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The effects of multiple head micro-trauma on cognitive function in high school football and soccer athletes

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The Effects of Multiple Head Micro-trauma on Cognitive Function in High School Football and Soccer Athletes

By

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ABSTRACT

There are limited studies that deal with the acute and chronic effects that high collision sports have on neurocognitive function. This study used a standardized concussion assessment (SAC) test to examine the effects that participation in high school football and high school soccer has on athletes' neurocognitive functions throughout a season.

Forty-six male high school athletes participated in this study: 30 football players, and 16 soccer players. Each athlete underwent baseline SAC testing and a variety of SAC tests three additional times throughout the duration of the season, approximately 3 weeks apart.

Data analyses of the SAC scores did not show any significant decrease in neurocognitive function in either the sport of football or soccer throughout a season. The results of this study conclude that participation in the sport of football and soccer does not have any effect on an athletes neurocognitive function throughout a season.

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CHAPTER I

Introduction

Let's face it, you have to have a slightly recessive gene that has a little something to do with the brain to go out on the football field and beat your head against other human beings on a daily basis. – Tim Green

Sports has become an activity that people around the world compete in on a daily basis. However, various injuries, including head injuries, can occur in sports, the long-term effects of which are not known. Contact sports, such as football and soccer, are known for continuous collision with objects or people by using their head. By using the head in this manner, many injuries to the head result, while some may be unseen. The proposed study examined the effects of continuous micro-trauma to the head by quantifying cognitive function throughout the course of a season of high contact collision sports in the high school setting.

Head Injuries among High School Athletes

Head injuries are the most common catastrophic injuries and the leading cause of death in athletics today (Starkey, 2002). Mild Head Injury (MHI) occurs from a direct or indirect blow to the head through compressive, tensile, or shearing forces (Cooper, 2001). Injury rates for MHI are found to be higher during competition than during practices (Powell, 1999).

Concussion in Athletics

Approximately five percent of players in contact sports will incur a concussion, and athletes who have experienced a concussion increase their chances of

experiencing another one by five percent (Cooper, 2001). Concussions occur most frequently in football, followed by soccer, wrestling, and basketball. The incidence of concussions is approximately 0.6 - 1.78 per 1,000 athlete exposures (Cooper, 2001).

Concussions Effect on Memory

Loss of memory is one of the most obvious dysfunctions after brain trauma. Athletes can experience both retrograde amnesia and anterograde amnesia after a traumatic brain injury (Starkey, 2002). Research is limited regarding the acute and chronic effects a concussion has on cognition.

Statement of the Problem

The problem was to investigate the effects of multiple micro-traumas to the head in a single season of high school football and men's soccer on the athlete's cognition by testing each athlete prior to the season, through the course of the season, and post-season, using a standardized concussion assessment test.

Statement of the Purpose

The purpose of this study was to determine if cognitive function was reduced by participation in football and/or soccer by administration of a standard assessment of concussion (SAC) test.

Research Questions

1. Is there a difference in orientation within football and/or soccer players throughout a season?

2. Is there a difference in immediate memory within football and/or soccer players throughout a season?

3. Is there a difference in concentration within football and/or soccer players throughout a season?

4. Is there a difference in delayed memory recall within football and/or soccer players throughout a season?

5. Is there a difference in total SAC scores within football and/or soccer players throughout a season?

Definition of Terms

1. Concussion - Injury to the head in which brain trauma is present. Injury can involve a loss of consciousness and/or a loss of memory.
2. Retrograde Amnesia - Inability to recall events before the onset of injury.
3. Anterograde Amnesia - Inability to recall events after the onset of injury.
4. Collision Sport - Individual or a team sport relying on the physical dominance of one athlete over another in which physical violent contact is mandated.
5. Micro-trauma - Contact of the head to an object or person in which a concussion is not experienced.

Definition of Tests

1. Trial Making Test Part B - The participant sequentially connects a series of alternating letters and numbers that is measured by the time required for successful completion. It assesses visual conceptual, visuomotor tracking, and general brain function.
2. Wechsler Digit Span Test - The participant is presented with a random list of single-digit numbers (0 to 9 with no repetition) and asked to repeat the list in the same order (digits forward) or reverse order (digits backwards). The first bout

begins with three numbers and the next has four numbers, progressing up to 10. The number of successful trials is recorded for each part. This assesses short-term memory, auditory attention, and concentration.

3. Stroop Color Word Test - The participant is presented with a list of 100 words (5 columns with 20 words each). The test itself consists of three trials, each 45 seconds in length. In the first trial, the patient is asked to read through the list as quickly as possible and read aloud the words "red," "green," and "blue," which are written in black ink. During the second trial, words are replaced with "XXXX" written in red, green, or blue ink, which the patient must identify the proper color. In the third trial, the words "red," "green," and "blue" are written in a color other than their own (e.g., "red" is written in blue ink). The patient must identify the color the word is printed in, not the word itself. It is measured by the sum total of the number of correct responses in each subset. It assesses cognitive processing speed, and concentration ability to filter out distractions.

Assumptions

1. Sports teams selected would represent the majority of the top collision sports in a high school setting in relation to concussion and head trauma.
2. Participants will respond to the test and questions honestly and to the best of their ability.
3. The SAC test will accurately test memory recall in athletes tested.

Study Limitations

1. Sample was limited to high school students between the ages of 15 and 18.
2. Sample was limited to a small B division high school.

3. Instrumentation was limited to four variations of SAC test performed randomly.
4. Sample was limited to varsity men's football and men's soccer players.
5. Study was limited to a small sample size at the high school.

Study Delimitations

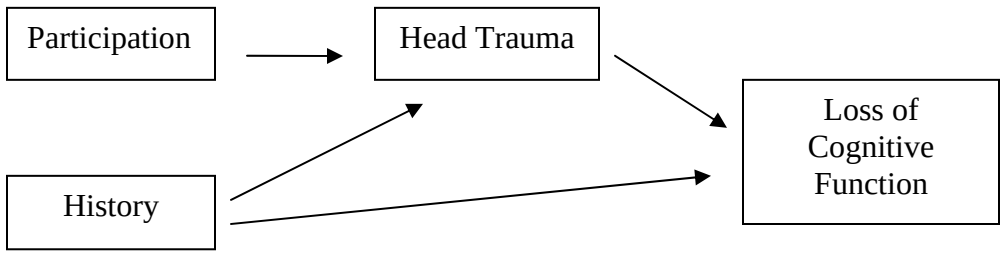
1. Participants were tested over a period of 12 weeks.
2. Participants were 46 high school males.
3. The study took place during one season of football and soccer.

Significance of Study

Because little is known about the effects of concussions, even less is known about the effects of continuous micro-trauma to the head during collision sports. This study provided baseline data used to indicate whether athletes experience loss of cognition when participating in a collision sport, without experiencing an overt concussion.

Theoretical Framework

Figure1. Theoretical Framework



The theoretical framework represents the effects that participation in contact sports and history of concussion have on cognitive function. Athletes who participate

in contact sports are more likely to experience head trauma, which thus results in a loss of cognitive function. Also, if an athlete has a history of head trauma, a loss in cognitive function may ensue. If this occurs, the athlete would be more likely to experience another incident of head trauma based on past research by Cooper (2001), which will result in further loss of cognitive function.

CHAPTER II

Review Of The Literature

Introduction

The purpose of the present study was to test high school football and soccer players' cognitive function through a three-month season using a standardized assessment of concussion test to identify the risk of multiple micro-traumas to the head in sports and its effects on memory and concentration. This chapter presents a review of the pertinent literature. The first section presents literature on head trauma among high school athletes, including the problem, concussions effect on memory, occurrences, the risks in soccer including chronic and acute effects of concussion, and the risks in football. The last section presents the assessment of concussion, including the history of assessment testing, standardized concussion assessment, and the validity of the SAC.

Head Trauma among High School Athletes

Mild traumatic brain injury (MTBI), otherwise known as a concussion, suffered by athletes has become a major concern in the health field. Information on the frequency of MTBI in high school athletes has been limited in the past but is a current topic of research in athletics today.

Problem

Head injuries are the most common catastrophic injuries and the leading cause of death in athletics today, despite the significant protection by the skull, cerebral spinal fluid, and other related structures. The density of the bone reduces the amount

of physical shock transmitted inwardly and protects the brain. It is also protected by the round shape of the skull by deflecting it quickly. The skin increases the strength of the skull, increasing its breaking force from 40 pounds per square inch to 425 to 490 pounds per square inch by absorbing and redirecting forces from the skull (Starkey, 2002). Mild head injury (MHI) occurs from a direct or indirect blow to the head through compressive, tensile, or shearing forces (Cooper, 2001). As explained by neurosurgeon Dr. Karen Johnston, during a concussion the soft tissue of the brain swivels inside the skull and rebounds off the bone, as if bouncing around like Jell-O inside the head. As a result, the brain gets bruised. This could be occurring at the molecular level and would therefore make it difficult to grade the severity of a concussion (Branswell, 2001).

Effects On Memory

Loss of memory is one of the most obvious dysfunctions after brain trauma. Athletes can experience both retrograde amnesia and anterograde amnesia after a traumatic brain injury. Fading or foggy memory is a sign of a progressive deterioration of cerebral function. These could be short term events that happened a short period after the incident where the athlete can not remember what happened post-injury (Starkey 2002).

Occurrences

Concussions occur most frequently in football, followed by soccer, wrestling, and basketball. The incidence of concussions is approximately 0.6 - 1.78 per 1,000 athlete exposures. However, approximately five percent of players in contact sports

will incur a concussion, and once experienced, athletes are five times more likely to have another concussion (Cooper, 2001).

In a study conducted by Cooper **(**2001), athletic trainers from 114 U.S. high schools were surveyed on the type and occurrences of injuries that occurred throughout the year in each participating sport. The respondents reported a 5.5 percent head injury rate of all injuries reported. The highest percentage of mild head injury (MHI) occurrences were in football players (63.4%), followed by wrestlers (10.5%), girls soccer players (6.2%), boys soccer players (5.7%), and girls basketball players (5.2%).

Powell and Barber-Foss (1999) sought to measure the incidence rate of head traumas reported by athletic trainers over a 3-year period. The results showed that injury rates for MHI were higher during competition than during practices. Soccer players were 16.2 times more likely to experience head trauma during competition, followed by football players, 11 times more likely to occur during competition than during practice (Powell, 1999).

In a football-specific study performed by Gerberich (1983), more than 100 high schools athletic trainers in Minnesota were surveyed on athletic injuries in a season. Results showed that there was approximately a 15 percent risk for MHI each season of play for high school football players. Nineteen percent of reported concussions experienced were characterized by loss of consciousness and loss of awareness (Cooper, 2001).

Risks in Soccer

Soccer related head injuries usually result from collision of the head with another object in an attempt to redirect the ball with the head. This nature of forcible contact is responsible for up to 22 percent of all soccer injuries (Broglio, 2001). A series of subconcussive blows to the head from years of head-to-ball contact might be comparable to boxers receiving multiple blows to the head in a match, in which they might display signs and symptoms of an inebriated individual immediately after receiving several hits, and functions never return to normal. A degeneration of brain tissue is attributed to permanent cognitive signs and symptoms. Even though a single incident of heading a soccer ball might not show any clinical consequence, long-term effects of heading might be equal to that of multiple subconcussive blows that will result in decreased brain and cognitive function over time (Broglio, 2001).

Chronic Effects Of Concussion.

Broglio reviewed a study conducted at the University of North Carolina (UNC) at Chapel Hill that examined the chronic effects of soccer heading. A total of 91 collegiate soccer athletes were compared to 53 student control subjects. The soccer athletes had played an average of 15.27 ± 3.99 seasons of soccer prior to testing. All subjects were asked to provide their history of concussion and scores received on the Scholastic Aptitude Test (SAT). The soccer athletes reported an average of 1.07 ± 1.83 prior experienced concussions, compared to a 0.21 ± 0.53 concussions reported by the participants in the control group. A series of neurocognitive tests that included the Trail Making Test Part B, The Stroop Color-

Word Test, and the Wechsler Digit Span Test were used. The results revealed no significant difference between the two groups (Broglio, 2001).

Acute Effects Of Concussion.

A review conducted by Broglio identified a study by Miller (1997) examining the acute effects of heading among U.S. soccer players. Twenty-three male varsity and club soccer athletes were divided into two randomized groups, heading and non-heading. The neurocognitive tests including the Trail Making Test Part B, The Stroop Color-Word Test, and the Wechsler Digit Span Test were administered to both groups on three consecutive days. On day two, the heading group was put through a 20-minute soccer-heading drill before being administered the tests. The analysis of the data collected revealed no significant difference between the two groups on any of the neurocognitive tests during any of the three days. However, deficits were likely to be found in the digit span and planning deficits in the Trail Making B testing (Broglio, 2001).

Broglio also reviewed a study by Matser (1998), who administered some of the same cognitive tests to 53 active soccer players against 27 controls, reporting a significant difference between the two groups. Matser administered another study in 1999 to amateur players and used swimming and track athletes as the controls. The data showed significant deficits in the memory and planning functions of the soccer athletes, suggesting that participation in amateur soccer could become a public health concern (Broglio, 2001).

Risk In Football

The high level of contact in football enhances the risk of concussion. As stated in past research, football players have a 15 percent risk of incurring a concussion each season (Cooper, 2001). Although most concussion studies are performed in the sport of football, there is little information about the effects of concussion immediately after onset and even less of the long term effects.

Acute Effects Of Concussion

In a study performed by McCrea (2003), the effects and natural recovery course relating to symptoms, cognitive functioning, and postural stability following a sport related concussion were examined. One thousand, six hundred and thirty-one football players from 15 colleges in the United States were tested. All players underwent baseline testing on concussion assessment measures over a course of 3 years. Ninety-four players who had incurred a concussion during the season and 56 non-injured controls underwent assessment of symptoms, cognitive functioning, and postural stability immediately after injury, three hours after, and 1, 2, 3, 5, 7, and 90 days after injury. Symptoms were measured using a Graded Symptom Checklist (GSC). The Balance Error Scoring System (BESS) test was used for postural stability. Cognitive functioning was tested using a standardized concussion assessment test (SAC); a neuropsychological test battery was also used. Results indicated that the injured group experienced more severe symptoms, cognitive impairment, and balance problems than did the control group immediately after concussion. Within three to five days, balance deficits dissipated. Within five to seven days, cognitive functioning improved to baseline levels, and mild impairments

in cognitive processing and verbal memory were resolved by day seven. On average, symptoms resolved by day seven. There were no significant differences in symptoms of functional impairments in the concussion and control group 90 days after concussion. This study indicated that several days for recovery of a concussion are needed to return to play. It also indicated that there is not a chronic effect of concussion in the players over time (McCrea, 2003).

Assessment Of Concussion

The detection of a concussion can be easy to determine if there is a loss of consciousness (LOC). However, more than 90 percent of sport-related head injuries have no observable LOC and only slight disorientation. A decrease in neurocognitive functioning, including memory and concentration, are most common after head trauma. These neurocognitive functions are more subtle than obvious to detect, making it difficult to determine the severity of a concussion (McCrea, 2001).

History of Assessment Testing

Brief standardized methods of concussion have been developed to give accurate results of concussion severity and to decrease the amount of "guessing" often encountered by sports medicine professionals on the sidelines. These tests include measures of neurocognitive status, postural stability, and postconcussive symptoms (McCrea, 2001). These tests can be used as both an acute measurement of status and as a recovery status (McCrea, 2001). Certified Athletic Trainers have demonstrated that the use of standardized concussion assessment methods have helped in making the injury evaluation more accurate and clinically informative.

Standardized Concussion Assessment

The most widely used and most valid instrument for sideline examination is the standardized assessment of concussion (SAC; Randolph, 2001). The SAC was developed to give physicians a method for immediately assessing an injured athlete's mental status on the sport sideline within minutes of experiencing a concussion. It is used as a supplement to other methods of assessing a concussion but not intended for measurement alone to determine the severity of a sports-related concussion (McCrea, 2001). It consists of a 30-point scale that measures orientation, attention, and anterograde memory (Randolph, 2001).

Validity of the SAC

McCrea (2001) sought to determine the validity of the SAC in differentiating injured and uninjured subjects after sport-related concussion and to provide an objective measure of post-injury neurocognitive recovery. A total of 1,325 high school and collegiate football players were studied during the 1998 and 1999 football seasons. The sample included 714 athletes from 16 high schools with a mean age of 16.23 ± 0.83 years, and 611 players from eight colleges with a mean age of 19.84 ± 1.30 years. All subjects underwent SAC testing prior to the start of the football season. A total of 63 injuries, 4.75 percent of total sample, occurred during the study, including 30 high school participants and 33 collegiate participants. Three of the injured subjects were reported to have had LOC, and four were reported to have measurable retrograde amnesia without LOC. None of the subjects experienced recurrent concussion or had any cases of second-impact syndrome. The SAC testing was administered within five minutes of injury and again at 48 hours post-injury.

McCrea found that injured subjects tested significantly lower than uninjured subjects immediately after injury on all sections of the SAC. Forty-eight hours post-injury, improvement was seen in SAC scores in the injured subjects. A drop of one point or more in sideline testing from baseline testing was 95 percent sensitive. Therefore, the use of standardized tests can improve the accuracy of sideline concussion assessment and can be a tool to determine when an athlete is safe to return to play (McCrea, 2001).

In a similar study, McCrea (1995) had athletic trainers administer the SAC to 568 non-concussed high school and college football players prior to the season. Thirty-three of the players experienced concussions and were tested immediately with the SAC, and 28 of the 33 underwent follow-up testing 48 hours after the injury. Results showed that the concussed players scored significantly below their pre-injury baseline scores and below their nonconcussed controls on all SAC measures. The follow-up testing documented a return to the pre-injury baseline score (McCrea, 1998).

Although sideline testing is limited due to time constraints, the SAC has proven utility in identifying neurocognitive impairments in players who are otherwise asymptomatic (Randolph, 2001).

Summary

Previous research has examined the effects of concussion in athletics and some of its short-term and long-term effects of neurocognitive function. However, research is still limited on the effects of multiple micro-traumas to the head in sport whether a concussion is experienced or not.

The present prospective research design utilized the use of the SAC on high school football and soccer players over a 3-month season. The data obtained provide information on the effects of multiple micro-traumas to the head throughout the season and determine whether or not there is an effect on neurocognitive function,

CHAPTER III

Methodology

The purpose of this study was to provide information on the effects of micro-trauma to the head, as opposed to a concussion, to improve the equipment used in collision sports. This chapter will describe the theoretical framework used to guide the development of this study as well as the methods and procedure used. It will include the instrumentation, sample and sample recruitment, data collection procedure, and data analysis.

Methods and Procedures

Institutional Review Board Approval

Prior to conducting the proposed study, approval was granted by the College of Health and Human Service's Human Subjects Review Committee.

Prospective Research Design

The proposed study used a prospective research design. The standardized concussion assessment test was used to determine orientation, immediate memory recall, concentration, and delayed memory recall. The test used baseline data prior to participation in sport in order to determine differences throughout the season and post-season. The standardized concussion assessment test has been shown reliable in detecting effects of concussion (McCrae, 2001).

Instrumentation

The following instrument was used to address the research questions guiding this research study.

Standardized Concussion Assessment Test

The Standardized Concussion Assessment Test (SAC) was used to obtain data scores (see Figure 1). Four variations of the SAC were administered, one for baseline testing and then followed by three different variations throughout the testing period. The following is a brief description of the testing measures:

1) *Orientation*: The athlete is asked of the month, date, day of the week, year, and time within an hour. One point is given for each correct answer, for a total of five points.

2) *Immediate Memory*: The athlete is given five words to memorize. The athlete is then asked to repeat the five words for a total of three trials. One point is given for each correct word. The total score equals the sum of all three trials, for a total of 15 points.

3) *Concentration*: The athlete is given a length of numbers and is asked to repeat the sequence backwards. If completed, the athlete moves on to the next string of numbers. If the athlete does not complete the first time, a second trial of numbers is given. Testing stops when failed at both trials. The athlete is then asked to name the months of the year in reverse order. One point is given for each correct answer, for a total of five points.

4) *Exertional Maneuvers*: The athlete is asked to complete a series of exercises: five push ups, five sit-ups, five jumping jacks, and five squats.

5) *Delayed Recall*: The athlete is asked to repeat the original five words used in the immediate memory section. One point is given for each correct answer, for a total of five points.

All points are tallied for a total score of 30 points. This test takes approximately five minutes to administer. The SAC test is 95 percent sensitive and 76 percent specific to correctly classifying injured and uninjured subjects (McCrae, 2001).

Data Collection

Sample and Sample Recruitment

The populations of interest for this research study were varsity football and soccer players from Stockbridge High School in Stockbridge, Michigan. The athletes ranged in age from 15-18 years. A letter of consent was sent home with the athletes on the first day of practice (see Appendix A). Parents were asked to sign an assent form (see Appendix B). Data collection began the first week of practice in August of 2006 and continued through the 2006 season.

Data Collection Procedure

Each participant was given one of four variations of the SAC test within the first two weeks of practice. The participants then participated in their sport throughout the remainder of the season. Each participant was tested again one third of the way through the season and again two thirds of the way through the season, using one of the four variations of the SAC test. Testing took place in the athletic training room before practice or competition. Within one week of the last competition, approximately 12 weeks after baseline testing, each participant was tested using one of the four variations of the SAC test. Head injury reports were also taken from each participant during each re-testing period. Four equivalent alternative forms of the test were used in this study to minimize practice effects from additional administration (see Figure 2). Each participant received an alternative variation of

the SAC during each test and retest period. A Certified Athletic Trainer and two student athletic trainers administered the SAC test individually.

In the event that a score fell below 22 total points, it was assumed that the athlete had significant neurological damage and was asked to withdraw from competition and referred to the team physician or affiliated neurologist for further testing. Once the athlete was cleared by the physician, a clearance to return to play was given. By law of the Michigan High School Athletic Association (MHSAA), an athlete may not return to competition if a concussion, or any loss of consciousness, is present until cleared by an affiliated physician. If a participant suffered a severe concussion in which loss of playing time occurred or an injury which prevented the athlete from participating for more than two weeks, the participant was dismissed from the study.

Figure 2. SAC Test – Version 1

Athlete ID Number: _____

Athlete Age: _____

Athlete Sport: _____

Years Playing Sport: _____

Experienced A Concussion Before?

Yes No

If Yes, How Many? _____

Date Of Last Concussion: _____

1) Orientation:

What Month Is It?	**0**	**1**
What Is Today's Date?	**0**	**1**
What Day Of The Week Is It?	**0**	**1**
What Year Is It?	**0**	**1**
What Time Is It (within 1 hour)	**0**	**1**

Total Orientation Score ____/5

2) Immediate Memory:

	Trial 1	Trial 2	Trial 3
Telephone	**0 1**	**0 1**	**0 1**
Trash	**0 1**	**0 1**	**0 1**
Drum	**0 1**	**0 1**	**0 1**
Bus	**0 1**	**0 1**	**0 1**
Tree	**0 1**	**0 1**	**0 1**
TOTAL:	**/5**	**/5**	**/5**

Total Immediate Memory Score _____/15
(Note: Subject is not informed of delayed recall testing of memory)

3) Concentration:
Repeat series of numbers backwards:
(If correct go to next string length. If incorrect, read trial 2. Stop after incorrect on both trials.)

Trial 1	Trial 2	
9 – 4 – 3	**2 – 4 – 1**	**0 1**
8 – 2 – 1 – 3	**3 – 7 – 8 – 2**	**0 1**
9 – 2 – 5 – 8 – 7	**1 – 8 – 5 – 6 – 4**	**0 1**
7 – 9 – 2 – 5 – 1 – 8	**8 – 2 – 6 – 3 – 1 - 4**	**0 1**

Months in reverse order: (entire sequence correct for 1 point)
Dec-Nov-Oct-Sep-Aug-Jul
Jun-May-Apr-Mar-Feb-Jan _____ 0 1

Total Concentration Score _____/5

Exertional Maneuvers

5 Jumping Jacks **5 Push-ups**

5 Sit-ups **5 Partial Squats**

4) Delayed Recall:

Telephone	**0 1**
Trash	**0 1**
Drum	**0 1**
Bus	**0 1**
Tree	**0 1**

Delayed Recall Total Score _____/5

Summary of Total Scores:

Orientation: _____/5
Immediate Memory: _____/15
Concentration: _____/5
Delayed Recall: _____/5

Overall Total Score _____/30

CHAPTER IV

Results

The present study used a standardized concussion assessment (SAC) test to assess the effects that participation in high school football and soccer has on cognitive function. This chapter presents a description of the sample, background characteristics which include years participating in sport, and past concussion history. In addition, the chapter presents the results from the multivariate analyses used to answer the research questions.

Description of the Sample

The SAC test was completed by 46 male high school athletes, 30 of whom participated in varsity football and 16 in varsity soccer. The participants ranged in age from 15 to 18 years, with a mean age of 16.4 years (see Table 1).

Attrition

Thirty-eight of the original 46 participants continued participation in the study following completion of the baseline assessment. Thus, 83 percent of the participants completed all four SAC tests.

Cases Dropped From the Study

Participants who experienced an injury that required a break from participation for a minimum of two weeks were omitted from the study (n=4). Four participants were dropped from the study because of discontinued participation on either the soccer or football team during the study.

Table 1
Background Characteristics of Participants

Characteristics	Number	Percent
Age (years)	(n=46)	
15 years old	4	8.7
16 years old	19	41.3
17 years old	22	47.8
18 years old	1	2.2
Football	(n=30)	
15 years old	2	6.7
16 years old	14	46.7
17 years old	13	43.3
18 years old	1	3.3
Soccer	(n=16)	
15 years old	2	12.5
16 years old	5	31.3
17 years old	9	56.3
18 years old	0	00.0
Participation (years)	(n=46)	
1-3 years	17	37.0
4-6 years	11	24.0
7 + years	18	39.0
Football	(n=30)	
1-3 years	12	40.0
4-6 years	8	27.0
7 + years	10	33.0
Soccer	(n=16)	
1-3 years	5	31.0
4-6 years	3	19.0
7 + years	8	50.0

Background Characteristics

Years of Sport Participation

Participants were asked to recall the years that each had participated in either soccer or football. Thirty-seven percent participated one to three years, 24 percent participated four to six years, and 39 percent participated seven years or more. In relation to each sport, football had 40 percent with one to three years of experience, 27 percent with four to six years, and 33 percent with seven or more years. Soccer had 31 percent with one to three years of experience, 19 percent with four to six years, and 50 percent had played for seven or more years (see Table 1).

Concussion History

Each participant was asked to recall past concussion and the amount of concussions experienced. Of the 30 football participants, six (20 %) had previously experienced one or more concussions, while two (12.5 %) of the 16 soccer participants had a history of concussion. The football participants with a history of concussion experienced an average of 1.83 concussions per participant. An average of two concussions per soccer participant was experienced among those with a history of concussion (see Table 2).

Table 2
Concussion History of Participants

Characteristics	Number	Percent
History of Concussion	(n=46)	
Football	6	20.0
Soccer	2	12.5
Total	8	17.4
Number of Concussions	(n=8)	Average/ Participant
Football	11	1.8
Soccer	4	2.0
Total	15	

Results of Research Questions

Repeated-measures analyses of variance (MANOVAs) were conducted to analyze SAC scores over time from baseline to test 2, test 3, and test 4. Statistical significance of $P < .05$ was set a priori for the MANOVAs. The following section contains a discussion of each of the research questions.

Research question 1: Is there a difference in orientation within football and/or soccer players throughout a season?

A one-way MANOVA was used to examine the mean difference between football players and soccer players' orientation scores. A significant effect was found in football. Follow-up univariate ANOVAs indicated that orientation scores significantly improved throughout the season ($F[5,97] = 3.897$, $p = .011$). Orientation scores were not significantly different throughout the season among soccer players ($F[5,55] = .778$, $p = .511$; see Table 3).

Research question 2: Is there a difference in immediate memory within football and/or soccer players throughout a season?

A one-way MANOVA was used to examine the mean difference between football players and soccer players' immediate memory scores. Univariate ANOVAs showed a trend to increase in score throughout the season in football players ($F[5,97] = 2.54$, $p = .061$). Immediate memory scores were not significantly different throughout the season in soccer players ($F[5,55] = .148$, $p = .930$; see Table 3).

Research question 3: Is there a difference in concentration within football and/or soccer players throughout season?

A one-way MANOVA was used to examine the mean difference between football players and soccer players' concentration scores. Concentration scores were not significantly different throughout the season between football players ($F[5,97] = .608$, $p= = .612$) or soccer players ($F[5,55] = .135$, $p = .939$; see Table 3).

Research question 4: Is there a difference in delayed memory recall within football and/or soccer players throughout a season?

A one-way MANOVA was used to examine the mean difference between football and soccer players' delayed memory recall scores. Delayed memory recall scores were not significantly different throughout the season between football players ($F[5,97] = .825$, $p = .483$) or soccer players ($F[5,55] = .245$, $p = .865$; see Table 3).

Research question 5: Is there a difference in total SAC scores within football players and/or soccer players throughout a season?

A one-way MANOVA was used to examine the mean difference between football and soccer players' total SAC scores. No significant differences were found

in Total SAC scores between football players (F[5,97] = .482, p = .696) or soccer players (F[5,55] = .762, p = .520; see Table 3).

Table 3
Summary of MANOVA Results

	Mean Differences	SD	*F*	*p*-value
Orientation				
Football	4.8252	.38162	3.897	.011
Soccer	4.8192	.46577	.778	.511
Immediate Memory				
Football	14.6699	.93293	2.540	.061
Soccer	14.8525	.60100	.148	.930
Concentration				
Football	3.3883	1.28516	.608	.612
Soccer	3.1967	1.28866	.135	.939
Delayed Memory				
Recall	3.4466	1.18593	.825	.483
Football	3.4918	1.04280	.245	.865
Soccer				
Total SAC Scores				
Football	26.3592	1.88313	.482	.696
Soccer	26.3443	1.58869	.762	.520

CHAPTER V

Discussion

The purpose of the present study was to test high school football and soccer players' cognitive function through a three-month season using a standardized assessment of concussion test to identify the risk of multiple micro-traumas to the head in sports and its effects on memory. This chapter will discuss the results and provide possible reasoning for its significance. It will also compare results with past literature. This chapter also presents a conclusion of study and possibilities for further research in the subject area.

Summary of Findings

The research questions in this study were guided by hypotheses derived from the literature on the perceived relationship between head trauma experienced during sporting competition and subsequent cognitive function. The following is a summary of the important findings for each of the research questions explored in this study.

Differences in Orientation

A significant increase in mean orientation scores was seen among football players. This could be due to baseline testing being performed prior to the school year. There is a possibility that during the summer vacation, high school students have a difficult time remembering the date or day of the week. However, once school begins, students are constantly keeping track of time and dates because of upcoming assignments and school events. Guskiewicz et al. (2004) recommends that baseline testing for fall sports be done during the spring, before school is recessed for the

summer. Baseline testing for the current study took place in late summer. Also, becoming accustomed to the test and knowing that the date and time would be asked during the test could help one to consciously remember the date.

The results indicated that there were no significant differences among soccer player's orientation scores. This could be due to the lack of intensity of play within the tested athletes. If the players did not have a high amount of head-to-ball contact, it would not cause enough micro-trauma to the brain in order to disorient them (Broglio, 2001). This finding is consistent with previous research (Matser 1998; Miller, 1997). Only two of the soccer players in the current study reported a history of concussion. This lack of past head trauma could have contributed to the non-significant result yielded by the current study.

In addition, the relative intensity of impact on the brain with different sports is a variable to consider when interpreting these results. According to Tysvaer (1992), the varying mass at contact in football relative to the known mass of a soccer ball when heading the ball could explain the different forces of impact between the two sports. Also, a soccer athlete will typically know ahead of time when head-to-ball contact is imminent. Therefore, the athlete will "fix" the head by contracting the neck muscles (Janda, Bir, & Cheney, 2002). This lowers the risk of head injury. A football player very rarely knows when a head impact will take place and, therefore, will have less means of protection.

Differences in Immediate Memory

There was a trend to increase scores in immediate memory amongst football players. This could largely be due to becoming accustomed to the test, which

threatens the internal validity of the results. During baseline testing, the participants did not know what to expect when asked to memorize and repeat words; therefore, words were forgotten immediately. However, during the re-testing, players may have become accustomed to the test and became more cognizant that the words would be asked to be repeated. It is possible that a method to remember the words more easily was employed with each successive testing period. Grindel (2001) explained that the more a test is given to an athlete, the better the athlete tends to do from previous exposure, particularly in tests of memory. This threat to internal validity could have been decreased had the time frame between the testing sessions been lengthened.

There were no significant differences found among soccer players and immediate memory. Again, this could be related to the lack of intensity in the sport and a small head-to-ball contact ratio among the 16 soccer players in the current study.

Differences in Concentration

No significant association was found between football players and concentration levels. In addition, there were no significant differences found between soccer players and concentration levels. In a review by Broglio (2001), Miller examined the acute effects of heading among U.S. soccer players. It was concluded that deficits were likely to be found more within the concentration tests (Broglio, 2001). Although concentration tests have been found to be most difficult for athletes who have experienced a concussion, the current study found that the consecutive micro-trauma to the head does not significantly affect the athlete's level of

concentration. The results could also be related to the relatively low occurrence of concussions experienced by the participants during the course of the study.

Differences in Delayed Memory Recall

No significant differences were found between either football players or soccer players and delayed memory recall levels. A large part of this could be due to both groups becoming accustomed to the test. After baseline testing, the participants could have remembered that each would be asked repeat the immediate memory words at the end of the test. Therefore, extra attention could have been given to memorize the words. Bethune (1981) explains that a loss of consciousness will impair delayed memory recall for long periods after other mental functions have fully recovered. Assuming there was no loss of consciousness, in which a concussion would have been experienced, would indicate why there was not a significant difference in delayed memory recall throughout the season.

Differences in Total SAC Scores

There were no significant differences found between total SAC scores and football players or soccer players. McCrea performed studies to test the validity of the SAC test among football players experiencing a concussion. It was found that there was a decrease in each area (orientation, immediate memory, concentration, and delayed memory recall) of the SAC test after an athlete experienced a concussion (McCrea 1998, 2001). This differs from the current study in that there was not a concussion experienced during testing, and data did not show any significant decrease in score in any area of the test. This result could indicate that the constant head

collision each day while participating in football or soccer throughout a season does not equal that of a concussion.

Lack of Intensity

Possibilities for little significant difference in SAC scores could have been due to a lack of intensity in the sport. Coming from a small division II high school, in which both teams of participation obtained losing records during the season, leaves a possibility that the participating athletes did not have the same quantity or the same intensity of head contact as those at a larger, more successful and intense athletics program. Tim Gabbett (2004) performed a study comparing the influence of intensity of injuries in rugby players. Information was obtained on injuries and intensity of training, and matches were graded using a rating of perceived exertion (RPE) scale for a rugby team throughout a season. It was found that injuries were highly correlated with the intensity, duration, and load of matches (Gabbett, 2004). Even though this study does not give much reference to head injuries, it can be assumed that head injuries can be directly correlated with the intensity of play. Therefore, the lesser intensity of play among the participating athletes could have contributed to the insignificant results in the current study.

Relation to Theoretical Framework

In relation to the theoretical framework for this study, it was indicated that even though an athlete participates in the contact sport, there is not enough micro-trauma to the brain to cause a decrease in cognitive function. This study was inconclusive as to whether a history of concussion would lead to a decrease in cognitive function from micro-trauma inflicted during a season of sport participation.

Limitations

Several limitations of the present study must be acknowledged. Given the small number of participants to complete all four SAC tests, the current results cannot be generalized to high school football and soccer players around the country. However, given the lack of research reported in the literature, the results of this study can significantly contribute to the field of study.

More participants in soccer with a long history of participation could have helped to give more significant results within the sport. Also, doing baseline testing during the summer months and follow-up testing during the school year may have limited the chance to see a significant decrease in orientation throughout a season. Most studies, as discussed by Broglio, were either conducted as acute differences in which the baseline testing was followed by head contact drills and then again retested, or they were longitudinal studies in which athletes who had experienced concussions while participating in sport were tested years later to search for differences in their cognitive function (Broglio, 2001). There are not any studies to date that report the cognitive differences in collision sports throughout a season.

It has also been recommended to document participants' history of attention deficient disorders, learning disability, or other cognitive development disorders that could have affected the SAC scores (Guskiewicz et al., 2004). The current study did not control for these variables.

Conclusion

The following is the major finding of this study:

1. Based on the results, participation in football and soccer does not have a negative effect on cognitive function throughout the length of a season.

Recommendations for Future Research

Further research into the relationship between cognitive function and head trauma among high school soccer players and football players should focus on:

1. The need to develop a longitudinal study of participation in athletics over a length of a career could help to show if there is an effect on cognitive function, such as testing high school athletes as freshmen and throughout their high school career.
2. The use of prior history of concussion can be tested to see if both a history of concussion and the number of concussions have a greater effect on a participant's memory during a season than those who have not experienced a concussion.
3. The need to test the athletes later in the year (post-season) to see if SAC scores throughout a season return to baseline scores a month after the season's end.

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APPENDICES

Appendix A

Participant Consent Form

Eastern Michigan University
College of Health Promotion and Human Performance

CONSENT TO ACT AS A HUMAN SUBJECT

Title of Project:
The Effects of Multiple Head Micro-Trauma on Cognitive Function in High School Football and Soccer Athletes.

Principal Investigator: Jessica M. Cole, ATC Phone: 734-***-****

Name: _____ Date: _____

Methods: You have been invited to participate in a study examining the effects that participation in contact sports has on memory function. If you plan on participating in either the sport of football or men's soccer and are between the ages of 15-18 you will be asked to participate in this study.

A series of concussion assessment tests will be administered to you throughout the course of the season. The test will be administered by either the Athletic Trainer or one of the student assistants before practice or games. The test will take approximately 5 minutes to complete, and will include a history of concussion. Within the first 2 weeks of practice, a baseline test will be given. You will again be re-tested using the same standard test after the first month, second month, and finally at the end of the season. The test that will be administered to you consists of questions that will involve memorization and recall. There will also be an exertional maneuver that will consist of performing 5 jumping jacks, 5 push ups, 5 sit ups, and 5 lunges. The test is scored on a number system in which a final score will be given. This score will be used for research purposes only. In the event that a score is significantly lower than average, it will be assumed that there has been a significant amount of trauma to the head and will be further tested for signs and symptoms of concussion including referral to the team physician for testing and clearance to return to participation.

The information obtained in this study will be used confidentially. You will be assigned a code number and will be identified only by this number. The list identifying your name and code number will be kept secure in a locked cabinet in the

athletic training room and will be destroyed at the end of the study. Reports written about the study will not identify you in any way.

If at any time the testing causes you any discomfort, you are asked to please notify the athletic trainer. You may decide to withdraw from the study at any time. If you wish to discontinue participation, simply notify the athletic trainer and you will be free to withdraw without penalty.

Benefits: The test that will be administered will aid in the assessment of a concussion in the event that a concussion occurs throughout the season. It may give evidence if you are at risk for further injury. The results of this study may create interest in further research of the subject and possibility to improve equipment to decrease severe head injury. It will show trends that head trauma has on the effects of memory and brain function in sport.

Risks: There are no risks of injury by participation in this study.

Inquiry: I understand that I may contact the chairperson of the Committee on the Use of Human Subjects in Research, Dr. Stephen Sonstein, 734-487-1238, or Dr. Stephen McGregor, 734-487-7120 ext. 2726, Chair of the IRB-AA board or any member of the committee, if I feel that there is any infringement upon my right.

By signing your name and the date below you give consent to participate in the following research study.

Signature: _____ Date: _____

I hereby certify that I have given an explanation to the above individual of the contemplated study and its risks.

_____
Principal Investigator

Appendix B

Parent Assent Form

Eastern Michigan University
College of Health Promotion and Human Performance

ASSENT FOR CHILD TO ACT AS A HUMAN SUBJECT

Title of Project:
The Effects of Multiple Head Micro-Trauma on Cognitive Function in High School Football and Soccer Athletes.

Principal Investigator: Jessica M. Cole, ATC Phone: 734-***-****

Methods: Your Child has been invited to participate in a study examining the effects that participation in contact sports has on memory function. If your child plans on participating in either the sport of football or men's soccer and are between the ages of 15-18 they will be asked to participate in this study.

A series of concussion assessment tests will be administered to your child throughout the course of the season. The test will be administered by either the Athletic Trainer or one of the student assistants before practice or games. The test takes approximately 5 minutes to complete, and will include a history of concussion. Within the first 2 weeks of practice, a baseline test will be given. They will again be re-tested using the same standard test after the first month, second month, and finally at the end of the season. The test that will be administered to them consists of questions that will involve memorization and recall. There will also be an exertional maneuver that will consist of performing 5 jumping jacks, 5 push ups, 5 sit ups, and 5 lunges. **The testing will not affect your child's participation in sport in any manner.** The test is scored on a number system in which a final score will be given. This score will be used for research purposes only. In the event that a score is significantly lower than average, it will be assumed that there has been a significant amount of trauma to the head and your child will be further tested for signs and symptoms of concussion including referral to the team physician for testing and clearance to return to participation.

The information obtained in this study will be used confidentially. Each child will be assigned a code number and will be identified only by this number. The list identifying the names and code numbers will be kept secure in a locked cabinet in the athletic training room and will be destroyed at the end of the study. Reports written about the study will not identify your child in any way.

If at any time the testing causes you or your child any discomfort, you are asked to please notify the athletic trainer. Your child may decide to withdraw from the study at any time. If you or your child wishes to discontinue participation, simply notify the athletic trainer and they will be free to withdraw without penalty.

Benefits: The test that will be administered will aid in the assessment of a concussion in the event that a concussion occurs throughout the season. It may give evidence if your child is at risk for further injury. The results of this study may create interest in further research of the subject and possibility to improve equipment to decrease severe head injury. It will show trends that head trauma has on the effects of memory and brain function in sport.

Risks: There are no risks of injury by participation in this study.

Inquiry: I understand that I may contact the chairperson of the Committee on the Use of Human Subjects in Research, Dr. Stephen Sonstein, 734-487-1238, or Dr. Stephen McGregor, 734-487-7120 ext. 2726, Chair of the IRB-AA board or any member of the committee, if I feel that there is any infringement upon my right.

By signing your name and the date below you give assent to allow your child to participate in the following research study.

Name of Child: _____

Parent/Guardian Name(please print): _____

Parent/Guardian Signature: _____ Date: _____

I hereby certify that I have given an explanation to the above individual of the contemplated study and its risks.

_____
Principal Investigator, Athletic Trainer