing was completed prior to contact in practice and was conducted in a quiet and climate controlled room. For the RYFA athletes, this testing occurred in a room located near the RYFA fields in Rochester, MN. For Arizona Pop Warner athletes, this evaluation occurred at the Arizona Pop Warner offices in Phoenix, AZ. Pre- and post-season testing was conducted at the same location for both groups. This subset of athletes completed the full Child-SCAT3 assessment prior to full contact practice and again within two-weeks upon completion of the season. The means of the three cognitive assessment categories of the Child-SCAT3, including orientation score, immediate memory score, and concentration score were used to determine cognitive impairment from pre- to post-season. If an athlete in this subset sustained a concussion during the season, the athlete was asked to complete the symptom evaluation every 2-3 days post-concussion until full recovery was achieved.

**Measures**

A set of background questions was administered to all participants and athletes were instructed to complete the questions together with a parent or legal guardian. The questionnaire included general health history, allergies, past concussion history, learning patterns, education history, injury history, and family health history. This questionnaire was completed online via a HIPAA compliant Survey Monkey account. The following questions were asked in this survey:

1. “What is your dominant hand?”
2. “How many concussions has the child had in the past?
3. “What was the most recent concussion?”
4. “How long was the recovery from the most recent concussion?”
5. “Has the child ever been hospitalized or had medical imaging done (CT or MRI) for a head injury?”
6. “Has the child ever been diagnosed with headaches or migraines?”
7. “Does the child have ADD/ADHD?”
8. “Does the child have a seizure disorder?”
9. “Has the child ever been diagnosed with depression, anxiety, or other psychiatric disorder?”
10. “Has anyone in the family ever been diagnosed with any of these problems?”
11. “Does the child have a learning disability or dyslexia? If yes, please specify.”
12. “Is the child on any medications? If yes, please specify.”

The Child-SCAT3 is a standardized method of evaluating injured youth athletes for concussion and can be used in children aged from 5 to 12 years. The complete assessment includes a sideline assessment, background questions, a symptom evaluation and a cognitive and physical evaluation. The sideline assessment is scored with the Glasgow coma scale (GCS), which evaluates eye response, verbal response, and motor response, the child-Maddocks Score, which asks 4 questions including: "Where are we at now?" "Is it before or after lunch" "What did you have last lesson/class?" and "What is your teacher's name?" and a yes/no report about potential signs of concussion. The physical evaluation includes a neck examination, a balance examination scored using the Balance Error Scoring System (BESS), a coordination examination, and a SAC delayed recall. For the complete cognitive assessment and symptom evaluation, see Appendix A. The Child-SCAT3 Symptom Evaluation asks the child to rate their current experience of 20 symptoms on a 4-point Likert scale (0=Never, 1=Rarely, 2=Sometimes, 3=Often). Parents rate the child on the same symptoms using the same Likert scale.

The K-D Test is an objective remove-from-play sideline concussion-screening test used to identify athletes with head trauma (aid in detection of concussion in athletes). The test consists of a demonstration card and three test cards with a series of single-digit numbers separated by varying spacing, either with or without a connecting line between numbers. Participant read through the numbers on the printed cards from left to right as fast as possible without making mistakes. The total time to read all three cards without error is recorded. Coaches and athletic trainers used this test on the sideline if concussion was suspected during play. Concussion was confirmed based on comparison to obtained baseline values of the individual athlete.

# Results

## Cognitive Functioning

A total of 51 athletes meeting inclusion and exclusion criteria participated as a subgroup and underwent more comprehensive pre- to post-season assessments using Child-SCAT3 (see Appendix A). Based on the cognitive assessment portion (Child Version (SAC-C)[4]) of the Child-SCAT3, this subgroup produced an orientation mean change of 0.10 (SD=0.5) and an immediate memory mean change of 0.57 (SD=1.9) from post-pre season. The pre-season orientation mean was 3.70 (SD=0.5) and post-season orientation mean was 3.77 (SD=0.4). The pre-season immediate memory mean was 13.67 (SD=1.5) and post-season immediate memory mean was 14.23 (SD=0.9). The pre-season concentration mean was 4.04 (SD=1.1) and post-season concentration mean was 4.12 (SD=0.9). All of these averages reflect the Child-SCAT3 Cognitive Assessment means for the 51 participants.

Five athletes sustained concussions from this group. A decline was present from pre-season orientation to post-season orientation for 3 of the 5 concussed athletes. Three of the 5 athletes scored a 4 at pre-season and then dropped to a score of 3 at post-season. One athlete remained the same from pre-season to post-season with a score of 3 and 1 athlete increased his score from pre- to post-season by 1 point. Three of the 5 athletes who had sustained a concussion had a constant immediate memory score of 15 from pre- to post- season, while 2 of the 5 athletes showed an increased immediate memory scored from pre- to post- season with a 1-2 point increase. In terms of concentration from pre- to post-season, 1 athlete decreased his score by 2 points, 2 athletes increased scores by 1 point, and 2 athletes remained the same with a score of 4 (see Figure 1). Although requested, useable data was not obtained during the course of recovery (every 2-3 days) for the 5 concussed athletes.

**Recovery Time**

A total of 20 participants reported a history of past concussion on the background questionnaire administered to all 213 participants meeting inclusion/exclusion criteria. Seventeen athletes reported a history of 1 total sustained concussion and 3 athletes reported a history of 2 total sustained concussions. Twelve of the 17 athletes who sustained 1 total concussion reported a recovery time of 1-3 days. The remaining 5 of the 17 athletes with 1 sustained concussion reported a recovery time of 1 week. The 3 athletes with a history of 2 total concussions reported a recovery time of 5-8 weeks.

**Pre-Season Symptom Rating and Frequency**

There were 213 athletes meeting inclusion criteria who combined with their parents produced useable data on the pre-season symptom evaluation. Athletes produced a mean symptom rating of 8.04 (SD=8.5, range 0-36) at baseline. Parents produced a mean symptom rating of 8.67 (SD=8.4, range 0-30) at baseline. Child and parent ratings were highly correlated ($r=0.74$, $p<.001$). Only 23.3% of athletes and 25.6% of parents produced a symptom rating of 0 at the pre-season baseline assessment.

Both athletes and parents rated “easily distracted” as the most commonly occurring symptom at pre-season. Athletes and parents also frequently endorsed difficulty paying attention, difficulty concentrating, and difficulty with memory. Headache was endorsed by approximately 40% of athletes and was the most common physical symptom. Issues with vision, such as double vision or blurred vision, as well as faintness or feeling as though the room is spinning were the least reported symptoms by both athletes and parents, endorsed by less than 10%. When strictly comparing parent to child for cognitive versus physical symptoms, parents more frequently endorsed cognitive symptoms and the athletes more frequently endorsed physical symptoms (see Tables 1 & 2; Figure 2).

**Symptom Evaluation (Post-Season)**

Of the 213 athletes and parents completing the pre-season symptom evaluations, 21 post-season symptom evaluations were obtained from non-concussed athletes and respective parent or legal guardian. The change from pre- to post-season mean athlete response was -2.57 (SD=7.2) and the pre- to post-season mean parent response was -2.19 (SD=8.1). Nine of the 21 athletes reported a higher symptom rating from pre-season to post-season, mean of 2.3 (SD=2.2), and 12 of the 21 athletes reported a lower symptom rating from pre- to post-season, mean of -6.25 (SD=7.5). Nine of the 21 parents reported a higher symptom rating of athlete from pre-season to post-season with an average increase of 3.9 (SD=4.3), and 12 of 21 parents reported a lower symptom rating of athlete from pre- to post-season with a mean decrease of -6.75 (SD=7.3). The majority of athletes and parents reported lower presence of symptoms post-season in comparison to pre-season.

## Discussion

While it was hypothesized that cognitive functioning would be significantly impaired if a concussion were sustained, causing short-term neurologic changes and heightened physical symptoms, the effects were very small in the pool of data collected for concussed athletes, therefore no firm conclusions can be drawn at this time. However, although the effects were small, the results suggest that some young people who sustain a concussion might experience some declines in mental orientation or concentration. This slight decline in mental orientation and concentration could therefore be pinpointed as two potential cognitive effects that could stand out as impairments of sustained concussion in the youth population if tested in a larger data population or a population in which more sustained concussions are reported. Immediate memory cannot be considered a potential cognitive effect at this time due to the results in which two athletes memory scores actually improved from pre- to post-season and three athletes remained unchanged. With the results pointing to a slight improvement or stagnant score in the category of immediate memory, it can be understood that sustained concussion during the length of one football season does not cause impairment to immediate memory and, further, the possible reason for this is the rapid development of the neurologic system of the 10-12 age-group population could lend to improved immediate memory scores even if a concussion is sustained. However, with such small effects and the small population size being scrutinized, this speculation about improvement or stagnant immediate memory should be further scrutinized in a larger youth population.

Based on the questionnaire administered to the athletes, in whom they were instructed to complete while under the supervision of or with, a parent or legal guardian, information regarding total past concussions and proper recovery time showed that 1-3 days is the average recovery time for a youth athlete's first concussion, although full recovery time of 7days is not uncommon. For participants who had sustained more than 1 concussion, 5-8 weeks was the reported average recovery time. Such findings point toward the snowball effect of concussions, specifically in terms of the time in which full recovery can be achieved. These findings are crucial for the determination of return to play, particularly in terms of the length of time that should be expected for an athlete aged 10-12 to return to his baseline score according to his concussion history. Further, athletic trainers and coaches should be aware of the concussion history of each individual athlete in order to accurately predict full recovery.

In terms of pre-season baseline symptom ratings, a rating of 0 prior to first full contact was not typical for youth athletes. Not only is a baseline rating of 0 at pre-season not a realistic assumption for youth athletes in regards to their ratings of themselves, the results indicating that only 25.6% of parents produced a rating of 0 when rating their child lends to the conclusion that the parents recognize symptoms at baseline as well, further validating the notion that a baseline rating of 0 is unrealistic and not representative for youth football players. Based on this conclusion, pre-season symptom ratings should be routinely obtained from youth athletes as expecting them to be "symptom free" prior to play may be inappropriate. Further, the highly comparable symptom ratings at baseline among 10-12 year old athletes and parents suggests that athletes of this age are capable of reliably reporting their symptoms. This understanding of reliability among the youth athletes, in terms of recognizing and reporting symptoms, is important for identifying sustained concussion on the field and for the determination of whether or not the athlete has fully recovered and can return to play if a concussion is sustained.

At pre-season baseline, the more frequent report of cognitive symptoms in comparison to physical symptoms in both athlete and parent evaluations lends to the conclusion that endorsement of cognitive symptoms, particularly those related to attention and memory, is relatively common in un-injured athletes. Based on this assumption, physical symptoms, including issues with vision and dizziness, might be better indicators of sustained concussion or injury in the youth population and should be closely examined when making such determinations on the side-line or for return to play purposes.

Specifically, visual symptoms (e.g., blurred or double vision) and sensations of the room spinning or feeling faint were rare (endorsed by <10%); indicating that the presence of these specific symptoms may be a strong indicator of an injury or other problem. Such findings not only speak to the potential sensitivity of physical symptoms in the detection and monitoring of concussion, but also that subjective cognitive symptoms are frequently endorsed by un-injured young athletes and their parents, so these may not be reliable indicators of concussion or recovery.

In terms of further implications and future studies, a larger sample size of youth athletes participating in a contact sport, preferably football, should be examined with the same Child-SCAT3 test in order to collect a larger pool of data for sustained concussions. With more reported concussions and a larger population size, the cognitive impairments and physical effects of sustained concussion could be better evaluated and the reliability and validity of such conclusions would be greater. In addition, a larger sample size and greater potential for more reported concussions during the season would increase the chances of accurately collecting useable data for post-concussion data during the season, such as symptom reports every 2-3 days after a sustained concussion until full recovery is achieved. With this data, conclusions could be made as to the short-term and immediate effects of concussions on the youth population and pre- to post-season data from the control group of un-injured athletes could be better compared to data of the concussed at pre-season, during-season (post-injury), and post-season. The short-term, immediate changes in the psychological wellness and cognitive functioning of the athlete would result in biomarkers for possible long-term impairment, such as future learning disabilities, increased risk of future concussion, impaired cognitive functions, and neurologic disorders and diseases, all of which could be scrutinized in future studies that span the course of multiple seasons of individual athletes. If a trend in immediate and short-term cognitive, physical, and psychological effect post-injury is validated in the youth population, these biomarkers can be utilized to predict the long-term consequences for youth athletes participating in a contact sport.

The major limitation of the current study was the extremely small outcome measure of reported concussed athletes, resulting in a population size of only 5 concussed athletes. Not only did this limitation constrain the amount of data collected on the concussed athletes in order to draw conclusions about the cognitive and physical effects of sustained concussion, but the 5 concussed participants did not complete the symptom report post-concussion every 2-3 days, so the collected data was strictly limited to a pre- to post-season design. In terms of generalizability of the current findings, the study population of this study consisted of only male athletes, yet there are several sports in which female athletes are put at the same risk of concussion, so results and implications cannot be generalized and applied to the female youth athlete population. A further limitation of this study is the potential for alternative explanations that could arise as to the cognitive abilities of the athletes from pre- to post-season. With this youth population aged 10-12, it is difficult to determine whether the cognitive abilities (increase or decrease) is due to simple brain development or sustained concussion.

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**Appendix A.**

## Cognitive assessment

**Standardized Assessment of Concussion – Child Version (SAC-C)[4]**

### Orientation (1 point for each correct answer)

| | | |
|---|---|---|
| What month is it? | 0 | 1 |
| What is the date today? | 0 | 1 |
| What is the day of the week? | 0 | 1 |
| What year is it? | 0 | 1 |
| **Orientation score** | | of 4 |

### Immediate memory

| List | Trial 1 | | Trial 2 | | Trial 3 | | Alternative word list | | |
|---|---|---|---|---|---|---|---|---|---|
| elbow | 0 | 1 | 0 | 1 | 0 | 1 | candle | baby | finger |
| apple | 0 | 1 | 0 | 1 | 0 | 1 | paper | monkey | penny |
| carpet | 0 | 1 | 0 | 1 | 0 | 1 | sugar | perfume | blanket |
| saddle | 0 | 1 | 0 | 1 | 0 | 1 | sandwich | sunset | lemon |
| bubble | 0 | 1 | 0 | 1 | 0 | 1 | wagon | iron | insect |
| Total | | | | | | | | | |

| | |
|---|---|
| **Immediate memory score total** | of 15 |

### Concentration: Digits Backward

| List | Trial 1 | | Alternative digit list | | |
|---|---|---|---|---|---|
| 6-2 | 0 | 1 | 5-2 | 4-1 | 4-9 |
| 4-9-3 | 0 | 1 | 6-2-9 | 5-2-6 | 4-1-5 |
| 3-8-1-4 | 0 | 1 | 3-2-7-9 | 1-7-9-5 | 4-9-6-8 |
| 6-2-9-7-1 | 0 | 1 | 1-5-2-8-6 | 3-8-5-2-7 | 6-1-8-4-3 |
| 7-1-8-4-6-2 | 0 | 1 | 5-3-9-1-4-8 | 8-3-1-9-6-4 | 7-2-4-8-5-6 |
| Total of 5 | | | | | |

### Concentration: Days in Reverse Order (1 pt. for entire sequence correct)

| | | |
|---|---|---|
| Sunday-Saturday-Friday-Thursday-Wednesday-Tuesday-Monday | 0 | 1 |
| **Concentration score** | | of 6 |

**SYMPTOM EVALUATION:** **"How has the child been the last 24 hours?"**

| Parent Report: The child... | Never | Rarely | Sometimes | Often |
|---|---|---|---|---|
| 1. has trouble paying attention | 0 | 1 | 2 | 3 |
| 2. is easily distracted | 0 | 1 | 2 | 3 |
| 3. has difficulty concentrating | 0 | 1 | 2 | 3 |
| 4. has problems remembering what he/she is told | 0 | 1 | 2 | 3 |
| 5. has difficulty following directions | 0 | 1 | 2 | 3 |
| 6. tends to daydream | 0 | 1 | 2 | 3 |
| 7. gets confused | 0 | 1 | 2 | 3 |
| 8. is forgetful | 0 | 1 | 2 | 3 |
| 9. has difficulty completing tasks | 0 | 1 | 2 | 3 |
| 10. has poor problem solving skills | 0 | 1 | 2 | 3 |
| 11. has problems learning | 0 | 1 | 2 | 3 |
| 12. has headaches | 0 | 1 | 2 | 3 |
| 13. feels dizzy | 0 | 1 | 2 | 3 |
| 14. has a feeling that the room is spinning | 0 | 1 | 2 | 3 |
| 15. feels faint | 0 | 1 | 2 | 3 |
| 16. has blurred vision | 0 | 1 | 2 | 3 |
| 17. has double vision | 0 | 1 | 2 | 3 |
| 18. experiences nausea | 0 | 1 | 2 | 3 |
| 19. gets tired a lot | 0 | 1 | 2 | 3 |
| 20. gets tired easily | 0 | 1 | 2 | 3 |
| Total number of symptoms (Maximum = 20) | | | | |
| Symptom Severity Score (Maximum = 60) | | | | |

**SYMPTOM EVALUATION:** **"How do you feel today?"**

| Child Report | Never | Rarely | Sometimes | Often |
|---|---|---|---|---|
| 1. I have trouble paying attention | 0 | 1 | 2 | 3 |
| 2. I get distracted easily | 0 | 1 | 2 | 3 |
| 3. I have a hard time concentrating | 0 | 1 | 2 | 3 |
| 4. I have problems remembering what people tell me | 0 | 1 | 2 | 3 |
| 5. I have problems following directions | 0 | 1 | 2 | 3 |
| 6. I daydream too much | 0 | 1 | 2 | 3 |
| 7. I get confused | 0 | 1 | 2 | 3 |
| 8. I forget things | 0 | 1 | 2 | 3 |
| 9. I have problems finishing things | 0 | 1 | 2 | 3 |
| 10. I have trouble figuring things out | 0 | 1 | 2 | 3 |
| 11. It's hard for me to learn new things | 0 | 1 | 2 | 3 |
| 12. I have headaches | 0 | 1 | 2 | 3 |
| 13. I feel dizzy | 0 | 1 | 2 | 3 |
| 14. I feel like the room is spinning | 0 | 1 | 2 | 3 |
| 15. I feel like I'm going to faint | 0 | 1 | 2 | 3 |
| 16. Things are blurry when I look at them | 0 | 1 | 2 | 3 |
| 17. I see double | 0 | 1 | 2 | 3 |
| 18. I feel sick to my stomach | 0 | 1 | 2 | 3 |
| 19. I get tired a lot | 0 | 1 | 2 | 3 |
| 20. I get tired easily | 0 | 1 | 2 | 3 |
| Total number of symptoms (Maximum = 20) | | | | |
| Symptom Severity Score (Maximum = 60) | | | | |

**Figure 1.**

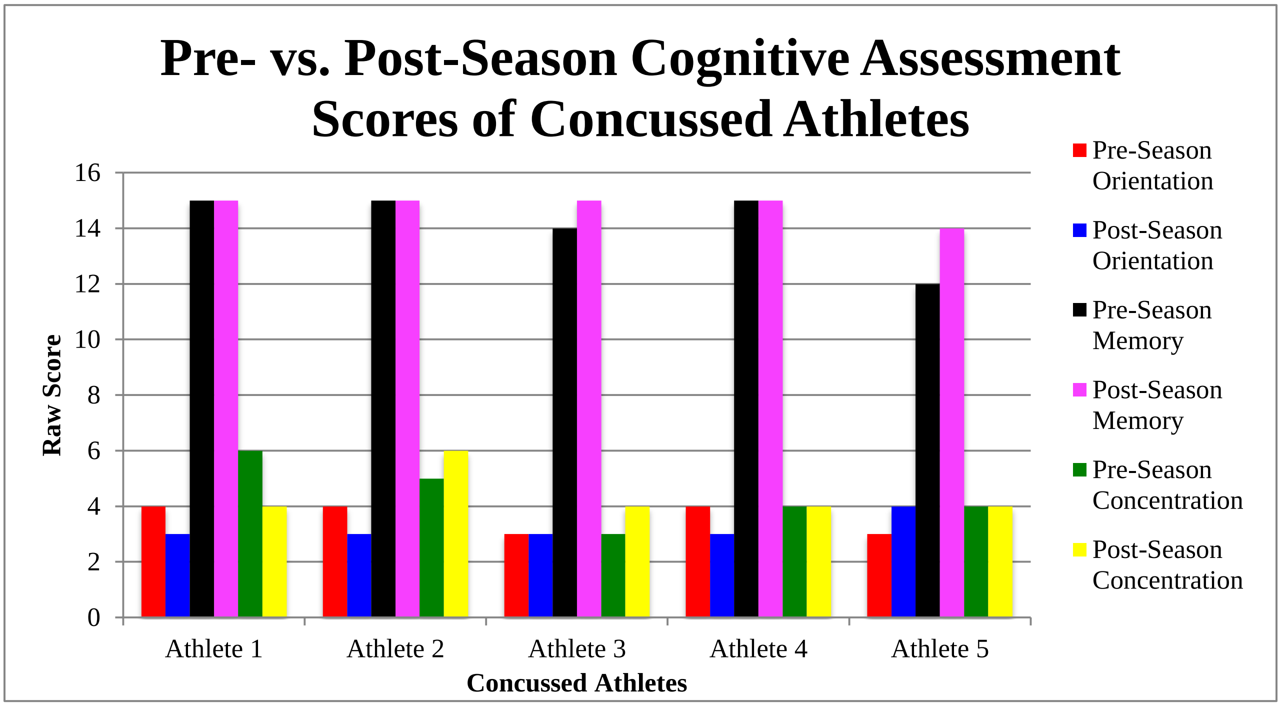


**Figure 2.**

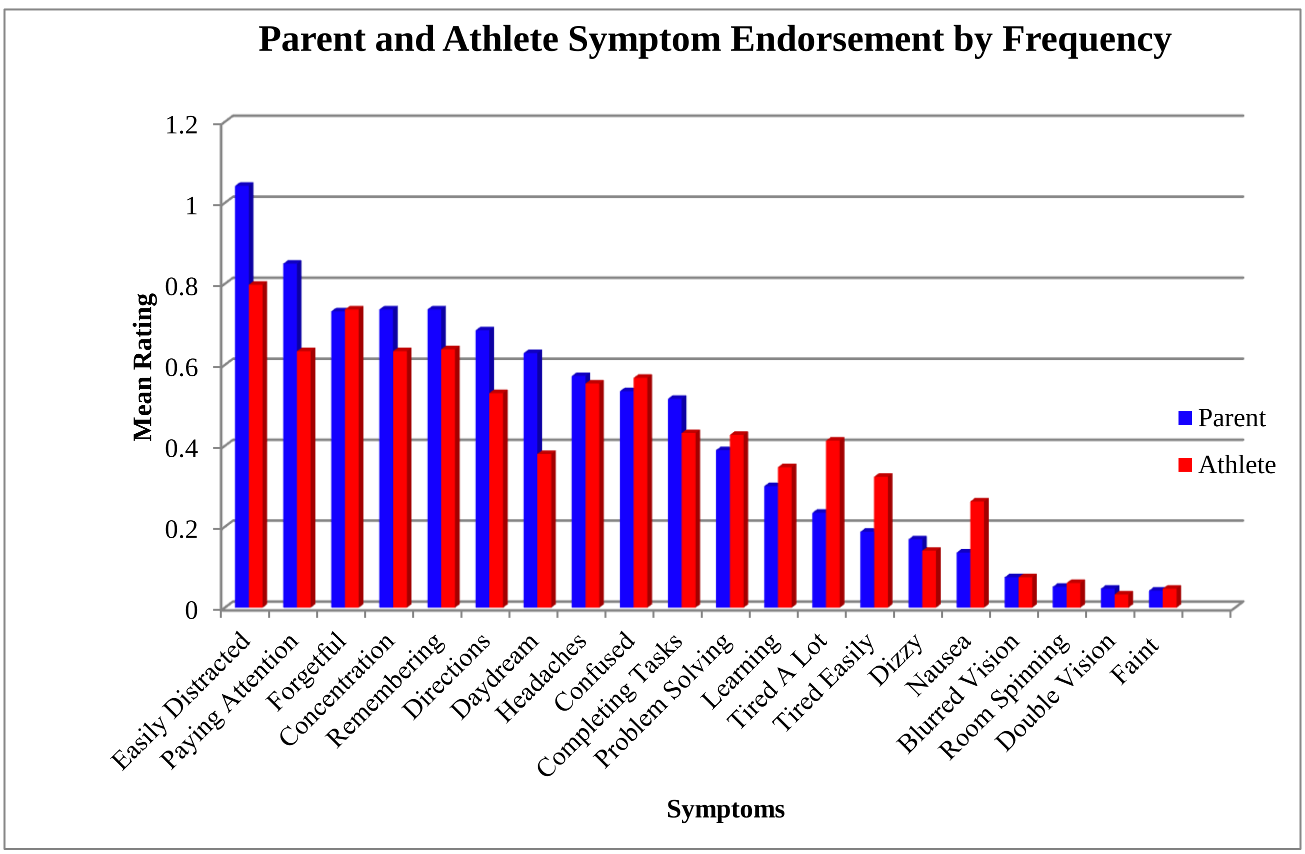

**Table 1.**

Athlete Symptom Ratings (n=213)

| CHILD | Often (3) | Sometimes (2) | Rarely (1) | Never (0) | % Endorsed |
|---|---|---|---|---|---|
| Easily Distracted | 11 | 36 | 65 | 101 | 53% |
| Forgetful | 4 | 37 | 71 | 101 | 53% |
| Remembering | 5 | 28 | 65 | 115 | 46% |
| Paying Attention | 3 | 34 | 58 | 118 | 45% |
| Concentration | 5 | 31 | 58 | 119 | 44% |
| Confused | 1 | 26 | 66 | 120 | 44% |
| Directions | 2 | 29 | 49 | 133 | 38% |
| Headaches | 5 | 26 | 51 | 131 | 38% |
| Completing Tasks | 1 | 19 | 51 | 142 | 33% |
| Problem Solving | 0 | 20 | 51 | 142 | 33% |
| Tired A Lot | 5 | 11 | 51 | 146 | 31% |
| Daydream | 4 | 16 | 37 | 156 | 27% |
| Learning | 2 | 16 | 36 | 159 | 25% |
| Tired Easily | 4 | 9 | 39 | 161 | 24% |
| Nausea | 0 | 7 | 42 | 164 | 23% |
| Dizzy | 0 | 5 | 20 | 188 | 12% |
| Blurred Vision | 0 | 2 | 12 | 199 | 7% |
| Room Spinning | 0 | 1 | 11 | 201 | 6% |
| Faint | 0 | 1 | 8 | 204 | 4% |
| Double Vision | 0 | 1 | 5 | 207 | 3% |

**Table 2.**

Parent Symptom Ratings (n=213)

| PARENT | Often (3) | Sometimes (2) | Rarely (1) | Never (0) | % Endorsed |
|---|---|---|---|---|---|
| Easily Distracted | 12 | 70 | 46 | 85 | 60% |
| Paying Attention | 5 | 59 | 48 | 101 | 53% |
| Forgetful | 4 | 38 | 68 | 103 | 52% |
| Concentration | 5 | 40 | 62 | 106 | 50% |
| Remembering | 2 | 48 | 55 | 108 | 49% |
| Directions | 5 | 34 | 63 | 111 | 48% |
| Daydream | 7 | 28 | 57 | 121 | 43% |
| Headaches | 4 | 27 | 56 | 126 | 41% |
| Confused | 2 | 25 | 58 | 128 | 40% |
| Completing Tasks | 1 | 25 | 57 | 130 | 39% |
| Problem Solving | 2 | 14 | 49 | 148 | 31% |
| Learning | 2 | 10 | 38 | 163 | 23% |
| Tired A Lot | 0 | 8 | 34 | 171 | 20% |
| Tired Easily | 0 | 5 | 30 | 178 | 16% |
| Dizzy | 0 | 1 | 34 | 178 | 16% |
| Nausea | 0 | 1 | 27 | 185 | 13% |
| Blurred Vision | 0 | 2 | 12 | 199 | 7% |
| Room Spinning | 0 | 2 | 7 | 204 | 4% |
| Double Vision | 0 | 1 | 8 | 204 | 4% |
| Faint | 0 | 0 | 9 | 204 | 4% |