EFFECTS OF SUBCONCUSSIVE HEAD IMPACTS ON CONCUSSION
SYMPTOMS, CLINICAL REACTION TIME, AND OCULOMOTOR
FUNCTION IN MEN’S LACROSSE PLAYERS

by

Andrew E. Waer

A thesis submitted to the Faculty of the University of Delaware in partial
fulfillment of the requirements for the degree of Master of Science in Exercise Science

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ABSTRACT

Context: To clinicians, researchers, and athletes alike, the recent evidence suggesting the detrimental effects of subconcussive head impacts (SCHI) in collision sport athletes is alarming. The sport of lacrosse like football, ice hockey, and soccer, has a high-risk for sport-related concussions (SRC). However, there is paucity in research examining male lacrosse players despite the high risk for SRC and the opportunity for repeated SCHI to the helmet during competition. Unlike American football, unique to the sport of lacrosse is the fact that they are often asked to play games with minimal rest periods in between which provides for a chance to study SCHI in this population during a truncated week of competition. Objective: The primary goal of this study was to examine if SCHI had an effect on concussion-related symptoms, clinical reaction time, and oculomotor function in men’s lacrosse players (MLAX) in a shortened time frame between two regularly scheduled games (Wednesday and Saturday). Design: Two-group pretest-posttest design. Setting: Quiet, climate-controlled research laboratory. Patients or Other Participants: Subjects consisted of 18 men’s (height=181.3±6.6cm, mass=86.3±6.4kg, age=20.6±1.3yrs.) and 13 women’s (height=168.6±6.0cm, mass=61.3±4.6kg, age=19.7±1.1yrs.) lacrosse players from an NCAA Division-I institution. The non-helmeted female lacrosse players
(WLAX) were chosen to serve as controls. MLAX consisted of selected individuals who were expected to see a considerable amount of playing time in games.

**Interventions:** Each subject was tested on 3 separate occasions (baseline [BASE], post-game 1 [POST], and prior to game 2 [PRIOR]). Games 1 and 2 were separated by 2 days. Testing included a concussion symptom checklist (SXC), clinical reaction time (CRTA), and the King-Devick (K-D Test™) test of oculomotor function. **Main Outcome Measures:** SCHI were counted using videotape replays of all lacrosse games. The total number of symptoms was determined at each test session. The 3 CRT trials (time in msec.) were averaged. The KD test yielded both a total time (sec.) to completion score and total number of errors committed. Analysis of covariance statistical techniques was used to determine if differences existed between BASE and POST, as well as BASE and PRIOR across all dependent measures between MLAX and WLAX. **Results:** The SCHI ranged from 0-4 for MLAX and 0-3 for WLAX. In both groups across BASE to POST and BASE to PRIOR comparisons for all dependent variables (SXC, CRTA, KD time, and KD error) none were found to be statistically significant at p=0.05. CRTA BASE to PRIOR was trending towards significance with F=3.812 and p=0.061. **Conclusions:** Interestingly the number of SCHI in the MLAX group was well below what we had anticipated, and quite different from their helmeted counterparts in ice hockey and football. It was somewhat alarming to learn that 7 of the 13 WLAX experienced SCHI to their unhelmeted head during competition. Despite the aggressive and full-collision nature of the MLAX game, our study has determined that there are no detrimental effects on
several measures of concussion following the small number of SCHI during competitive games.

**Key Words:** Concussion, Subconcussive head impacts, lacrosse, clinical reaction time, oculomotor function

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Chapter 1

INTRODUCTION

For the past decade, lacrosse has been one of the fastest growing team sports in the United States at all levels of competition. According to the US Lacrosse 2012 participation report, there were 722,000 athletes playing that year, a 5.5% growth rate from 2011. Overall during the period between 2007-2012 there was a 47.2% and 43.1% increase in the number of boys and girl’s high school lacrosse programs in the US, respectively. The NCAA reports the number of schools sponsoring men’s and women’s lacrosse has increased ~30% since 2007. Although men’s and women’s lacrosse are similar they are also vastly different; including equipment that is worn and in how the game is played and governed. Men are required to wear helmets, shoulder pads, elbow pads, and padded gloves due to the high contact nature of the sport. In the United States however, women are only required to wear goggles because it is intended to be a low contact sport as opposed to their international counterparts who are not required to wear goggles at all. With increased numbers of participants, there has been a subsequent increase in sport-related injury, including head injuries. Lincoln et al. found that boys’ lacrosse had an incidence of .466 concussions per 1,000 exposures, which steadily increased over the course of the 11-year study, coinciding with the significant growth the sport experienced over that same time period. Lacrosse is one sport were sport-related concussions occur frequently, other sports include American football, ice hockey, and soccer.
Even with the greater knowledge and availability of health care, there is an estimated 3.8 million sports-related brain injuries that occur each year in the United States, many of which go undiagnosed. 5 Sport-related concussions also occur at high frequencies in individual sports such as boxing, taekwondo, and karate. 6 A concussion is defined as a “complex pathophysiological process affecting the brain, induced by traumatic bio-mechanical forces. 7 Concussions, sometimes referred to as mild traumatic brain injuries (mTBI) are diffuse axonal injuries that result in functional impairment. Most concussions result in cognitive deficits, memory loss, balance disturbances, and other somatic symptoms. 8 Concussions commonly occur due to an injurious blow directly to the head or an indirect impact where the blow is to another part of the body that puts the head in motion. 9 In recent years there has been a focus on subconcussive head impacts (SCHI) and their effect on the brain. SCHI is defined as an impact to the head that does not cause any sign or symptom of a concussion. 10 Despite the research being performed there still remains questions about whether SCHI have a cumulative effect, in turn lowering the threshold impact force causing SRC and/or whether or not SCHI have negative effects on cognitive function.

To clinicians, researchers, and athletes alike, the recent evidence suggesting the detrimental effects of SCHI in collision sport athletes is alarming. 11,12 Several recent studies involving American football players have examined neurocognitive performance in non-concussed athletes over a competitive season and found mixed results. 10-14 In addition there have been several reports utilizing soccer athletes that have suggested SCHI during competition results in cognitive decline. 15-17 Despite the high risk for SRC 18 and the opportunity for repeated SCHI, there is paucity in
research involving male lacrosse players. This population is unique to that of the commonly studied American football players in that they are asked to play games with minimal rest periods in between (i.e. Wednesday game followed by Saturday game).

Pressure on sports health care professionals to efficiently and accurately diagnose SRC’s is important. There are a variety of tools available to measure cognitive impairments, visual-motor deficits, as well as concussion symptoms on the field or in a clinical setting. These tools provide an efficient collection of assessment techniques to carefully monitor any detrimental effects from SCHI. In addition, these tools allow healthcare providers to easily track SRC characteristics over short periods of time. Our study utilized three such tools including: a symptom checklist, a clinical reaction time test, and the King-Devick test (K-D Test™) of cognitive visual processing and performance. With Eckner et al.’s validation of a clinical reaction time apparatus (CRTA) and subsequent research on how CRT is affected by concussion, this makes a case for determining whether CRT is affected by SCHI as well as concussive head impacts. The cranial nerves, specifically II, III, IV, and VI which controlling saccadic eye movements (optic, oculomotor, trochlear, and abducens) originate in the diencephalon and midbrain an area of the CNS most affected during rotational forces associated with concussion. Galetta et al. used the K-D Test™ as a screening tool for SRC and showed that there is a use for oculomotor testing in concussion screening in athletes. The K-D Test™ has never been used to determine whether oculomotor function is affected by SCHI in much the same way as it was able to function as a tool for concussion diagnosis. Concussion symptom checklists are commonly used in concussion assessment and as a part of return-to-play
decisions, this makes a symptom checklist a viable tool to use regardless of the subjectivity with the self-assessed nature of the test.

Therefore, the purpose of this study was to examine if repeated SCHI have an effect on concussion-related symptoms, clinical reaction time, and oculomotor function in the men’s lacrosse population between two regularly scheduled games in a shortened competition week. Secondarily, we hoped to gain insight into the number of SCHI to the helmeted men’s lacrosse player during the course of a regularly schedule contest utilizing video technology. We hypothesized that concussion symptoms would increase, while oculomotor function would decrease, and clinical reaction time scores would become slower in men compared to women as a result of fewer SCHI sustained during competition.
Chapter 2

MATERIALS AND METHODS

2.1 Design

Two-group pretest-posttest design.

2.2 Participants

Eighteen male and thirteen female intercollegiate lacrosse players were recruited from their respective teams based on amount of time played. Demographic information is located in Table 1. Subjects were excluded if they were not playing at the time of study due to an injury, had a history of oculomotor disability, if they had sustained a concussion within the past six months, or had sustained two or more concussions in their lifetime. Due to the physical contact and equipment differences between the men and women, the helmeted men were used as the experimental group and the women were used as the control group. Furthermore, while physical contact is commonplace in the men’s game, the women’s game relies more on finesse; in fact, unnecessary contact is often penalized. While our primary purpose was to examine SCHI in the male lacrosse population, our experimental design is strengthened by the inclusion of their female counterparts. All subjects signed a consent form and followed terms approved by a university Institutional Review Board in the spirit of the Helsinki declaration (UDIRB-404161-1). In addition, each subject filled out a medical questionnaire that included demographic information.
2.3 Instrumentation
Symptom Checklist:

A checklist of 22 symptoms associated with SRC was used to help identify any that the subjects may have. These symptoms are graded on a 7-point Likert scale (0-6) with 0 being no symptom and 6 being severe symptom. We used the symptom evaluation section of the SCAT3™ (Sport Concussion Assessment Tool -3rd edition released by the 4th International Conference on Concussion in Sport in Zurich) to examine concussion symptoms (Figure 1). The athletes self-administered the checklist by grading each symptom without experimenter intervention. Only the total number of symptoms (maximum possible 22) was used.

King-Devick Test (K-D Test™):

The King-Devick Test (K-D Test™ Oakbrook Terrace, IL) is a tool created to help measure the speed in which a person can rapidly read numbers aloud. The test consists of four standardized index cards. (Figure 2) The first index card serves as a practice or demonstration card. This card contains five horizontal lines consisting of a series of randomly spaced single digit numbers. Directional arrows are also included which guide the participant in reading left to right and top to bottom. The remaining three cards are used for testing purposes and read aloud by the participant as quickly as possible, without mistakes, in the fashion displayed by the first demonstration card. The investigator used a stopwatch to record the time it took the participant to complete this process and the number of errors made during the reading. The 3 timed trials are then added together to create the overall score in seconds. In addition, the total
number of errors throughout the test were used in data analysis. The K-D Test™ has been shown to be a valid and reliable tool for concussion screening.\textsuperscript{21,22}

**Clinical Reaction Time Apparatus (CRTA):**

A Clinical Reaction Time Apparatus was used to assess reaction time. Eckner et al. have shown that this apparatus is a reliable and valid measure of reaction time.\textsuperscript{1,19} Participants sat with the dominant forearm resting on a flat desk or surface, with their open hand at edge of the surface. The CRTA was suspended vertically with the weighted disc aligned with the top of the participant’s open hand. (Figure 3) At predetermined time intervals (4-15 sec.) the apparatus was released and subject caught it as quickly as possible. The distance travelled by the apparatus was recorded in centimeters and converted to milliseconds using the formula for a free body falling under the influence of gravity \(d = 0.5gt^2\) to solve for time \(t\).\textsuperscript{1,19} Three practice trials were followed by three test trials. Although Eckner et al. performed eight test trials\textsuperscript{1,19}, out of convenience and time restraints, we chose to only record three test trials.

**2.4 Procedure**

Each of the 18 male and 13 female intercollegiate lacrosse student-athletes was baseline tested utilizing the instrumentation described above prior to the start of the competitive season. The athletic training research lab provided a quiet and distraction free environment during testing. The entire baseline test session took 15 minutes to complete. A certified athletic trainer administered the K-D Test™ and CRTA to each participant while the symptom checklist was self-administered.

Prior to the start of the competitive season, we identified two shortened competitive weeks whereas the teams were involved in competitions on Wednesday
and another on Saturday rather than games separated by one week. Nine volunteers from the men’s team and 7 from the women’s team were randomly chosen to participate from the first game and 9 men and 6 females for the second game. Subjects were notified after each game that they had been chosen to participate in the follow up testing sessions and given directions to follow for the remainder of that day and night. These directions included: no drinking alcohol, use proper nutrition and hydration for the remainder of the day as they normally would, no coffee or energy drinks in the morning, and eat breakfast before returning to the athletic training research lab the next day for testing. The post-game testing procedures included the completion of the symptom checklist, K-D Test™, and CRTA in an exact manner described in baseline testing. In addition, the student-athletes were required to come in the next day (day two post-game) for another round of testing as described above. During both post-game test days subjects remained on their regular schedule of practice, sleep, and diet. Each subject was tested on two separate days and went through the test series once each day.

Using video playback equipment, we were able to account for the number of SCHI for each player participating in this investigation. During playback, the participant’s jersey number was identified and tracked throughout the entire game while any contact to the head was counted. A head impact constituted any hit to any part of the body above the shoulders, including helmet-helmet, helmet-stick, helmet-ball, and helmet-ground. This procedure was repeated for every subject.
2.5 Statistical Analysis

The independent variable compared in this study was gender. This separated the groups into our experimental group (men’s lacrosse players) and control group (women’s lacrosse players). Four dependent variables were examined and included the number of concussion symptoms, CRTA measured in milliseconds, number of K-D Test™ errors, and time in seconds to completion of K-D Test™. All data were analyzed with an alpha level set \( a \text{ priori} \) at \( P \leq 0.05 \). For each dependent variable an ANCOVA was used to compare means for baseline vs. test 1 a separate ANCOVA was used to compare baseline vs. test 2. This analysis was used to give us insight into whether SCHI have negative effects on neurocognitive performance.
Chapter 3

RESULTS

SCHI

The number of SCHI to the control group throughout the course of a single competitive game ranged from 0-3 with a mean of 0.80±0.9, compared to the experimental group, which ranged from 0-4 with a mean of 1.1±1.4. Table 1 shows the dispersion of SCHI. The total number of SCHI in MLAX group was 20, of which 14 were stick-to-helmet contact, 4 were body-to-helmet contact, 1 ball-to-helmet, and 1 helmet-to-helmet. The total SCHI in WLAX group was 10 with 9 being from stick-to-helmet contact and 1 body-to-helmet contact.

Symptom Checklist

There were no significant differences between the control group (2.4±5.0) vs. the experimental group (3.7±6.0) from baseline to test 1 (F$_{1,28}$=0.09; P=0.76). There were no significant differences between the control group (1.5±3.1) vs. the experimental group (2.2±4.5) from baseline to test 2 (F$_{1,28}$=0.002; P=0.96). The means and standard deviations for the symptom checklist scores are depicted in Figure 4.

Clinical Reaction Time

There were no significant differences between control group (147.2±18.0 msec.) and experimental group (153.0±17.9 msec.) from baseline to test 1 (F$_{1,28}$=1.24; P=0.24). Interestingly, there was a trend towards significance (F$_{1,28}$=3.81; P=0.06)
where the experimental group’s reaction time (155.5±27.4 msec.) was higher (worse) compared to their control counterparts (142.4±17.7 msec.) whose decreased when comparing baseline to test 2. Means and standard deviations are depicted in Figure 5.

**King-Devick Test™**

There was no significant difference between control group (36.8±5.2 sec) and experimental group (37.9±8.0 sec) from baseline to test 1 \((F_{1, 28}=0.15; P=0.69)\) for mean time to completion of K-D Test™. There was no significant difference between control group (35.3±5.3 sec) and experimental group (37.2±8.1 sec) from baseline to test 2 \((F_{1, 28}=0.77; P=0.38)\). Means and standard deviations are depicted in Figure 6.

Mean K-D Test™ error scores showed no significance between control group (0±0) and experimental group (0.2±0.4) from baseline to test 1 \((F_{1, 29}=2.43; P=0.13)\). There was no significant difference between control group (0.1±0.28) and experimental group (0.22±0.55) from baseline to test 2 \((F_{1, 29}=0.76; P=0.38)\).
Chapter 4

DISCUSSION

This was the first study to look at SCHI in the lacrosse population. We were especially interested in determining whether or not the SCHI had an effect on concussion-related symptoms, oculomotor function, and clinical reaction time. Our study suggests that there are no significant deficits in any of the above named constructs after a single NCAA Division-I men’s lacrosse game. Unlike their American football counterparts the number of SCHI in this cohort of men’s lacrosse players is relatively low.

Interestingly, the number of SCHI in the MLAX group was well below what we had anticipated, and quite different from their helmeted counterparts in ice hockey and football. If throughout the course of the game the max number of SCHI sustained by any one player was 4. McAllister et al. reported a mean of 469 SCHI/season in a population of ice hockey and football players. If we were to extrapolate our highest number of SCHI (4) over the course of a 15 game season it would equate to 60 SCHI in this collegiate lacrosse cohort; substantially lower than that reported by McAllister et al. Furthermore our numbers are considerably lower than those reported by Crisco et al. in their collegiate football athletes. Using their numbers we calculated an average of 10 SCHI across all positions assuming a 12-game football season, which would equate to a total of 120-plus SCHI in a season. Unlike football and despite
rules against these contacts, helmet-to-helmet hits throughout the course of a men’s lacrosse game are not the primary source of SCHI. Instead, our video analysis indicated that the majority of SCHI were stick-to-helmet contact. We contend that the forces imparted to the helmet as a result of these SCHI are lower than those forces imparted by direct helmet-to-helmet contact as seen in football and to a lesser degree in ice hockey. Additionally, we reported a total of only 4 body-to-helmet contacts during our video analysis, while low; a previous report by Lincoln et al. raised concern about these types of contacts as they were the primary mechanism for concussion in the boy’s high school lacrosse population they analyzed.\textsuperscript{26} Lastly, our population of interest was a group of highly skilled NCAA Division-I men’s lacrosse players. Despite having a competitive advantage over their counterparts at lesser collegiate divisions as well as high school participants, in the fact that they are in most cases bigger, faster, stronger; we contend that the high level of skill required to participate at this high level results in play requiring more finesse rather than the wild extremes of aggressive play seen at other levels of lacrosse. This, we argue, may result in more SCHI resulting from stick-to-helmet, body-to-helmet types of blows.

SCHI has been studied in multiple sports, but the main focus has involved American football and soccer.\textsuperscript{10-12,15,24,27-29} As is the case with SRC management there is a variety of tools available for researchers to study the effects of SCHI in these sporting populations. Previous studies have included both computerized and paper-and-pencil neuropsychological tests to measure cognitive performance while others have used standardized balance assessments.\textsuperscript{9,10,13,14,23,26-28} Of those studies examining
the effects of SCHI some have reported deficits on such measures as reaction time, visual memory, symptoms, and fMRI \cite{11,12,24,28} while still others report no influence on such constructs as balance, verbal learning, color word association, and mathematical processing. \cite{10,15,27,29} Similar to other studies \cite{10,12,24,28} examining SCHI we incorporated a symptom checklist, however to our knowledge this is the first study to include both oculomotor function and a unique measure of clinical reaction time. The results of our study involving this cohort of male collegiate lacrosse players determined no significant changes across any of these measures used in contemporary concussion evaluation.

Counter to our hypothesis we did not find a significant change in self-reported concussion-related symptoms in our men’s lacrosse players at the two post-game time points measured. Although not significant, there was a slight increase in the number of symptoms above baseline at 24 hours post-game that returned to a level below the baseline value the day before the next game. A recent report by Gysland et al. (2012) reports a slight increase in the number of symptoms above baseline in a group of collegiate football players after one season of play. \cite{28} Whether the slight increase in the number of symptoms in our cohort is related to SCHI or some other physiological mechanism (i.e. stressors of ADL’s or exercise) is open for interpretation. The symptoms that were most reported 24 hours after competition included, “pressure in the head” and fatigue (6 subjects), drowsiness and feeling slowed down (5 subjects), and 4 other random symptoms reported in 4 subjects. In addition to the number of symptoms, the SCAT3 symptom checklist allows for a symptom severity measure to
be computed. Although not part of our analysis it was interesting to note that there was a slight increase in symptom severity above baseline at 24 hours post-game that remained higher at the start of test 2, the day before the next competition. Gysland et al. reported a similar finding in their football players post season.  

Eckner et al. devised the CRTA to be a useful, easy to use sideline assessment tool. 1 When comparing our results to the reaction times reported by Eckner et al., our mean baseline time of 159.2 msec. was considerably lower (faster) when compared to their time of 202.0 msec. 19 This difference in reaction time between studies may be related to the fact that our population of collegiate men’s lacrosse players whose very sport depends greatly on hand-eye coordination resulted in the quicker times versus the football, soccer, and ice hockey athletes used in the Eckner et al. study. When our reaction times are compared to an earlier report by Eckner et al., using a population of non-athletic healthy adults, the difference is even greater (159.2 msec. vs. 268 msec.).

Interestingly, the mean reaction time in our control group of collegiate women’s lacrosse players was very close in time to that of their male counterparts (159.2 msec. vs. 165.3 msec.), additional proof that athletes whose sport relies heavily on hand-eye coordination may have faster CRTA. The fact that no differences in CRTA from baseline to either of the two post-game tests, points to the fact that the limited number of SCHI had no impact on CRTA scores. In their 2014 paper Eckner et al. reported differences in CRTA in a group of collision-sport athletes post-concussion; so had there been differences in our lacrosse players we’re confident that the CRTA would have detected such changes. 19
In contrast to the current study, previous research regarding SChI by Miller et al.\textsuperscript{10} and McAllister et al.\textsuperscript{24} used the ImPACT neuropsychological computer program; whereas we utilized a symptom checklist, the K-D Test\textsuperscript{TM}, and CRTA. Both Miller et al. and McAllister et al. had reported ImPACT reaction time composite scores that varied. McAllister et al. whose subject pool was football and ice hockey players reported deficits in reaction time composite score post-season and attributed it to the SChI that occurred in their respective sports. Conversely, Miller et al. using a group of collegiate football players reported no difference in pre, mid, and post-season ImPACT reaction time composite scores.\textsuperscript{10} While the Miller et al.\textsuperscript{10} findings related to reaction time compare favorably to our results, we are quick to point out that there are differences in the mode in which reaction time is measured (computer vs. manual CRTA). However, a recent report by Eckner et al. argues that there is good evidence demonstrating the short-term and long-term reliability of CRTA and its validity with relation to a computerized measure of reaction time in athletes.\textsuperscript{30}

Drawing from previous research examining oculomotor function following acute sport-related concussions we hypothesized that there would be an increase in both time to completion and number of errors on the K-D Test\textsuperscript{TM} in the period following the lacrosse game. The sensitivity of the K-D Test\textsuperscript{TM} in examining subtle changes following sport-related concussions made it a logical choice to use in our study of SChI.\textsuperscript{31} The results of our study indicated no significant change in K-D Test\textsuperscript{TM} performance (time and errors) between baseline and test 1 and baseline and test 2. Again we attribute the lack of change in K-D Test\textsuperscript{TM} performance to the fact that
very few SCHI occurred to our athletes. Therefore, they are looked at as if they are asymptomatic athletes with no ill effects from the SCHI. Braun et al. spoke to the learning effect associated with the K-D Test™ following repeated trials. If true in our cohort of subjects we would have seen a decrease in time between baseline and test days 1 and 2, however this was not the case.

Although not the primary focus of this research effort, we were alarmed to learn that 7 of the 13 WLAX participants experienced SCHI to the un-helmeted head during competition, which begs the question whether the sport of women’s lacrosse should address this issue and protect the athlete with a helmet. Although the sport of women’s lacrosse is categorized as a non-collision sport and despite the penalties that are called when excessive contact is rendered we report in 7 different cases where contact to the player’s head occurred. In majority of these cases it was stick-to-head contact. Beyond the scope of this paper it suggests the need for additional research in this specific population of WLAX players.

We wish to point out a few limitations with the current study. Video analysis was used to count the number of SCHI throughout the lacrosse game by manually counting when each case of SCHI occurred. We did not account for any collisions that may have produced “whiplash” forces to the head/neck segment. Furthermore, we did not account for the amount of force that was imparted with each SCHI. Additionally, we did not account for SCHI that could have occurred at the two practices that took place between games because they were not videotaped. However, our coaching staff does very little contact activities when games are scheduled so close
together versus a traditional week in-between. Despite these limitations, the few
SCHI that did occur lead us to believe that our findings are an accurate portrayal of
SCHI throughout a competitive lacrosse game.

Ours was the first study to examine SCHI in the sport of lacrosse; one of the
fastest growing sports in the United States. Despite the aggressive and full-collision
nature of the MLAX game, our study has determined that there were no detrimental
effects produced by SCHI on several measures (symptoms, reaction time, and
oculomotor function) used in sport-related concussion assessment. We argue that the
relative few number of SCHI during a competitive game is the primary reason for the
lack of change in these variables. A long-term prospective study over the entire
competitive lacrosse season is warranted. Lastly, our findings concerning SCHI in un-
helmeted women’s lacrosse players strongly suggests the need for further research.
## Chapter 5

**TABLES AND FIGURES**

Table 1: Subject Demographics

<table>
<thead>
<tr>
<th>Gender</th>
<th># of Subjects</th>
<th>Age (years)</th>
<th>Mass (kg)</th>
<th>Height (cm)</th>
<th># Concussions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>18</td>
<td>20.6±1.3</td>
<td>86.3±6.4</td>
<td>181.3±6.6</td>
<td>0.4±0.6</td>
</tr>
<tr>
<td>Female</td>
<td>13</td>
<td>19.7±1.1</td>
<td>61.3±4.6</td>
<td>168.6±6.0</td>
<td>0.4±0.7</td>
</tr>
</tbody>
</table>
Table 2: Distribution of SCHI during competition

<table>
<thead>
<tr>
<th>Gender</th>
<th>Total Hits</th>
<th>Stick-to-Head</th>
<th>Ball-to-Head</th>
<th>Body-to-Head</th>
<th>Head-to-Head</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>20</td>
<td>14</td>
<td>1</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Female</td>
<td>10</td>
<td>9</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
Figure 1: Symptom checklist section from the SCAT3™

<table>
<thead>
<tr>
<th>Symptom</th>
<th>None</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>“Pressure in head”</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Neck Pain</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Nausea or vomiting</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Dizziness</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Blurred vision</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Balance problems</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Sensitivity to light</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Sensitivity to noise</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Feeling slowed down</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Feeling like “in a fog”</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>“Don’t feel right”</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Difficulty concentrating</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Difficulty remembering</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Fatigue or low energy</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Confusion</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Trouble falling asleep (if applicable)</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>More emotional</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Irritability</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Sadness</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Nervous or Anxious</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Total number of symptoms (Maximum possible 22)
Symptom severity score
(Add all scores in table, maximum possible: 22 x 6 = 132)
Figure 2: King-Devick Test™ - The top left card is the demonstration card showing the subject how to read the card. The remaining three cards (top right, bottom left, and bottom right) are the testing cards that are progressively harder.
Figure 3: Clinical Reaction Time Apparatus (CRTA) validated by Eckner et al.\textsuperscript{1} to report clinical reaction time. Subject is seated with hand off a table. At random time intervals between 4-12 seconds the apparatus is released and the subject is told to catch it as quickly as possible.
Figure 4: Total number of symptoms (Mean±SD) comparing Men’s LAX and Women’s LAX baseline, test 1, and test 2.
Figure 5: CRTA values (Mean±SD) comparing Men’s LAX and Women’s LAX baseline, test 1, and test 2.
Figure 6: Depicts K-D Test™ (Mean±SD) comparing Men’s LAX and Women’s LAX Baseline, test 1, and test 2.
REFERENCES


7. McCrory, Paul, Meeuwisse, Willem H., Aubry, Mark, Cantu, Robert C., Dvorak, Jiri, Echemendia, Ruben J., Engebretsen, Lars, Johnston, Karen, Kutcher, Jeffrey S., Raftery, Martin, Sills, Allen, Benson, Brian W., Davis, Gavin A., Ellenbogen, Richard, Guskiewicz, Kevin M., Herring, Stanley A., Iverson, Grant L., Jordan, Barry D., Kissick, James, McCrea, Michael, McIntosh, Andrew S., Maddocks, David, Makdissi, Michael, Purcell, Laura,


Appendix A

SPECIFIC AIMS

Lacrosse, like its collision sport counterparts, football, ice hockey, and soccer, the risk of concussion is high. As sports health care professionals, the recognition and treatment of sport-related concussions (SRC) is paramount. Since the release of guidelines following the 1st International Conference on Concussion in Sport in November 2001 there is still much to learn about concussions and how they occur. The recent guidelines set forth following the 4th International Conference on Concussion in Sport offer insight into the latest and most up to date care guidelines.

To clinicians, researchers, and athletes alike, the recent evidence suggesting the detrimental effects of subconcussive head impacts (SCHI) in collision sport athletes is alarming. Several recent studies involving American football players that have examined neurocognitive performance in non-concussed athletes over a competitive season have mixed results. In addition, there have been several reports utilizing soccer athletes that have suggested SCHI during competition result in cognitive decline. However, there is paucity in research examining male lacrosse players despite the high risk for SRC and the opportunity for repeated SCHI to the helmet during competition. Unlike American football, unique to the sport of lacrosse is the fact that they are often asked to play games with minimal rest periods...
in between which provides for a chance to study SCHI in this population during a truncated week of competition (mid-week game followed by weekend game).

Pressure on sports health care professionals to efficiently and accurately diagnose SRC’s is important. There are a variety of tools available to expeditiously measure cognitive impairments, visual-motor deficits, as well as concussion symptoms on the field or in a clinical setting. These same SRC assessment tools provide an efficient collection of assessment techniques to carefully monitor any detrimental effects from SCHI. In addition, these tools allow healthcare providers to easily track SRC characteristics over short periods of time. Our methods utilize three such tools including: symptom checklists, the King-Devick test (KD test) of cognitive visual processing and performance, and a clinical reaction time test.

Utilizing athletes from a NCAA division 1 men’s lacrosse program along with their non-helmeted women’s lacrosse counterparts the primary goal of this study is to examine if repeated blows to the head(SCHI) have an effect on concussion-related symptoms, clinical reaction time, and oculomotor function; in this population in a shortened time frame between two regularly scheduled games (Wednesday and Saturday). Secondarily, we hope to gain insight into the number of SCHI to the helmeted men’s lacrosse players during the course of a regularly scheduled competition utilizing video technology.

Specific Aim 1: To assess if sub-concussive head impacts (SCHI) cause a deficiency in clinical reaction time (CRT), oculomotor function, or an increase in concussion
symptoms after a single game of lacrosse and determine if the subjects return to their baseline scores before their next competition.

*Hypothesis 1a:* There will be a decline in CRT and oculomotor function after a single game of lacrosse, but the athletes will have returned to baseline before the next competition.

*Hypothesis 1b:* There will be an increase in concussion symptoms after the first game and resolve by the second game.

*Specific Aim 2:* Determine if there is a significant difference in KD, CRT, and symptom scores after one game between men’s lacrosse players (experimental group) and women’s lacrosse players (control group).

*Hypothesis 2:* There will be a significant decrease in men’s scores compared to women’s scores due to sub-concussive impacts sustained during one game.

The expected outcome of this study includes, 1) an insight into the frequency of head impacts sustained by collegiate men’s lacrosse players during a regular game, 2) and an understanding of clinical reaction time, oculomotor function, and concussion symptoms after a contact-heavy intense exercise bout compared to a non-contact intense exercise bout.
Appendix B

BACKGROUND & SIGNIFICANCE

In recent years, SRC have received significant attention from the media and medical experts. The guidelines for recognition and treatment of concussions have become more stringent during this time. More concussions are being diagnosed due to better awareness and the availability of a licensed health practitioner such as an athletic trainer, and subsequently more athletes are missing playing time because of these injuries due to better awareness and diagnosis. Even with the better guidelines and greater availability to health care, it is estimated that there may be upward of 3.8 million sports-related brain injuries occurring in the United States every year, many of which go undiagnosed. The amount of time missed varies greatly, as each concussion is treated on an individual basis; no two concussions will resolve according to a set schedule. American football has been notorious for concussions due to the high velocity impacts associated with the sport. Although football receives most of the media attention, concussions occur in other sports as well. Lacrosse can be compared to football and ice hockey in that the sports involve high-mass, high-velocity, body-to-body collisions and low-mass, high-velocity, object-to-body impacts that can cause serious and sometimes life-threatening injuries. Men’s lacrosse has one of the highest occurrences of concussions along with football, ice hockey, and soccer. According to the National Collegiate Athletic Association’s (NCAA) injury
surveillance system from 2004-2006, concussions comprised 20% of all game injuries in lacrosse. In an 11-year study looking at trends in sport concussions from 1998-2008 in a high school district, Lincoln et al. found that boys’ lacrosse had the 2nd highest amount of concussions behind football and the third highest concussion rate behind football and girls’ soccer at a rate of .30 per 1000 athlete exposures. In another high school based study, Meehan et al. found that boy’s lacrosse had an incidence of .466 concussions per 1,000 athlete exposures and a percentage of 18.9 of the total injuries represented concussions. Despite lacrosse being a sport that requires athletes to wear helmets that are approved by National Operating Committee on Standards for Athletic Equipment (NOCSAE), there is still a growing number of concussions. It is well-known that helmets will reduce impact forces on the skull. However, helmets do not prevent someone from sustaining a concussion and in fact, may give a false sense of security while playing. A helmet’s main safety feature is the hard outer shell that provides protection against skull fractures. Concussions are commonly caused by an injurious blow that makes direct contact with the head or an indirect impact where the blow is to some other part of the body and puts the head in motion, which is more commonly known as whiplash.

The 4th International Conference on Concussion in Sport in November 2012 defined a concussion as “a complex pathophysiological process affecting the brain, induced by traumatic bio-mechanical forces.” Even with the consensus statement on concussion in sport that was released as a result of this conference, there are still many questions about how the brain is affected as a result of a concussion. Concussions, also
known as mild traumatic brain injuries or (mTBI) are diffuse axonal injuries that result in functional impairment which differs from moderate to severe traumatic brain injury. Diffuse axonal injury can affect the center of the brain responsible for vital mechanisms such as heart rate, breathing, and consciousness. Typically concussions result in cognitive deficits, memory loss, balance disturbances, and other somatic symptoms. Greater than 90% of concussions result in no loss of consciousness, minimal or no post-traumatic amnesia, and little disorientation. In 1964, the Congress of neurological surgeons described mTBI with symptoms including altered mental state, vision problems, and balance disturbances. With relation to SCHI, if these impacts are causing similar axonal injury, but on a smaller scale there could be effects when repeated SCHI happen. Questions regarding whether SCHI may have a cumulative effect, which could decrease the impact force needed to sustain a concussion and performance on baseline neurocognitive testing remain as well as having a negative effect that disturbs cognitive function. There is no timetable for someone to be healed from a concussion. Likewise, there is no research stating how long multiple SCHI can affect an individual, but it has been suggested that SCHI could be a possible cause of chronic brain injury. Concussions have been shown to have acute effects on oculomotor function, so the question remains to whether multiple sub-concussive exposures may have an effect on oculomotor function as well. 

A SCHI is defined as an impact to the head that does not cause any signs or symptoms of a concussion. Several studies have examined neurocognitive performance in various ways and with various tools regarding the effects of SCHI.
Two studies from the 1990’s showed that repeated SCHI could cause deleterious effects histopathologically, and cognitively. In 2005, Killam et al. assessed the enduring residual neuropsychological effects of head trauma in athletes who participated in contact sports. Their results suggest that there were impairments of memory in athletes who never reported a diagnosed concussion. In 2012, McAllister et al. examined cognitive effects of a season of head impacts in football and ice hockey players and found that ImPACT reaction time composite scores showed poorer performance and were associated with higher scores on several head impact exposure metrics. Gysland et al. examined the relationship between SCHI and concussion history on neurologic performance, their results showed that deficits that were shown on measures of balance and symptoms from preseason to postseason were associated with the number of SCHI greater than 90 g’s, total number of SCHI to the top of the head, and the number of years of collegiate football participation. However, Miller et al. (2007) looked at comparing preseason, midseason, and postseason neurocognitive ImPACT and SAC scores in uninjured collegiate football players. No significant differences between the pre, mid, and post seasons’ scores were found. This study was conducted over the course of an entire season, and did not examine events that occurred weekly or within each game. Mulligan et al. in 2012, made findings that suggested in a moderate number of subjects there was neurocognitive and balance changes within 48 hours of the final football game of the season after no report of sustaining a concussion. The most frightening study that suggests SCHI have effects on cognitive impairment is from Talavage et al. Their study found that
50% of football players with no clinically-observable impairments showed significant alterations in their in-season fMRI as well as neurocognitive impairments when looking at ImPACT scores. Using the Head Impact Telemetry system, they found that this group had experienced the most events to the top-front of their head. This study challenges the findings by Miller et al. in 2007 who suggested that there were no mid-season or post-season changes in football players. Along with American football, SCHI in soccer are of concern due to the number of purposeful headers that occurs during practice and competition. Despite the high velocity that a soccer ball is usually traveling when it is headed, it still has a relatively low mass compared to a football or lacrosse player. Moreover, the duration of contact is often shorter. The idea of purposeful heading is different from these sports as well because when an athlete heads a ball, they contract the neck muscles and prepare for the impact of the ball; whereas a lacrosse or football player does not always know when they will be contacted causing them to have less protection from the dynamic stabilizers of the head.

Neurocognitive testing has been recognized as helpful in the diagnosis and management of concussions. Several neurocognitive tools used include: the Standardized Assessment of Concussion (SAC), Sport Concussion Assessment Tool Three (SCAT3), Automated Neuropsychological Assessment Metric (ANAM), King Devick Test (KD), and most notably the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT). Each of these tests test a different battery of symptoms or cognitive function, which is why it is imperative that we use a multi-dimensional...
approach to determining cognitive function. Although these tests are used to determine neurocognitive performance when the patient has a concussion, they are only one part of a comprehensive concussion assessment and should not be used as the sole diagnostic tool for concussions.\textsuperscript{39} With Eckner et al.’s validation of a clinical reaction time apparatus (CRTA) and subsequent research on how CRT is effected by concussion\textsuperscript{1,19}, this makes a case for determining whether CRT is effected by Schi as well as concussive head impacts. Galetta et al. used the King-Devick test as a screening tool for SRC and showed that there is a use for oculomotor testing in concussion screening,\textsuperscript{21,22} we will try to determine whether oculomotor function is effected by Schi using the KD test in much the same way as it was able to function as a tool for concussion diagnosis.

With all of the recent research that has been done on Schi and their effects on various neurocognitive functions they all lack one thing that is important when studying lacrosse in particular. A major difference between the sports of football and lacrosse is game scheduling. Within a lacrosse season, games may be played a week apart or only two days apart. This makes it imperative to examine the neurocognitive performance of players when there are only a couple of days between games. Examining athletes between these mid week games will help determine if Schi throughout a game will cause a decrease in clinical reaction time and oculomotor function, and whether their brains will recover from those impacts before the next game. If there is a significant decrease in scores compared to baseline prior to the next game this will show a correlation between sub-concussive blows and decreased
neurocognitive performance. If it is determined that the players are deficient, this will suggest that SCHI can have a cumulative effect, which could eventually lead to a concussion. If there is a detrimental effect from SCHI, a recommendation could be made as to how many days apart games should be played.

The expected outcome of this study includes, 1) an insight into the frequency of head impacts sustained by collegiate men’s lacrosse players during a regular game, 2) and an understanding of clinical reaction time, oculomotor function, and concussion symptoms after a contact-intensive exercise bout compared to a non-contact intense exercise bout.
Appendix C

MEDICAL HISTORY QUESTIONNAIRE

MEDICAL HISTORY QUESTIONNAIRE

Research Study: Effects of sub-concussive head impacts on concussion-like symptoms, oculomotor function, and clinical reaction time in men's lacrosse players

Investigator: Andrew Waer, ATC
Advisor: Thomas Kaminski, PhD, ATC, FNATA, FACSM

PART 1: (All participants must fill out)
Name:______________________________________________
Age:_______ yrs. Gender(Please circle one): M F Height:_______ in.
Weight:_______ lbs.

Have you ever been diagnosed with any type of eye movement or reading disorder?
YES NO

PART 2: (For previously concussed student-athletes only)

1. Have you ever been diagnosed by a health care professional (i.e. physician, nurse, athletic trainer) as sustaining a concussion? (Please circle one) YES NO
If, yes, how many?_____
2. In the space below, can you please list the date(s) (to the best of your ability) on which your concussion(s) was/were sustained, followed by the approximate amount of time until all of your symptoms were resolved? (Ex: Jan. 2011- 4 days)

PART 3: (All participants must fill out) I, the participant, have filled out this questionnaire to the best of my ability and sign that all the above information is correct to my knowledge:

Participant’s Signature: ___________________________ Date: ___________
Appendix D

INFORMED CONSENT FORM

Title of Project: Effects of sub-concussive head impacts on concussion-related symptoms, oculomotor function, and clinical reaction time in men’s lacrosse players.

Principal Investigator (s): Andrew Waer, ATC, Thomas W. Kaminski, PhD (professor) in the Department of Kinesiology and Applied Physiology

Other Investigators: Joan Couch MS, ATC, Courtney Butterworth MS, ATC, Dr. Geoffrey Gustavsen MD

You are being asked to participate in a research study. This form tells you about the study including its purpose, what you will do if you decide to participate, and any risks and benefits of being in the study. Please read the information below and ask the research team questions about anything you do not understand before you decide whether to participate. Your participation is voluntary and you can refuse to participate or withdraw at any time without penalty or loss of benefits to which you are otherwise entitled. If you decide to participate, you will be asked to sign this form and a copy will be given to you to keep for your reference.

WHAT IS THE PURPOSE OF THIS STUDY?
The purpose of this study to examine if contacts (intentional and unintentional) to your helmet during the course of a lacrosse game have an effect on concussion related symptoms, measures of reaction time, and eye movement function in collegiate men’s lacrosse players. We intend to compare your results to women lacrosse players who do not wear helmets during their games.

WHAT WILL YOU BE ASKED TO DO?
You are one of 16 men’s or 16 women’s lacrosse players from the University of Delaware being asked to participate in this study. Your participation will involve one baseline and two post-game test sessions. Each session will require 15 minutes each for a total of 45 minutes. The day of testing please refrain from the use of alcohol, pain medications, and coffee/energy drinks. All testing will occur in the Athletic Training Research Laboratory located on the back side of the Fred Rust Ice Arena. You will be asked to complete a medical questionnaire to obtain both general health and specific information.
regarding concussion history along with a 22 symptom checklist. Along with the lab testing, there will be a videotape analysis performed based on the game video that is filmed by the team throughout the game.

Upon completion you will be given instructions on how to perform the eye movement test (King-Devick Test - Figure 1). The lab environment provides a quiet area that is free from distractions. This test requires you to read aloud a series of numbers off of an index card from left to right, as quickly as possible but without making any errors. A practice card will be given to you so that the directions are thoroughly understood. The three remaining “test” cards will then be given one at a time. The time it takes for you to complete each card will be recorded. Speed and accuracy are important.

Figure 1:

![Demonstration card and test cards](image)

You will then be asked to complete a test using a clinical reaction time apparatus (Figure 2). In this test, you will be seated on a chair with your forearm resting on a table and your hand off the edge of the surface. The investigator will be holding a dowel that has a weighted disc attached to it. When the investigator drops the dowel, you should catch it as fast as you can, this will give a measure of reaction time. Each test should take about 2 minutes to complete. After both tests are complete, you are free to leave.

Figure 2
WHAT ARE THE POTENTIAL BENEFITS?
You will not benefit directly from taking part in this research. However, it is hoped that the result of this study will add to the growing body of evidence assisting sports health-care professionals in dealing with sport-related concussions.

HOW WILL CONFIDENTIALITY BE MAINTAINED?
Data will be kept confidential and your information will be assigned a code number. The list connecting your name to this number will be kept in a locked file. When the study is completed and the data have been analyzed, the list will be destroyed. Data will be kept securely in electronic storage formats and saved indefinitely. Your name will not be used in any report. We will make every effort to keep all research records that identify you confidential to the extent permitted by law. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared. Your research records may be viewed by the University of Delaware Institutional Review Board, but the confidentiality of your records will be protected to the extent permitted by law.

WILL THERE BE ANY COSTS RELATED TO THE RESEARCH?
There are NO costs associated with your participation.

WILL THERE BE ANY COMPENSATION FOR PARTICIPATION?
You will receive NO payment for participating in the study.

WILL THERE BE ANY RISK ASSOCIATED WITH PARTICIPATION?
There is no risk of physical or psychological injury associated with participation in the study.

WHAT IF YOU ARE INJURED BECAUSE OF THE STUDY?
If you are injured during research procedures, you will be offered first aid at no cost. If you require additional medical treatment, you will be responsible for the cost.

**DO YOU HAVE TO TAKE PART IN THIS STUDY?**

Taking part in this research study is entirely voluntary. You do not have to participate in this research. If you choose to take part, you have the right to stop at any time. If you decide not to participate or if you decide to stop taking part in the research at a later date, there will be no penalty or loss of benefits to which you are otherwise entitled. Your refusal will not influence current or future relationships with the University of Delaware. As a student, if you decide not to take part in this research, your choice will have no effect on your academic status or your grade in the class.

**WHO SHOULD YOU CALL IF YOU HAVE QUESTIONS OR CONCERNS?**

If you have any questions about this study, please contact the Principal Investigators: Andrew E. Waer at 856-217-4348 or awaer@udel.edu; Dr. Thomas W. Kaminski at 302-831-6402 or kaminski@udel.edu

If you have any questions or concerns about your rights as a research participant, you may contact the University of Delaware Institutional Review Board at 302-831-2137.

______________________________________________________________  
________________________

Your signature below indicates that you are agreeing to take part in this research study. You have been informed about the study’s purpose, procedures, possible risks and benefits. You have been given the opportunity to ask questions about the research and those questions have been answered. You will be given a copy of this consent form to keep.

By signing this consent form, you indicate that you voluntarily agree to participate in this study.

________________________________       ______________________
Signature of Participant              Date

________________________________
Printed Name of Participant

________________________________       ______________________
Principal Investigator              Date
Appendix E

IRB LETTER
DATE: December 13, 2012

TO: Thomas Kaminski
FROM: University of Delaware IRB

STUDY TITLE: [404161-1] Effects of sub-concussive blows on concussion-like symptoms, oculomotor function, and simple reaction time in collegiate men's lacrosse players.

SUBMISSION TYPE: New Project

ACTION: APPROVED

APPROVAL DATE: December 13, 2012

EXPIRATION DATE: December 12, 2013

REVIEW TYPE: Expedited Review

REVIEW CATEGORY: Expedited review category # 4, 6

Thank you for your submission of New Project materials for this research study. The University of Delaware IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a study design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the study and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the study via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document.

Please note that any revision to previously approved materials must be approved by this office prior to initiation. Please use the appropriate revision forms for this procedure.

All SERIOUS and UNEXPECTED adverse events must be reported to this office. Please use the appropriate adverse event forms for this procedure. All sponsor reporting requirements should also be followed.

Please report all NON-COMPLIANCE issues or COMPLAINTS regarding this study to this office.

Please note that all research records must be retained for a minimum of three years.

Based on the risks, this project requires Continuing Review by this office on an annual basis. Please use the appropriate renewal forms for this procedure.
If you have any questions, please contact Jody-Lynn Berg at (302) 831-1119 or jbergh@udel.edu. Please include your study title and reference number in all correspondence with this office.