DOES ALTERED EMOTIONAL REGULATION MODIFY VISUAL ATTENTION AMONG INJURED ATHLETES

by

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ABSTRACT

Context: Growing evidence suggests both orthopedic and mild traumatic brain injuries (mTBI), such as concussions, may be related to underlying neuropsychological factors potentially affecting sport performance. The ability of a person to visually assess their physical surroundings, fixate on relevant cues and make expedient decisions, can potentially affect the way an individual reacts to certain situations. Within athletics, this visual attention may influence emotional regulation and alter responses that shift a person's focus, thus affecting decision-making. Past injuries are strong predictors for athletes who tend to get hurt repeatedly, despite physical rehabilitation, and the cause may be due to neuroplastic changes in the brain that affect their attention to images in their visual field and emotional regulation, such as arousal, anxiety and fear. This sequence of events may explain the high incidence of re-injury related to errors in coordination or judgment. **Objective:** The purpose of this study was to examine the interactions between visual attention, emotional regulation, and injury history/severity among athletes. **Design:** Post-test only control group design. **Participants:** 38 NCAA DI student-athletes and club sport athletes (males n=6, females n=32) from the University of Delaware between the ages of 18-30, were recruited into two groups, previously injured (n=29) and healthy controls (n=9). **Methods:** Each participant completed the Nordic Musculoskeletal Questionnaire (NMEQ-E), Concussion History Questionnaire, Competitive State Anxiety Inventory-2 (CSAI-2), and Extended Sheehan Disability Scale to assess injury history, psychological state, and current physical state. Participants then viewed and rated 30 IAPS images based on valance, arousal, and fear. Visual attention was measured using eye tracking instrumentation (Pupil Labs), which captured pupil dilation, eye fixations/duration and blinks. **Statistical Analysis:** A two (group) by three (neutral, fear, injury images) analysis of variance (ANOVA, $p<0.05$) was used to determine if there was a difference between injured and control groups for anxiety, levels of fear, pupil dilation, blinks, number of image fixations, and duration of image fixation among the different types of images. A one-way ANOVA was used to compare group differences in anxiety (CSAI-2). An alpha level of .05 was set a priori to represent statistical significance. An independent t-test was used to assess all dependent variables against both injured and control groups as well as to assess severity (surgery/season ending injury) and frequency (days out of activity) within the control group. Chi square analysis was used when necessary when dependent variables were binary. **Results:** Individuals with one injury or greater, including season ending injuries and/or surgery, reported significant more total days out and total number of injuries when compared to the control group ($p<0.05$). The experimental group had a significantly larger pupil diameter when viewing pictures, however the control group reported a greater number of blinks during picture viewing. The experimental group had significantly higher arousal and fear scores ($p<0.05$), in addition to higher cognitive and somatic anxiety score, and lower self-confidence. The control group had significantly higher valance scores. Tukey post hoc tests showed several significant differences between picture types among the visual attention and emotional regulation variables, but no significant interactions were found between groups. Athletes with more severe injuries also had greater disability, arousal and fear, anxiety, and both fixation number and pupil diameter scores, but lower self-confidence. **Conclusion:** In aim one, athletes with a history of injuries present with different visual attention characteristics based on pupil diameter, fixation duration and blinks, as well as increased arousal, anxiety and current disability. In aim two, injury severity was also linked to differences in visual attention and emotion regulation. Clinicians and researcher should explore future studies and/or intervention strategies to ameliorate these characteristics, with the aspiration of minimizing the phenomena of recurring injury and disability among athletes.

Chapter 1

INTRODUCTION

Sensory information that is delivered to the brain from proprioceptive, kinesthetic, and visual sources is the basis for feedback and feed-forward neuromuscular control.[1] The high speed, dynamic and emotionally stimulating environment of competitive athletics requires quick decision making, in order to visually assess complex environments and plan coordinated movements in the near future, while also reacting to sudden unanticipated events.[1] When the neurocognitive faculties cannot function in unison with the physical demands of athletic maneuvers, musculoskeletal injuries may occur more often.[1] Not only does the environmental situation an athlete is placed in affect them at a subconscious level, but also the athlete can become consciously aware of the associated stress, and allow this phenomenon to alter the normal regulation of their emotions.[1] Thus, if stress levels begin to increase, the athlete becomes increasingly aware of the pressure being placed upon them.[2]

This scenario creates a dysfunction in the brain's emotional regulation, prompting excessive or inappropriate responses as a consequence.[3] Furthermore, these negative emotions that are experienced with injury can additionally stimulate abnormal cognition, attention, and evident psychological behaviors.[4] It is unknown how these emotions are regulated by the patient but they likely have important implications on the impact of how their pain is perceived, potentially creating altered levels in long-term function.[4] From this, researchers and clinicians can learn of the key role negative affect plays in an athlete as well as how pain is associated with suffering.[4] Additionally, it has been documented that when unanticipated events occur, they typically invoke a startle response to the individual within their central nervous system, creating a brief, but extensive change in how neuromuscular activity is prepared and achieved.[5] From this perceived emotional disturbance, studies have demonstrated a direct relationship between stress and emotional regulation, and how these may be linked to an individual becoming more prone to noncontact injuries.[5] With intense stress, the brain's visual focus fields and peripheral vision can begin to narrow and/or fixate, making individuals less aware of other potentially oncoming injurious environmental factors.[6] Moving through this dynamically evolving sport environment, requires integration of vestibular, visual, and somatosensory afferent information in order for the brain to coordinate body movements for both performance and safety.[6] The visual system specifically plays an integral part in this neurocognitive process to properly regulate motor control based on outside environmental cues.[6]

As an athlete competes in a sports related events, especially within a game situation, there is a heightened level of intensity that becomes associated with the incident.[6] Through neurocognitive testing, researchers have studied the body and brain's ability to prepare the neuromuscular system to be able to anticipate high-risk events or opposing players in a sports environment.[6] Typically, an athlete is able to cope with different levels of complexity and stress that are accompanied with their sport, however, as the intensity of a situation increases, their perception and cognitive systems can sometimes be overwhelmed with somatosensory information.[7] Consequently, the individual is then not able to mentally keep pace with the body's biomechanical demands.[7] In this situation, there can be periods of unexpected loads on the joints where the body has not had the appropriate time to plan ahead properly, and accept the impending loads, especially if the brain is unable to anticipate the correct movement strategies.[7] The mapping of this unanticipated spatial awareness through specific neural networks has recently been investigated with athletes who have sustained bilateral noncontact ACL tears.[7] Overall, this loss of concentration and spatial awareness has been linked with high stress environments and can cause the body to produce incorrect, pre-programmed levels of stiffness, and movement errors, leading to an increased risk for musculoskeletal injury.[7]

Although unanticipated events have been linked to injury, there is still an absence of literature as to where the exact connection is misinterpreted within the sensorimotor system. Additionally, most research that is being conducted on the relationship between brain function and injuries, is specific only to noncontact anterior cruciate ligament (ACL) tears, and not generally to other musculoskeletal injuries as a whole.[1,8] However recently there has been more research focused on the pure biomechanics of landing, yet little on why the athlete's brain chooses the wrong activation strategies that ultimately lead to poor biomechanics.[1] Though from this inference, the literature has shown that between 72% and 95% of ACL injuries occur from noncontact related mechanisms, as there is no player-contact present.[1] This examination demonstrates how maintaining dynamic neuromuscular control during high intensity athletic related events helps aid in appropriate muscle activation and simultaneous reflex coordination for the necessary action.[1] This is further due to the fact that regulatory feedback processing, within the cerebral cortex, has the function to adjust the reflexive motor responses after the body senses contact with the ground.[1] From here, peripheral and associative reflex pathways help activate and plan the next anticipated motor task through the feed forward processing system[1] Moreover, in order for these tasks to be appropriately and efficiently carried out, many other factors are interconnected, especially emotional regulation.

Emotional regulation and stress associated with activities of increased pressure have been shown to induce neuropsychological effects on the body.[9] This has mainly been analyzed because these high stress, unanticipated events typically instigate a startle response within the body. [6] This startle response can potentially include negative effects on emotional regulation, decreases or increases in heart rate, changes in muscle tone, awareness, and vision.[9] Furthermore, athletes with a past history of a musculoskeletal injury have been theorized to have an even larger startle response than athletes without a history of related injury.[6] Recent studies have examined the relationship between the psychological symptoms that occur after minor injuries and patient outcomes, one year post injury.[9] Additionally, this relationship is typically affected by the post-traumatic stress symptoms and psychological distress that can impact quality of life in patients with severe injuries.[9] Since one of the most overlooked areas of needed recovery post injury is an athletes psychological distress, the burden of the past injury can be carried with them for years, even after physical recovery has been completed.[9] Therefore, theoretically, psychological symptoms can affect emotional regulation in a high stress environment if an athlete is returning to play, but has yet to overcome a suppressed emotional fear and anxiety.[6] From this research, clinical applications have been implemented with health care providers who work in acute and outpatient settings, as they have been instructed to promote enhanced and early screening of psychological red flags and symptoms so these tools can be incorporated into a patient's rehabilitation if necessary.[9] However, minimal research has directly applied this knowledge specifically to athletes in return to play after injury. This is due to the fact that one of the most profound factors associated with emotional regulation is vision and the neural binding that occurs in the hippocampus to help represent working and long-term declarative or explicit memory, therefore how an individual is able to consciously recall memories and facts.[10,11] This relationship between emotional regulation and memory creates a spatial awareness as being visually attentive of one's surroundings during a high stress atmosphere is more typically necessary in athletics.[10,11] This research study will assess how the individual physiologically responds to images that possibly entice unpleasant memories.

Research has continued to show how emotional regulation and vision have been highly related.[7] Recently, experiments have been conducted analyzing participants gaze patterns and directions during the utilization of different types of arousing situations.[3] Also, pupil dilation, controlled by the autonomic nervous system, has demonstrated a response to emotional arousal during the viewing of images and auditory stimuli.[7, 12] The research concluded that pupil dilation directly reflects the autonomic nervous system activation, which has also been directly linked to emotional arousal.[7,12] Additionally, research has demonstrated that pupillary changes can also be affected by how long an individual fixates on a specific image, and if that image remains, a continual cycle of emotions may be created.[7,13] Moreover, individuals have been studied on how past conditioning, such as the Pavlovian fear conditioning, directly affects eye movement and pupil size.[12] The implicit learning that is associated with subconscious awareness has also shown to be related to a degree of past knowledge when viewing an image or being subjected to an auditory stimulus.[12] Although this knowledge is important, it creates a plethora of questions for researchers. Therefore, how an individual's previous memories of musculoskeletal injury history could become a potential stressor that would affect the responding somatosensory and visual systems will look to be further evaluated.

Although pupil tracking has been studied with physiological emotional responses, and many injuries have been evaluated on their relationship with long-term function, little research has been conducted on the relationship between the emotion physiological response as well as the individual's visual attention and the correlation between past injuries, while viewing fear-provoking images. The purpose of this study is to further investigate how an individual's visual attention and emotions may relate to past musculoskeletal injury. We will look to identify the physiological relationship between visual attention (eye movement, tracking, and gaze patterns) and the emotional response from the participants viewing these fear provoking images. From this, we hypothesize that the athlete participants who have had a previous history of musculoskeletal injury will demonstrate an increased number of fixations, and increased time to fixation on the fear images, and more specifically, injury related images, as well as an overall elevation of their emotional arousal and stress response through increased levels of anxiety, when compared to athletes with minimal or no history of injury.

1.1 Specific Aims and Hypotheses

Specific Aim 1**:** To identify group differences between anxiety, physiological changes (pupil dilation), pupil fixation, blinks and perceived fear from participants with previous injuries versus controls when viewing neutral, fear provoking, and injury related images.

Hypothesis 1: Individuals who have had a previous history of injury will demonstrate higher levels of anxiety, an elevated stress response through increased pupil dilation, increased number of image fixations, increased duration of image fixation, increased number of blinks, as well as increased levels of fear on the fear and injury related images opposed to athletes with minimal or no history of injury.

Specific Aim 2: To identify the group differences between severe and non severe groups on anxiety, physiological changes (pupil dilation), pupil fixation, blinks and perceived fear from all experimental participants with previous injuries viewing neutral, fear provoking, and injury related images.

Hypothesis 2: Individuals who have had a higher severity (season ending injury, surgery, out of activity for 10 or more days) of previous injury will have higher levels of anxiety, demonstrate an elevated stress response through increased pupil dilation, increased number of image fixations, increased duration of image fixation, increased number of blinks, and have increased reported levels of fear with the fear and injury related images.

Chapter 2

METHODS

2.1 Participants

Thirty-eight volunteer participants within the range of 18-30 years of age were recruited from the University of Delaware's Division I and Club Sports teams. Subjects were recruited by word of mouth throughout spring and summer months of 2018. The college age participants were required to be regularly physically active at least three times a week for at least thirty minutes a day. The participants must also have played at least one year of varsity athletics in high school and must be currently participating on an athletic team. There were no limitations on sex/gender or ethnicity/race. The control group included 9 healthy subjects, a mixture of males (n=1) and females (n=8), with very minimal past history of musculoskeletal injuries (one or no injuries without any season ending injuries and/or surgery). The experimental group contained 29 healthy subjects, a mixture of males (n=5) and females (n=24), with a varied history of more than one musculoskeletal injuries, which included season ending injuries and athletes whom have had surgery. The Investigator(s) provided written information that explained to the prospective subject groups the following information; (1) the criteria for participation, (2) the purpose of the research and the procedures, (3) participant's right to withdraw the testing at any time without any penalty, and (4) potential benefits by participating, (5) potential risks from the research, and (6) assurance of confidentiality. All participants were asked to sign an informed consent form approved by the Human Subjects Review

Board at the University of Delaware, and completed a demographic form prior to participation. Personal information was protected using a random identification number and only approved investigators in this study had access to the data. Exclusionary criteria were as follows:

1. History of an injury or surgery on the eye or face within the past 12 months
2. Has an implanted cardiac pacemaker
3. History of neurologic disease or surgery
4. History of recurring or severe headaches/migraine
5. Current signs and symptoms of a concussion
6. History of heart or brain surgery
7. History of seizures or epilepsy
8. Pregnant
9. Currently undergoing medical treatment for any psychiatric disorders

2.2 Inventories

2.2.1 Pupil Labs

The Pupil Labs (Berlin, Germany) headset and software consist of a 3D printed eyeglass frame with built in cameras that record eye movements and gaze patterns. The open source software was installed on a lab computer that was used throughout the research study, with the frame cameras connected into the computer via USB cable. Each participant was comfortably fitted with the lightweight Pupil Labs headset. The headset's center camera (world camera) captured what the participant saw in real time, while the side camera (focus eye camera) detected and focused on the pupil activity. The Pupil

Capture aspect of the Pupil Labs software that receives the video and audio stream, tracked the participants gaze pattern on the computer, identified markers within the computer screen, streamed data to be recorded in real time, and detected the activity of the pupil.

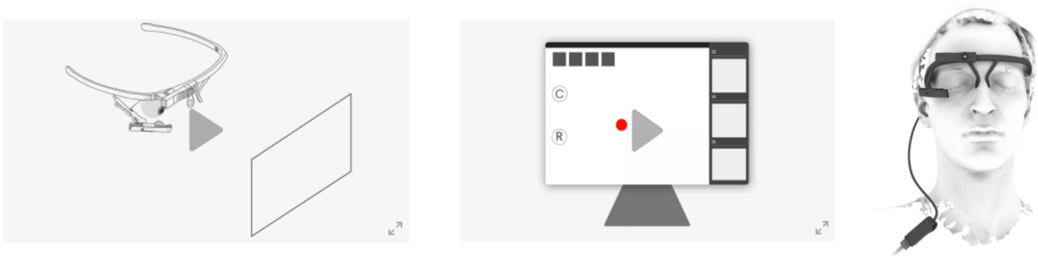


Figure 1.1: Pupil Labs Systems

2.2.2 International Affective Picture System (IAPS), Self-Assessment Manikin (SAM), and level of fear

The IAPS is a series of pictures that has been developed to induce a variety of emotions regarding judgments on two major dimensions of the SAM: affective valence, and arousal.[13] The SAM, which consists of a 9-point rating scale, represents 1 as a low rating and 9 as a high rating on each dimension.[13] The valence dimension is a ranging from 1=very unpleasant to 9=very pleasant, whereas the arousal dimension is a ranging from 1=very calm to 9=very aroused.[13] Preselected pictures (122) from the IAPS (62 pictures for neutral, 60 pictures for fear-related) will be utilized to represent the targeted neutral and fearful emotion.[13] The neutral pictures consist of neutral objects such as plants, office supplies, or a neutral human, were chosen from the range of valence (4.03-

5.20) and arousal (1.72-3.46).[13] The fear-related pictures, which include severely injured animals or humans, attacking animals, threatening people, or accident-related pictures, were chosen from the range of valence values (1.31-4.32) and arousal (5.9-7.15).[13]

Sixty sport injury-related pictures were also added to elicit fear associated with ankle, knee, back, shoulder, or hand, and were evaluated with psychophysiological responses, ratings of valence and arousal domains, level of fear and ocular tracking regulation strategies compared to the selected pictures from IAPS.[14] The criteria of sport selection were categorized into 3 common sport types according to the general injury rate and the sports supported in intercollegiate and club athletics at the University of Delaware. A picture was excluded if a resolution of the picture was lower than 1024 X 768 pixels.[14] Overall, six picture presentation sets were constructed and equally distributed such that each picture presentation set had distributed condition of 10-pictures from each neutral and fear-related type and the ranges of the valence and arousal domains, in addition to 10 sport injury-related pictures.[13, 14] The order of picture presentation sets between blocks was counterbalanced using *Latin Square* and pictures within the set were randomized across participants.[13,14] A participant's level of fear to each emotionally evocative picture were evaluated by using a 9-point Likert scale ranging from 1=not at all fearful to 9=extremely fearful.[13,14]

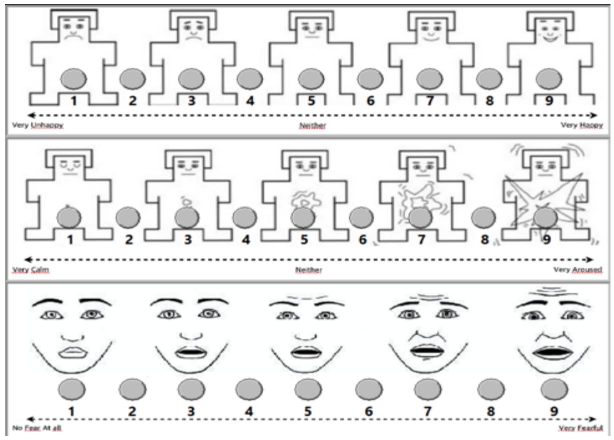


Figure 1.2. Emotion Rating Scales (***Top***; Valence, ***Middle***; Arousal, ***Bottom***; Level of Fear)

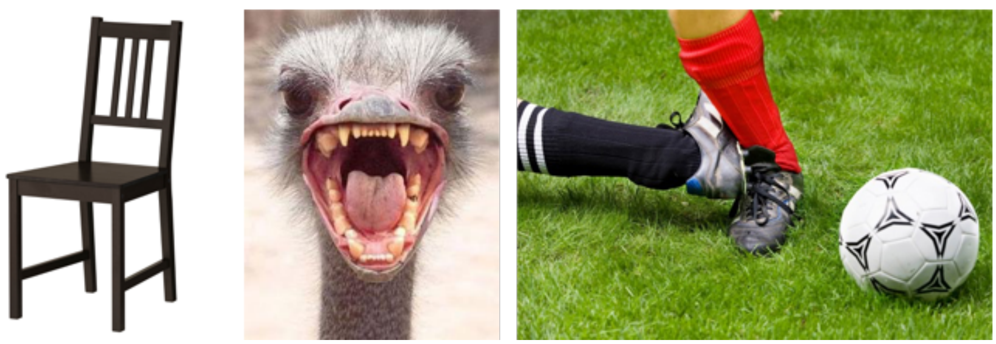


Figure 1.3. Example of Emotional Evocative Pictures: (***Left***; Neutral, ***Middle;*** Fear-related, ***Right***; Sport Injury-related)

2.2.3 Competitive State Anxiety Invetory-2 (CSAI-2):

A 27-item questionnaire that assess a multitude of different aspects of anxiety.[15,16,17,18] The CSAI-2 also has three subcategories, which include cognitive anxiety, somatic anxiety, and self-confidence, with 9 questions within each subcategory.[15,16,17,18] The questionnaire is assessed on a 4-point Likert scale, which ranges from “1=not at all” to “4=very much so.[15,16,17,18]” The scores of each subcategory are then totaled and then demonstrate the level anxiety within each component.[15,16,17,18] The values help researchers evaluate whether or not the athlete has a pre-established level of anxiety that is associated with their level of performance and if it in turn affects their outcomes. Extensive research has been done in order to establish the reliability and validity of the CSAI-2.[15,16,17,18]

2.2.4 History Questionnaires Addressing Musculoskeletal Injuries and Concussions Over Time

A 21-item Concussion History Questionnaire will assess the concussion history of an athlete including the quantity, severity, and treatment of the concussion using “yes” or “no” responses and open-ended responses.[19,20] The questionnaire also assesses in depth history of musculoskeletal injuries including the possibility of past fractures and surgeries also using “yes” or “no” responses and open-ended responses.[19,20] The Concussion History Questionnaire further includes a demographics section to assess the participant’s academic year in school, gender, and sport.[19,20] The extended version of the Nordic Musculoskeletal Questionnaire (NMQ-E) is a musculoskeletal screening tool that is used to assess past musculoskeletal injuries of the neck, shoulders, upper back, elbows, wrists/hands, hips/thighs, knees, and ankles/feet, using “yes” or “no” responses to further assess the participant’s injuries over time, specifically within the last 12 months.[21] Extensive research has been done on both questionnaires in order to establish reliability and validity.[21]

2.2.5 Sheehan Disability Scale

A brief self-report tool was used in order for the patient to rate the extent to which work/school, social life, and home life or family responsibilities are still impaired by their symptoms.[22,23] This helped researchers determine if participant is still experiencing any current disability from past musculoskeletal injuries as well as to further support injury frequency.[22,23] This was rated on a 10 point visual analog scale and the 10 point scale was then converted to a percentage and summed into a single dimension of global and functional impairment. [22,23] Recommendations have been made for individuals who score 5 or greater on any of the three separate scales as these have demonstrated to be related to significant functional impairment.[22,23] Participants also reported the days lost from injury.[22,23] The Sheehan Disability Scale has been reported to have a sensitivity of 83% and a specificity of 96% and extensive research has supported the reliability of the tool.[22,23]

2.3 Procedure:

Each subject reported to the Neuromechanics Lab at the University of Delaware for a single testing session lasting approximately one hour. Subjects were informed, before participating, that the purpose of this study is to investigate the relationship between previous injury, visual attention, and emotion using a variety of images**.** After completion of the consent form, CSAI-2, Extended Version of the Nordic Musculoskeletal Questionnaire, Concussion History Questionnaire, and Sheehan Disability Scale subjects completed the viewing of neutral, fear, and injury related images with a Pupil Labs headset device and Pupil Capture software. The subject's visual attention, fear perception, and emotion regulation were then measured while viewing the images. The participant's valance, arousal, fear, pupil diameter, number of blinks, number of fixations, and duration of fixation were measured using a predetermined rating scale and the custom Pupil Labs program.

Subjects were first asked to sit in a chair for a calibration phase of the equipment. Each participant was comfortably fitted with the Pupil Labs headset. Before calibration, the researcher made sure the pupil was properly detected. To begin, the headset and software was calibrated relative to the monitor and focused on the participant's pupil. The calibration process requires the subject to look at a series of calibration targets distributed evenly throughout the screen. Each target appeared one at a time where they are only visible for a predetermined time period through the Pupil Labs system. The total calibration process usually takes about 20 seconds to complete. The same sequence of calibration targets was then repeated for an accuracy screening. The Pupil Lab's algorithms then began to automatically detect the participant's pupils. Calibration then occurred within the system while the participant was instructed to keep their head still. The Pupil Capture software was also synchronized with a world view camera, directed at a monitor that displays the International Affective Picture System (IAPS) and a block of randomized neutral, fear, and sports injury pictures. The Pupil Capture detected the subject's pupil gaze pattern and tracked the path of their pupils across the images.

After the completion of the calibration phase, participants had two testing blocks. Each testing block was composed of 30 randomly ordered trials of images. The selected pictures were presented on 24-inch LCD monitor. Subjects had practice trials with two neutral pictures prior to the first testing block. Afterwards, each trial included a 2-sec black screen prior to picture onset (baseline), a 6-sec picture presentation, and a 12-sec emotional rating interval in which the picture was not be displayed. Subjects were then asked to rate valence (unhappy/happy), arousal (level of uneasiness), and level of fear regarding each picture. During the viewing, ocular tracking data via a custom IAPS program was collected and rating scores were separately reported for each trial. Participants were asked to keep their eyes open, but blink comfortably and normally, and to look only at the screen with the pictures during testing. Subjects were monitored and encouraged to minimize body or facial muscle movements to limit errors with pupil tracking.

2.4 Statistical Analysis

Data was analyzed using SPSS statistical software. A two (group) by three (neutral, fear, injury images) analysis of variance (ANOVA, $p<0.05$) was used to determine if there was a difference between injured and control groups for anxiety, levels of fear, pupil dilation, blinks, number of image fixations, and duration of image fixation among the different types of images. A one-way ANOVA was used to compare group differences in anxiety (CSAI-2). An alpha level of .05 was set a priori to represent statistical significance. An independent t-test was used to assess all dependent variables against both injured and control groups, as well as to assess severity (surgery/season ending injury) and frequency (days out of activity) within the injured group. Chi square analysis was used when the dependent variables were binary.

Chapter 3

RESULTS

For aim 1 the experimental group (one injury or greater including season ending injuries and/or surgery) reported significantly more total days out and total number of injuries (see Table A.1) when compared to the control group (one injury or less without any season ending injuries or surgery). The injured group also had significantly lower valance scores and significantly higher overall arousal and fear scores ($p<0.05$) (see Table A.1). Independent t-test results determined significant differences between groups for total days out, total number of injuries, number of injuries in the past 12 months, cognitive anxiety score, somatic anxiety score, self-confidence score, average pupil diameter during picture viewing, number of blinks during picture viewing, valance score during picture viewing, arousal score during picture viewing, and fear score during picture viewing (see Table A.2). All other dependent variables were not significant.

Visual Attention and Arousal

In aim 1, as observed in Figure 3.1, the experimental group reported a significantly higher cognitive anxiety score, somatic anxiety score and lower self-confidence score when compared to the control group (see Table A.2). The experimental group reported a significantly larger average pupil diameter when viewing pictures, however the control group reported a greater average of blinks during picture viewing (see Table A.2). Figure 1 demonstrates that the experimental group reported a significantly smaller overall average valance score when picture viewing, but an overall greater average of arousal and fear score during picture viewing when compared to the control group (see Table A.2).

Figure 3.1: Control vs. Experimental Group Average CSAI-2 Scores

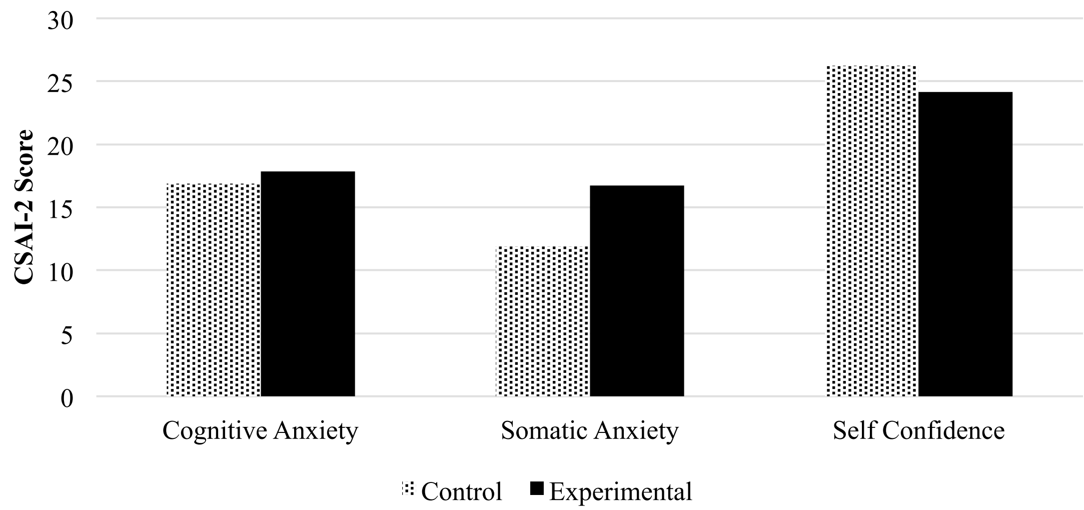
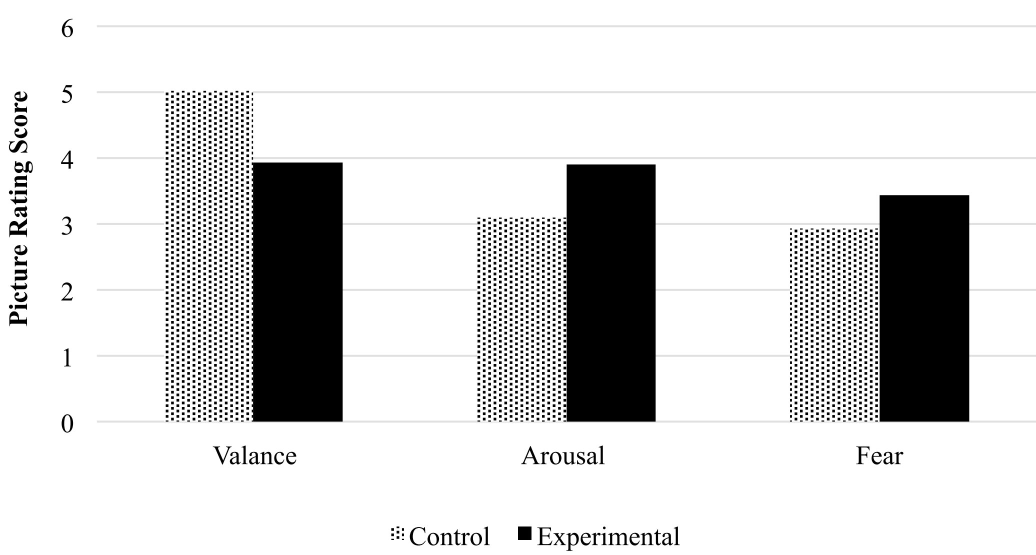


Figure 3.2: Control vs. Experimental Group Average Picture Rating Scores



Injury History

For aim 1, group statistics showed the experimental group reported an average of 44.24 total days out while the control group only reported an average of 2.89 total days out of activity (see Table A.1). The experimental group also reported an average of 2.97 total injuries while the control group only reported an average of 0.67 injuries (see Table A.2). The experimental group reported an average of 1 injury within the past 12 months while the control group reported on average 0.67 injuries in the past 12 months (see Table A.2).

For aim 2, experimental group contained 27.6% of participants that experienced a season ending injury (see Table A.3). Pearson chi-square showed a statistically significant difference between groups (see Table A.4). Experimental group contained 20.7% of participants that had surgery (see Table A.5). Pearson chi-square showed a statistically significant difference between groups (see Table A.6). Figure 3.3 demonstrates that the control group contained 44.4% of subjects with 0 concussions, 55.6% of subjects with 1 concussions and 0 subjects with 1 or more concussions (see Table A.7). Figure 3.4 shows the experimental group contained 75.9% of subjects with zero concussions, 17.6% of subjects sustaining 1 concussion, and 6.8% of subjects sustaining more than 1 concussion (see Table A.7). Pearson chi-square showed a statistically significant difference between groups (see Table A.8).

Figure 3.3: Control Group Concussion Statistics

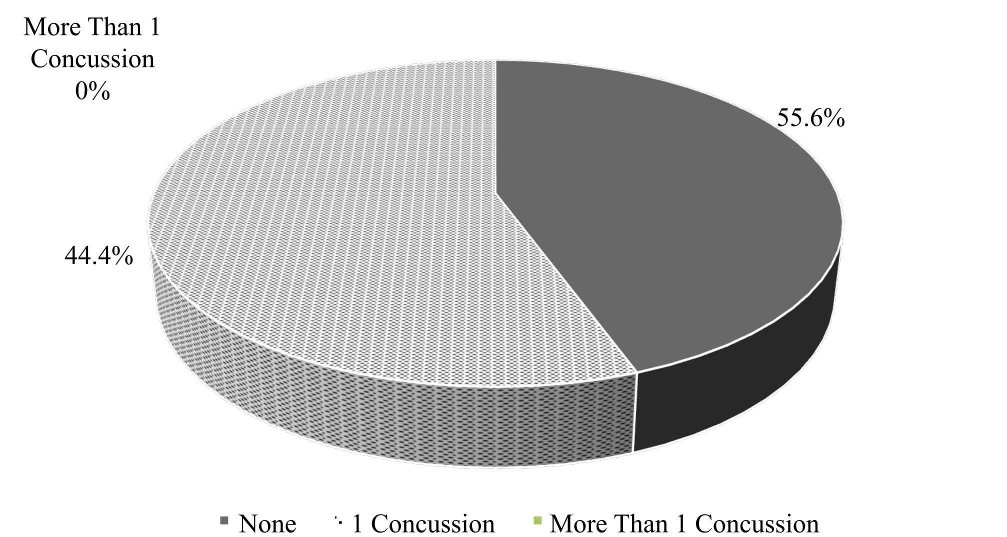
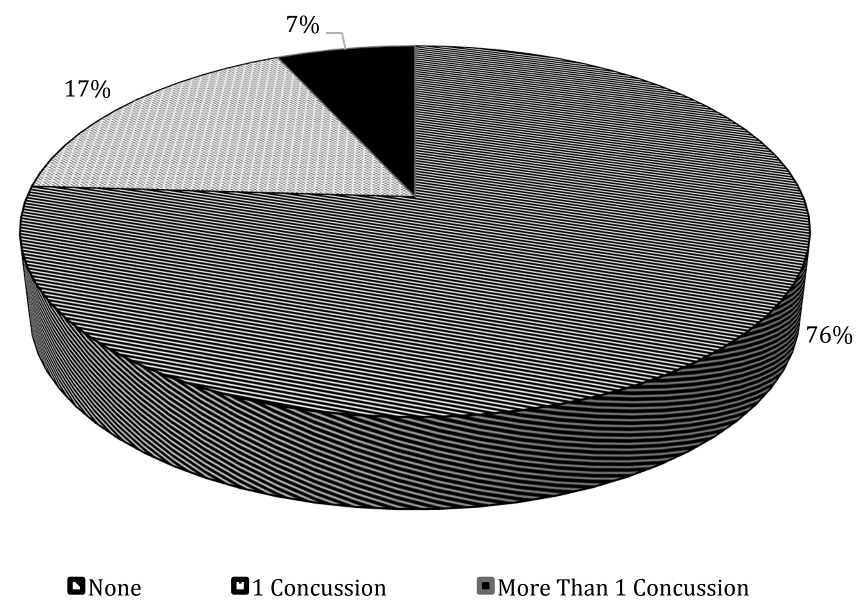


Figure 3.4: Experimental Group Concussion Statistics



Effects of Picture Type

For aim 1, two-way analysis of variance showed significant differences between picture type and longest duration of fixation, but there was no significant interaction between groups (picture type vs. control/experimental) (see Table A.10). Tukey post hoc tests showed significance between neutral and injury pictures, fearful and injury pictures, and fearful and neutral pictures (see Table A.11). For the control group longest duration of fixation occurred while viewing injury pictures (902.5ms) while the shortest duration of fixation was found while viewing the fearful pictures (837.1ms) (see Table A.9). For the experimental group, longest duration of fixation was also found when viewing the injury pictures (915. 9ms) and the shortest was also found while viewing the fearful pictures (866.6ms) (see Table A.9). However no significant interactions were found between groups.

For aim 1, significant differences between picture type and average duration of fixations were found but no significant interactions between groups were present (see Table A.13). Tukey post hoc tests shows significance was found between neutral and injury pictures as well as fearful and injury pictures with average duration of fixation during picture viewing (see Table A.14). The control group reported the longest average duration of fixation while viewing the injury pictures (523.8ms) and the shortest average duration of fixation while viewing the neutral pictures (475.81ms) (see Table A.12). Experimental group reported the longest average duration of fixation while viewing the injury pictures as well (543.8ms), but shortest average duration of fixation while viewing the fearful pictures (503.6ms) (see Table A.12). However no significant interactions were found between groups. Figure 3.5 demonstrates the longest duration of fixation, as well as the average duration of fixation for each picture type for both the control and experimental groups.

Additionally for aim 1, significant differences were found during picture type and in control/experimental groups for average pupil diameter during picture viewing, but there was no interaction between groups present (see Table A.16). Tukey post hoc test showed a significant difference between neutral and fearful pictures, as well as neutral and injury pictures for average pupil diameter during picture viewing (see Table A.17). Descriptive statistics for control group reported largest average pupil diameter during picture viewing was present while viewing fearful pictures (56.8 image pixels) while smallest average pupil diameter was reported while viewing neutral pictures (54.1 image pixels) as demonstrated in Figure 3.6 (also see Table A.15). For the experimental group, the largest average pupil diameter was found while viewing fearful pictures (60.9 image pixels) and smallest occurred while viewing neutral pictures (57.1 image pixels) (see Table A.15). However no significant interactions were found between groups (see Tables A.18-26). No other significant interactions between groups or within groups were present.

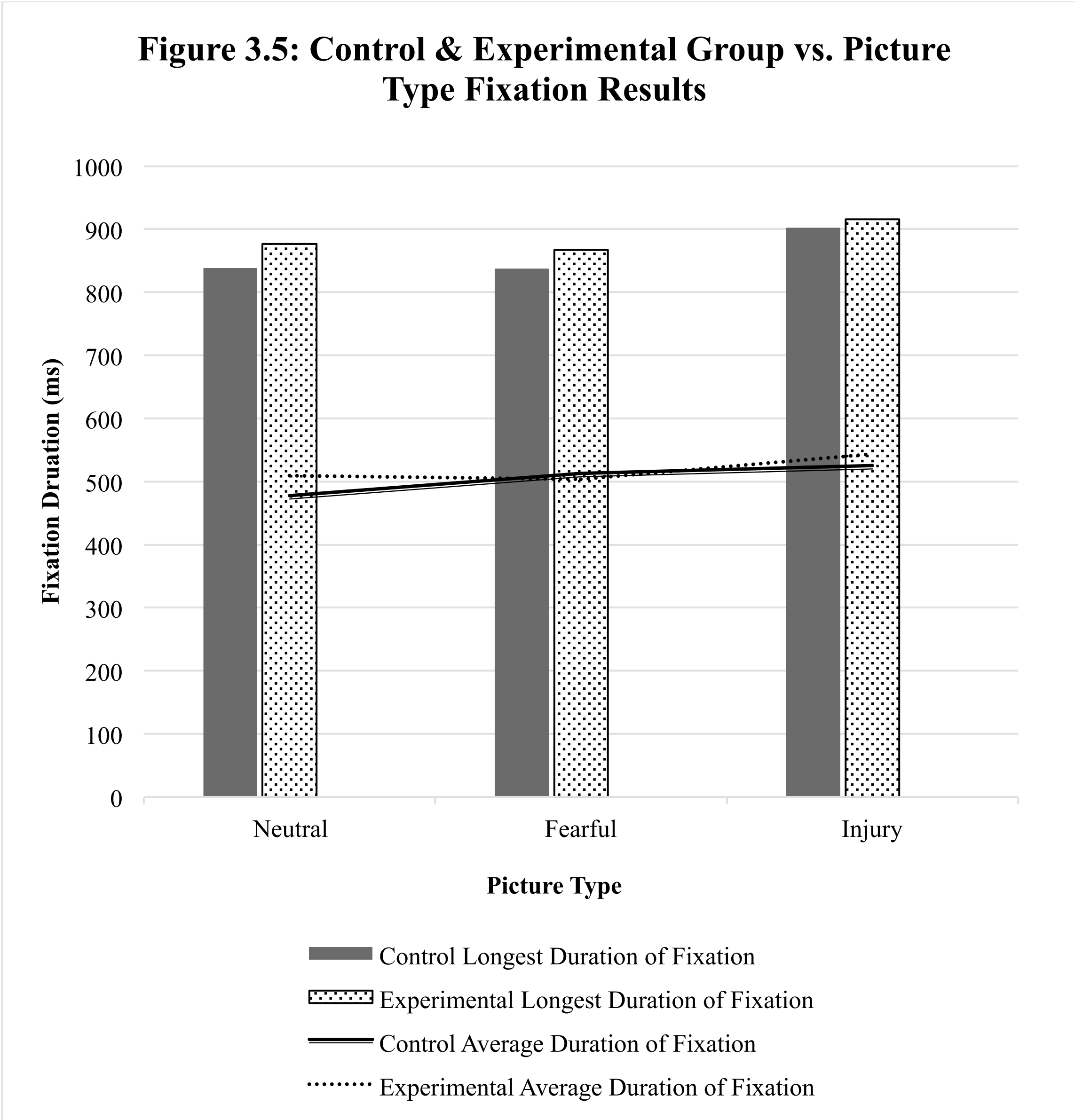
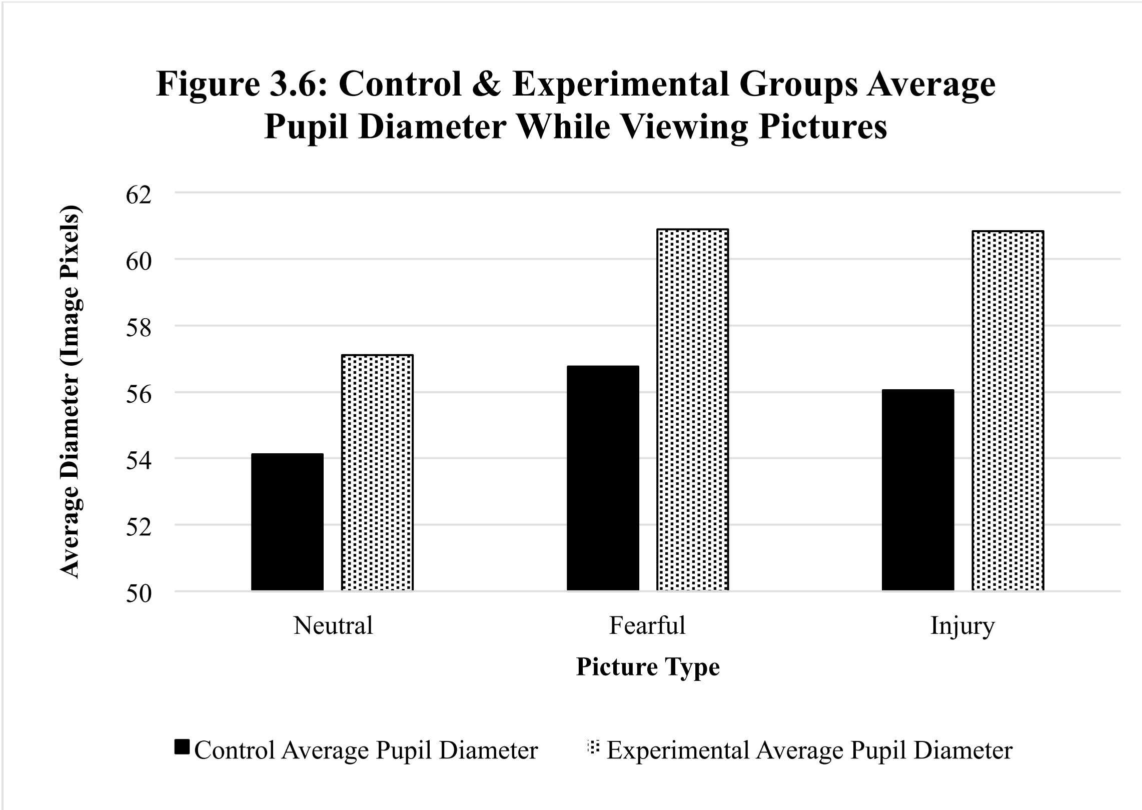


Figure 3.5: Control & Experimental Group vs. Picture Type Fixation Results
1000
900
800
700
600
500
400
300
200
100
0
Fixation Druation (ms)
Neutral
Fearful
Injury
Picture Type
Control Longest Duration of Fixation
Experimental Longest Duration of Fixation
Control Average Duration of Fixation
Experimental Average Duration of Fixation



Injury Severity

For aim 2, to assess severity within the experimental group, athletes with a season ending injury (n=8), surgery (n=6), and whom were out of activity for more than 10 days (n=18) were compared to the rest of the experimental subjects. Of the individuals who were out of activity for 10 or more days, 5 of these individuals also had season ending injuries and 4 had surgery. Significant differences were found among athletes who had a season ending injury with total days out, total number of injuries, number of injuries within the past 12 months, the Sheehan Disability Scale, cognitive anxiety score, somatic anxiety score, self-confidence score, and average pupil diameter during picture viewing (see Table A.28). All other dependent variables were found to not be significant.

Athletes with a season ending injury (aim 2) reported being out of activity for more days, (70.25 days) opposed to athletes who did not have a season ending injury (34.33 days) (see Table A.27). Athletes who had a season ending injury also reported having significantly less total number of injuries and less total number of injuries in the past 12 months ($p<0.05$) (see Table A.27-28). Athletes who had a season ending injury also reported a higher score on the Sheehan disability scale, as well as a higher cognitive anxiety score, higher somatic anxiety score and a lower self-confidence score than athletes who did not have a season ending injury (see Table A.27-28). Lastly, athletes who had a season ending injury also reported a larger average pupil diameter when viewing all pictures (see Table A27).

Significant differences were also found between athletes who reported having surgery (aim 2) and total days out, total number of injuries, total number of injuries within the past 12 months, somatic anxiety scores, self-confidence scores, number of fixations during picture viewing, average pupil diameter during picture viewing, arousal score during picture viewing, and fear score during picture viewing (see Table A.30). Group statistics found that athletes who sustained surgery reported more total days out, a lower total number of injuries, a lower total number of injuries in the past 12 months, a lower Sheehan disability score, a higher cognitive anxiety score as well as somatic anxiety score, a lower self confidence score, and a larger average pupil diameter when viewing pictures (see Table A.29).

Significant differences in the control group and athletes who have been out for 10 or more days (aim 2) were found between total days out, total number of injuries, Sheehan disability score, cognitive anxiety score, somatic anxiety score, self-confidence score, average diameter when picture viewing, valance score when picture viewing, and fear score during picture viewing (see Table A.32). Group statistics reported that athletes who were out of activity for more than 10 days reported being out for an average of 74.24 days with an average of 3.12 injuries opposed to athletes in the control group who were out for less than 10 days (see Table A.31). Athlete whom were out for more than 10 days collectivity also reported a higher Sheehan disability score, but lower cognitive and somatic anxiety scores and higher self-confidence scores (see Table A.31). Larger average pupil diameter when viewing pictures was reported for athletes who were out of activity for more than 10 days (see Table A.31). These athletes also reported a higher valance score and lower fear score then athletes in the control group who were out for less than 10 days of activity (see Table A.31).

Figure 3.7 demonstrates the CSAI-2 score differences between severe and non-severe groups while Figure 3.8 demonstrates the average pupil diameter differences while viewing pictures for severe and non-severe groups.

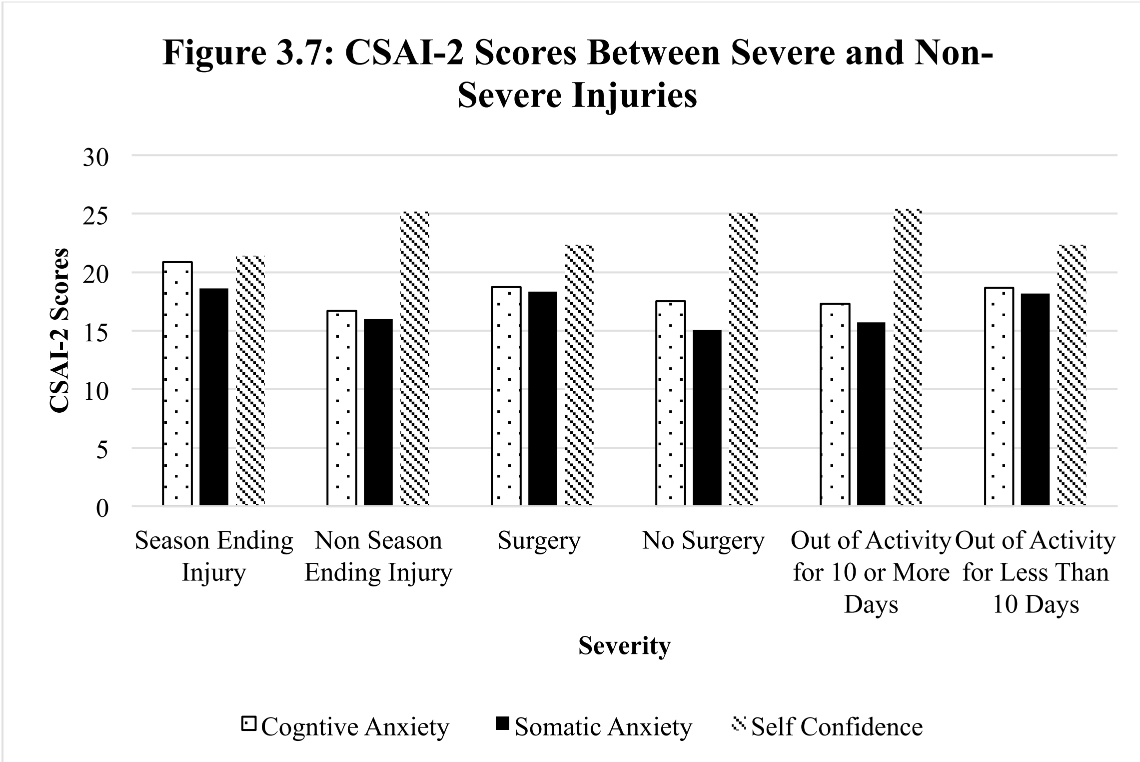


Figure 3.7: CSAI-2 Scores Between Severe and Non-Severe Injuries
CSAI-2 Scores
30
25
20
15
10
5
0
Season Ending Injury
Non Season Ending Injury
Surgery
No Surgery
Out of Activity for 10 or More Days
Out of Activity for Less Than 10 Days
Severity
Cogntive Anxiety
Somatic Anxiety
Self Confidence

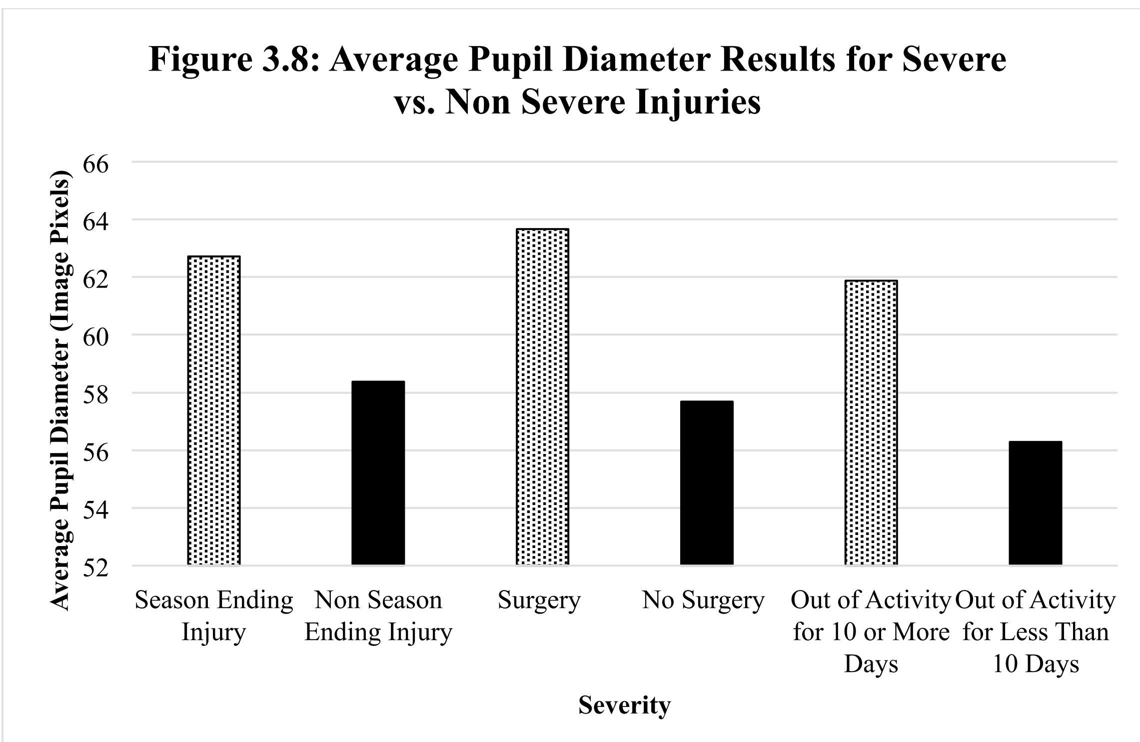


Figure 3.8: Average Pupil Diameter Results for Severe vs. Non Severe Injuries
Average Pupil Diameter (Image Pixels)
66
64
62
60
58
56
54
52
Season Ending Injury
Non Season Ending Injury
Surgery
No Surgery
Out of Activity for 10 or More Days
Out of Activity for Less Than 10 Days
Severity

Chapter 4

DISCUSSION

For this study it was hypothesized in that individuals who have had a previous history of injury (aim 1), as well as individuals who have had a higher severity of previous injury (aim 2) would demonstrate higher levels of anxiety, an elevated stress response through increased pupil dilation, increased number of image fixations, duration of image fixation, number of blinks, as well as levels of fear on the fear and injury related images opposed to athletes with minimal or no history of injury. Much research has analyzed the link between eye movements and attention processes or cognitive output such as reading and visual attention/visual screening.[3,24–26] This is relevant due to the eye-body coordination in sport as players must appropriately change their speed and direction, in response to what they are visually attending to in that moment. This is typically accomplished through learned visual cues in the environment and the individual's perception of what may happen next through visual scanning and anticipation.[3,24–26]

Additional research has found that within the visual system, the ambient pathway is important in providing information about where one is in space, helping to promote balance, movement, coordination, and posture, which are all extremely important concepts associated with high sport performance, and likely low performance associated with injuries.[25,27] When an individual is aware of where they are in space, nerve fibers from the peripheral retina are directed primarily to the midbrain, where they in turn then become a part of the sensory-motor pathway. [25,27] This is especially important in sport because it helps integrate visual external information with the internal kinesthetic, proprioceptive, vestibular, and tactile systems to help coordinate overall orientation and movement.[25,27] Thus our results partially agree with these previous studies.[28]

For the purposes of this study the experimental group included participants who reported one or more musculoskeletal injury, including season ending injuries and/or surgery, because this history was hypothesized to influence visual attention and arousal. The control group thus included participants who have had one or zero musculoskeletal injuries, without any season ending injuries and/or surgery. The results confirmed that the experimental group had a larger total number of days out of activity. Main findings (aim 1) demonstrated that the experimental group had lower valance scores, but higher arousal and fear scores when viewing any pictures. When assessing the valence scores the experimental group reported a lower average score for the neutral, fearful and injured pictures compared to the control group, demonstrating significant differences between the control and experimental groups. Next, the control group reported overall lower average scores for arousal during picture viewing for all three picture types when compared to the experimental group. Lastly, the control group also reported lower average fear scores for all three picture types when compared to the experimental group. This supports the theory that the experimental group could have found the fearful and injured pictures subconsciously more arousing and fearful on average than the control group due to their past history of musculoskeletal injuries.

Additionally, the experimental group reported higher cognitive anxiety and somatic anxiety scores and lower self-confidence scores when compared to the control group. This supports the statement that athletes with a past history of musculoskeletal injuries report higher levels of anxiety and lower self confidence levels, which can potentially effect performance due to subconscious attributes to obstacles on the playing field such as fear of re-injury and kinesiophobia as a whole. Previous research has found that this specialized type of fear has further been liked to an overall decrease in the level of performance and helps contribute to an athlete's reluctance to continue to engage in competitive sport after injury.[1,7,12] However, this can then lead to physical consequences, fear of re-injury, fear of future injury, target fixation, decreased visual acuity, altered levels of arousal, and altered attention deficits. [1,7,12]

Previous studies have also found that there is a relationship between the size of an individual's pupils and how the brain processes information cognitively.[28] The sympathetic nervous system prepares the body for direct, immediate action as well as confrontation through increasing pulse rate, pupil diameter, and blood supply to the body's large muscle groups.[25,27,29] Within the pupil, it is interesting to note that when sympathetic nervous system is activated, the ciliary muscle relaxes and forces an individual to focus their eyes at a far distance.[25,27,29] This occurs so that the individual can better behaviorally prepare for any oncoming threat.[25,27,29] Additionally, literature has also found that changes of focused attention on a bright versus a dark stimulus is accompanied by up to 33% of pupil change, while increases in pupil diameter has additionally been linked with emotional arousal and increases in stress levels. [30,31]

Thus, our results demonstrated that the experimental group on average had a larger pupil diameter during picture viewing as well. Furthermore, this is supported by the fact that both the experimental group and control group had their smallest pupil diameter while viewing the neutral images, and increases in diameter while viewing the fearful and injured picture types. Additionally, the experimental group had the highest overall average pupil diameter while viewing the injured pictures when compared to the rest of the pictures and in comparison to the control group. Demonstrating that athletes with a history of musculoskeletal injuries can have a subconscious increase in emotional arousal and/or stress while viewing fearful and injured pictures when compared to athletes who have not had a previous musculoskeletal injury.

Fixations are also studied for visual attentions and have been defined as the period of time where the eyes remain fairly still on an image, where new information is acquired from the visual input.[28] Previous literature has suggested that fixations can be properly assessed with parameters set between 75 and 100 ms,[24] however for the use of the Pupil Labs equipment, Pupil Labs operators have suggested that the minimum fixation be set to 100 ms.[32] Much research has been conducted to arrive at these numbers as it has been found that 60ms must pass before current visual information becomes available to the visual cortex for appropriate processing.[33] While additional research has determined that adding about 30ms to the original predetermined 65ms, allows for the brain to command onset of eye movement after a fixation.[34] Then an additional 10ms is also added to this equation to be able to appropriately process current stimuli before the addition of new stimuli.[34] Although there were no significant differences between the number of fixations in the control and experimental groups, the significance of the length of duration of fixation demonstrates that the experimental group fixated on all three picture types longer than the control group, with the longest duration of fixation on the injured pictures of the experimental group. Thus, this further supports that although the experimental group may not fixate any more than the control group, individuals with a history of past musculoskeletal injuries do fixate longer on certain aspects of the pictures. Furthermore suggesting that athletes with a history of musculoskeletal injuries are more likely to focus on specific aspect of an image, as opposed to healthy individuals who are more likely to scan the images

Interesting our findings negated the hypothesis that the experimental group would exhibit more blinks when viewing fearful and injury pictures opposed to the control group. Research has demonstrated that when an individual blinks, they cannot see, which impedes reaction time when responding to a visual stimulus.[35,36] From this it has been found that individuals on average blink about 15-20 times/minute, which causes about 4-5 seconds of visual suppression per minute. In turn, during sport related activity this can inhibit the athletes psychomotor performance on the field, creating susceptibility to injury when precise reaction time is necessary for response accuracy.[35,36] Additionally, eye blinking has been linked with an automatic defense response to a startling stimulus, and startle responses have been noted to be greater in individuals with greater levels of reported fear and anxiety, linking increasing blinks to increasing levels of anxiety.[35,37–39] Although the interaction of number of blinks was significant, it was significantly greater for the control group, when the experimental group was expected to have more blinks on average per picture for all picture types.[35-40] However, the experimental group had on average a lower number of blinks for each picture type when compared to the control group. This is speculated to have occurred because the experimental group was fixating longer on the images, as reflected by our findings, whereas the control group was not fixating images as long, yet blinking more often during the picture viewing.

For aim 2, when assessing severity within the experimental group all athletes that experienced a season ending injury, surgery, or who were out of activity for more than 10 days, collectively experienced more total days out of activity, more total number of injuries, a higher score on the Sheehan disability scale, altered levels of somatic anxiety as well as cognitive anxiety, a lower self-confidence score, and a larger average pupil diameter when viewing the fearful and injury picture opposed to athletes with past injuries who did not meet the severity criteria. This further supports the hypothesis that athletes with a more severe history of musculoskeletal injuries also have a history of obtaining more overall musculoskeletal injuries, as well as a higher score on the Sheehan Disability Scale indicating these individuals have a higher current impairment to their work/school, social life, and home life or family responsibilities due to their injury symptoms.

Additionally, the individuals who experienced surgery or season ending injuries reported higher levels of both somatic and cognitive anxiety as well as lower levels of self-confidence with the more severe their injuries are, which could potentially effect return to play. This has been supported in previous research that discusses how individuals that have had an athletic injury have also developed negative psychological responses such as tension, low self-esteem, depression, and anxiety.[41] In addition, fear is also a common emotion as to why athletes can be hesitant to return to sport and cause increase in anxiety.[41] When an athlete experiences these emotions, there is a greater likelihood that they will re-injure themselves as well.[42,41] Previous literature has also supported the fact that injury severity can be a similar factor as these individuals report experiencing ever more severe negative psychological emotions.[2,42–45]

Conversely, individuals who reported being out of activity for 10 or more days demonstrated the opposite results of lower levels of anxiety and higher levels of self-confidence. This could be due to the fact that of the 18 individuals who were out of activity for 10 or more days, only 5 of these individuals also had season ending injuries, and only 4 had surgery. Therefore, this suggests the potential hypothesis that these individuals overall still did not experience the severity of injuries as those with season ending injuries or surgery. However, further research is needed on the effect of severity to confirm or refute these findings.

Lastly, these individuals with a greater severity of injury also reported the greatest average of pupil diameter when viewing pictures, coinciding with the previous results stated above, indicating the subconscious emotional arousal presence that is occurring when viewing these fearful and injury pictures. Thus, the body's neuropsychological attributes are responsible for controlling and adapting situational awareness, sensory integration, motor planning, and coordination.[7,12] When an athlete demonstrates altered or inappropriate attention allocation and heightened emotional arousal, due to a history of previous injury and underlying psychological factors, the athlete puts themselves at risk for neuro-musculoskeletal injury due to overall decreased neuromuscular control.[7,12]

Previous research assessing neuropsychological testing has demonstrated that concussed patients have a lowered speed within the information-processing domain of the brain, as well as deficient cognitive processing.[46] Additional evidence has found that vestibular deficits in concussed college athletes can be noticeable for up to five days post injury.[46] This is relative due to the tight connection between the visual and vestibular systems during athletics.[46] There has also been research demonstrating the relationship between concussions and alterations in neural networks, in turn causing unintentional neuro-musculoskeletal injuries.[7,25,46,47] However, in this particular study, concussions were not noted to be a significant factor affecting outcomes within the small number control or experimental individuals and thus were not further examined

Clinicians will find this information useful as the results illustrate how previous injuries change visual attention, as does the severity of previous injuries. This may help support the importance of more research and visual training in relation to sport and sport rehabilitation during the return to play process. The use of visual training in the sport rehabilitation setting is growing in popularity and more research continues to support its methodology in addition to current rehabilitation techniques. Researchers have the hopes that with proper visual training during post injury rehabilitation, athletes can also begin to feel less anxiety and higher self-confidence when returning to sport, reducing the overall risk of injuries. These findings also indicate that there is a relationship with the more severe any injury is to an athlete and their emotional responses and anxiety levels that should be noted when clinicians are dealing with highly emotional athletes post-surgery and/or sustaining a season ending injury.

Future research should look into further examining where on an image an individual is specifically looking at, and the timing of their gaze especially when viewing injury pictures. For example, does an individual look at the injury or away from the injury, are the fixations and duration of the fixations focused on the injury or immediately away from the injury, and does the individual focus on the injured athlete's facial expressions, and does that influence their emotions towards the situation. These were all aspects that were noted anecdotally during picture evaluation in the current study, but were not feasible to analyze as variables this study.

Limitations to this study were noted to include a small sample size of only 38 participants, as well as a majority of the participants being female. All the athletes were majority NCAA Division I softball players and club sport athletes due to the availability of these athletes to the primary investigator. There was also no restriction on year in college for the participants, as some control participants could have been freshman in college whereas experimental participants being seniors in college with more competition experience. Lastly, participants were informed beforehand that they would be viewing sport injury pictures, thus athletes with a past history of musculoskeletal injuries could have had a starting larger baseline diameter when they were informed of this due to the subconscious arousal between the injury pictures and injury history relationship. This could have potentially affected the diameter results.

Chapter 5

LITERATURE REVIEW

Epidemiology

In athletics, the most common injuries occur to the musculoskeletal systems.[48] Within intercollegiate athletics, musculoskeletal injuries possess an overall rate of 63.1 per 1,000 athlete-exposures.[49] Moreover, Division I sports demonstrated 15.47 injuries per 1,000 athlete-exposures.[50] Additionally, the CDC reported a rate of 2.44 injuries per 1,000 athlete exposures for all high school sports.[51] For many musculoskeletal injuries, player-to-player contact is a large contributing factor to injury, specifically 58.0% of all injuries in games and 41.6% in practices.[50] On the other hand, noncontact injuries only account for 36.8% of injuries in practice and only 17.7% in games.[50] Thus, more then 50% of all reported injuries for the 15 different NCAA sports were to the lower extremity, predominantly the ankle and knee.[50] Furthermore over time the rates of ACL injuries as well as concussions have both demonstrated average annual increases, with ACL injuries increasing at a 1.3% rate and concussions doubling to 7.0% annual increase.[50] However, it has been reported that between 72% and 95% of injury related ACL injuries are noncontact injuries.[1,46,52] In collegiate sports, concussions have been noted to be responsible for 5%-18% of injuries, though represent up to 14% of the injuries resulting in 10 days or more of time lost from participation[50], helping to accumulate the 1.6-3.8 million concussions that occur annually in the United States.[53]

Injury Factors

When a musculoskeletal injury occurs, currently the typical conservative treatment across the board includes compression to control bleeding and inflammation, elevation, local cooling, non-steroidal anti-inflammatories, and injury specific physical therapy.[48] Thus, once an injury first transpires to the musculoskeletal system there are three distinct stages of healing that occur, including the inflammatory, repair, and remodeling phases.[48] When the body recognizes that an injury has occurred, inflammatory cells such as polymorphonuclear leukocytes flush the area of injury.[48] The leukocytes transform into macrophages in order to remove necrotic myofibers, while also utilizing fibroblasts to help produce chemotactic signals such as growth factors, cytokines, and chemokines to and from the brain.[48] To date, much research has been focused on and devoted to the therapeutic effects to promote this specific healing and regeneration to the tissues injured.[48] This is further associated with thorough literature on different rehabilitation protocols post-injury with goals to restoring function to as close to pre-injury status as possible.[48]

Sport related injuries to the musculoskeletal system can be expanded to be defined as time loss from a practice or game, decreased level of activity, and the need for medical attention.[51] In addition, musculoskeletal disorders can be categorized as requiring medical attention from the supervising physician or team Athletic Trainer, or restricting the athlete from participation for more than one day, for example.[51] Research has further demonstrated that these injuries can also be due to several varying extrinsic and intrinsic factors.[49] Extrinsic factors for musculoskeletal injuries have been known to include outside influences such footwear or playing surface.[49] Though, more recently there has been a greater focus of attention on the intrinsic factors that affect athletic injuries.[49] Therefore, these factors can potentially include an athlete's insufficient strength, high body mass index, history of previous injury, core dysfunction, landing techniques, and/or cutting biomechanics.[49] Many of these specific types of risks factors have been of a growing concern to researchers as a majority are considered modifiable, since they are related to the athlete's movement dysfunction, which is further correlated to the body's processing of coordination tasks regulated by the central nervous system.[49] Thus, if a particular risk factor has the potential to be corrected, then intervention programs can be used to target and adjust the specific adjustable problem.[49]

What research has shown is the anatomical and biomechanical intrinsic factors further influence this relationship due to training load and injury repetition as well as overall occurrence of injury.[54] While many sports require ground contact, ground reaction forces have been studied with their relationship to injury specifically while running.[54] Research has found that mechanical loading can have both positive and negative effects on the human musculoskeletal system.[55] Explanations for this theory come from current literature that discuss how despite the bio-positive effects of mechanical loading such as strengthening, the repetitive micro-trauma in conjunction with already anatomical and biomechanical variables, lead to a high potential of developing a musculoskeletal injury, especially without contact from another player.[55] Whether it is an intrinsic or extrinsic factor, predisposing individual features all lead to the possibility of non-contact musculoskeletal injuries.

Neuromuscular Control

There is one daunting aspect of sport related musculoskeletal injury that has yet to be thoroughly evaluated.[1] As discussed, there are numerous factors contributing to injuries that predispose individuals, however the underlying factor that accompany many of these injuries is the neurocognitive influences that also play a role in promoting the proper, or improper motor behavior.[1,74] When an individual is running, cutting, or landing, the ground reaction force can exceed up to five times the individuals body weight, thus in order to properly distribute these reactions, the individuals neuromuscular control complex must create, establish, and execute specific joint stabilization strategies from multiple angles.[1,74] The complex neuromuscular control includes numerous contributing factors such as proprioception, kinesthesia, visual, and vestibular body commands.[1,74] In order for this high level of motor control to be executed efficiently and effectively, the brain attend to critical environmental cues, predict forces and react to unanticipated events.[1,74] Additionally, it is pertinent that within high velocity movements, the actions that specifically occur within sport rely on the feed-forward processing to pre-program complex muscle activation strategies.[74] This in turn initiates reflex-mediated contractions in order to correctly carry out a coordinated execution of the specified task, through the cerebral cortex.[1,74]

As the body is interconnected as a whole, when there is trauma, the sensory receptors throughout the skin, muscles, and joints provide feedback to the central nervous system, including the premotor cortex, motor cortex, basal ganglia, and cerebellum.[56] This information, along with peripheral mechanoreceptors, visual receptors, and vestibular receptors throughout the body, is transmitted throughout the central nervous system to generate a motor response to the signified trauma.[56,74] Moreover, the most common motor responses the body produces include spinal reflexes, cognitive programming, and brainstem activity.[56,74] What aids in further controlling motor function from unexpected movement is the concept of proprioception and kinesthesia.[56,74] This then occurs when neural feedback is provided to the central nervous system through the cutaneous muscle and joint receptors, by means of cortical and reflex pathways, in addition to nociceptive free nerve endings in articular structures.[56,74]

Some of the mechanoreceptors that contribute to these transmissions of neural information include the Pacinian corpuscles, Ruffini ending, Ruffini corpuscles, and Golgi Tendon Organs.[56] This relationship between motor awareness with muscle and joint mechanoreceptors is supported by the neural components necessary for sensation of the said motion, as well as pain due to the trauma or injury that has occurred.[56,74] Intrafusal fibers within the muscle spindles are innervated by gamma-motor neurons, which can be influenced by several different sensory pathways, and in conjunction with the extrafusal fibers are responsible for generating muscle tone through alpha-motor neurons.[56,74] The co-contraction of alpha and gamma motor neurons is responsible for matching muscle-length tension relationships. [56] However if the muscle is unexpectedly loaded or the intrafusal fibers do not match extrafusal fiber lengths, then coordinated force production may be disrupted in the muscle.[56] This may occur under conditions where stress or fear heighten muscle tone via descending gamma motor regulation and increased spindle sensitivity.[56]

Brain's Role in Motor Control

The cerebral cortex plays an enormous role in motor control, which in turn, further dictates the brain-body connection.[27,74] For these research purposes, within the prefrontal region of the cerebral cortex there is of particularly importance.[27,74] This part of the brain is programmed to be able to coordinate many neural processes such as sending and receiving projections from all systems including sensory, motor, and many of the subcortical structures.[56,74] Furthermore, the dorsal aspect of the prefrontal cortex has privileged connections with the motor systems within the body that allows for motor control.[56,74] This area is further connected with areas of the medial frontal lobe, the premotor cortex on the lateral frontal lobe, the cerebellum, and the superior colliculus.[56,74] Interestingly enough, the prefrontal cortex can also send projections to the frontal eye fields, important for controlling voluntary shifts in gaze patterns, which will play a crucial aspect in relationship to be later discussed.[56,74] Therefore, the relationship between the premotor cortex of the cerebral cortex has been thoroughly investigated in animal studies, as there has been found to be a near identical relationship between human and monkey cerebral cortex functions, allowing for these concepts to be explored.[57,74]

Thus, when the brain sustains injury there is a cascade of consequences. In the event of a mild traumatic brain injury, first depolarization occurs and an action potential is generated, this is followed by a neurotransmitter release where there is a potassium efflux and simultaneous cellular sodium and calcium influx.[58] Next, there is an increase in membrane pumping, causing an overdrive, and thus hyperglycolysis and an overall energy crisis.[58] This is then followed by an accumulation of lactate, followed by calcium sequestration and mitochondria dysfunction.[58] The mitochondria dysfunction therefore causes a decrease in ATP production, followed by enzyme activation and apoptosis of the cell.[58] With all of these changes it is pertinent to notice the difficulties with returning an athlete to play post-concussion. The pathophysiology behind concussions is a continuum result of oxidative stress, impaired axonal transport, and altered neurotransmission.[58] Thus, it has been discussed how history of a previous concussion is associated with extended recovery in both animal and human models and if another concussion occurs, there is an increased risk for further injury, slower recovery, and increased neural vulnerability due to decreased cerebral blood flow found to last up to 10 days following concussions.[59] This has further been concluded from animal studies, demonstrating how the increased lactate accumulation causes neurons to be more vulnerable to secondary ischemic injury, allowing for potential injury.[59]

The Relationship Between Concussion History and Musculoskeletal Injury

Post-concussion, one of the most commonly reported long lasting symptoms is fatigue, and is often considered to be one of the most bothersome of the post-concussion consequences.[60] However, what research has not further evaluated are the multiple different components of fatigue that an individual can encompass, such as increased physical fatigue post-concussion.[60] Further research has from this suggested that post-concussion syndrome can affect up to 20%-30% of patients who have suffered any type of a mild-closed head injury.[61] Thus, not only can fatigue be associated with lacked concentration during aspects of sport activity, it can also contribute to motivational deficits when an athlete is returning to play.[60] It has further been evaluated that fatigue persists as a problem in concussed individuals up to 6 months post initial injury.[60] Therefore, an individual sustains a concussion various neural networks can be affected.[62] Research assessing neuropsychological testing has demonstrated that concussed patients have lowered a speed within the information-processing domain of the brain as well as deficient cognitive processing.[63] As further evidence has found that vestibular deficits in concussed college athletes can be noticeable for up to five days post injury.[63]

There has also been research demonstrating how there is a relationship between concussions causing alterations in the neural network operating system, in turn causing unintentional musculoskeletal injuries.[7,74] Further research provided evidence demonstrating how just before joint loading, there is a short period of time where the sensory integration and the complex motor system must plan, and accurately predict the next mechanical movements and forces.[7] When the brain's cerebral cortex and processing centers of executive function are unable to successfully adjust to quick changes in stimuli, this alters the course of action-planning networks, creating task uncertainty.[7] Therefore, when there is an unanticipated movement or stimuli, the body encounters a momentary loss of situational awareness and physiological startle responses may occur.[7] This in turn leads to an overall loss of neuromuscular control, in addition to the inability to appropriately regulate joint stiffness and dynamic postural stability.[7,74] Additionally, unanticipated events create a startle response within the body.[7] The startle response can create a brief, but daunting, moment of "inattentional blindness" where necessary visual cues are not being recognized.[7] When an individual is startled, it does not matter whether the type of stimuli is frightening, unanticipated, or even a friendly face, the body still physiologically responds in an extremely similar manner, by altering the normal joint stiffness-regulation patterns.[7] This has the potential for causing injury depending on the athletes immediate biomechanics and environment.[7] This theory has been evaluated through research on non-contact anterior cruciate ligament tears from uncoordinated, high velocity movement patterns.[7] The body's neuropsychological attributes are what are responsible for controlling and adapting situational awareness, sensory integration, motor planning, and coordination.[7]

Moreover, evidence provides data that the ACL can tear in less then 70 milliseconds, though the earliest reflexive response, where the body does not develop muscle tension, does not occur until at least 35 milliseconds after the body is aware of the change in a situation.[7] Furthermore, a large part of cognition is responsible for regulating adjustments in coordination, which can take up to 500 milliseconds, as well as changes in anticipatory postural adjustments.[7] Additionally, reactive muscular contractions with involuntary reflex processes are thoroughly organized in the supraspinal regions.[7] Thus, demonstrating how high velocity movements in athletic activity require advanced cognitive awareness through feed forward processing motor control.[7] Overall, the viscoelastic properties that make up the body's muscles rely on the individual anticipating the next function, such as landing, cutting, or deceleration.[7] The individual's ability to fine-tune their muscle mechanics through neural connections, has an overall effect on the muscles timing of contraction, therefore resulting in joint stiffness that can maximize performance, joint equilibrium, and overall postural stability.[7] Certain motor movements require a greater degree of stiffness then others.[7] With a greater demand of muscle stiffness, the brain uses its unconscious awareness to make necessary modifications, so consequently when motor movements include a large sense of conscious "overthinking," from heightened arousal levels, routine functional movements can be delayed or interrupted.[7]

Response to Situational Awareness

The brain's ability to maintain overall control, and redirect situational awareness from environmental cues, while also simultaneously choosing the appropriate next motor skill, is a complicated skill that determines the coordination of the next task.[7] A major component of the motor coordination system that is responsible for aiding in this process, is the visual-spatial system.[7] If there is any disorientation in the visual spatial relationship, task uncertainty is typically high.[7] This could include multiple factors such as suddenly changing tasks or if multiple tasks are being approached at one time.[7] Typically, competitive athletes are proficient in their sport specific activity, however whenever high speed, complex movements, and heightened cognitive awareness are required, the stress can lead to failure when attempting to meet the necessary neurocognitive and biomechanical demands.[7]

Additionally, the anticipatory movements of other muscles of the body have been studied as well.[14] Within the shoulder, rapid flexion causes an anterior shift in the center of mass of the body, along with equal and opposite reactive moments, simultaneously causing trunk flexion, counteracted by posterior muscles including the erector spinae group, hamstrings, and gastrocnemius complex.[14] Furthermore, trunk muscles including the transversus abdominis and internal oblique, are also activated through shoulder flexion by contributing to lumbar spine stability through tightening of the thoracolumbar fascia.[14] In order to further maintain postural stability during unexpected sudden movements, the contralateral internal oblique muscles rotate the trunk away from the moving limb, opposing forces from the flexed shoulder.[14]

Interestingly, there has been data suggesting that the order in which the feed forward processing system activates trunk stability, is age-dependent.[14] Moreover, this muscle pattern has been noted to occur in a predominately distal to proximal pattern of muscle fiber recruitment, noted in a study of children ages 8-12 during rapid arm flexion.[14] What researchers observed were ipsilateral activity occurring in the biceps femoris first, then erector spinae, and lastly the anterior deltoid.[14] However, postural muscle activity can also be influenced by physical restraints of the task such as task symmetry, direction, speed, load, and dominance; while also being influenced by behavioral context such as level of task certainty and condition of the movement time.[14] Thus, a complex reaction-time task, such as in sport specific activity, increases variability through the several alternative unpredictable stimuli.[14] Research has also noted that when adults demonstrated uncertainty in a specific complex task, there is an increased onset of latency of postural muscles, decreasing the preparation the muscles have to respond to the stimuli.[14] Nevertheless, when memory becomes involved, separate muscle patterns are recognized.[14]

Visual Attention

There is a tremendously important difference between nontrivial learning, from memory, and it is the individual's ability to generalize.[64] This is especially significant when it is applied to motor learning.[64] Within the brain, the ability to generalize typically depends on the architectural foundation of the neural networks established during the process of learning, opposed to the specific standard rules of synaptic plasticity.[64,74] What is most interesting to note in this network, is how this ability to generalize begins with the relationship that is established between the visual and motor systems.[64,74] Neurons throughout different levels of the visual cortex are all simultaneously in tune, all responding to particular input patterns, each maximizing their attributed value in order for the brain to interpret a specific direction of movement and orientation.[64,74] Typically, visual recognition relies on older, more highly developed neurons, which respond selectively to the precise combination of presented visual features.[64,74] Within the visual cortex, circuits deep in the infratemporal cortex and prefrontal cortex combine the activities of neurons to tune into different objects, allowing focus to alter between learned past experiences while using recognition tasks such as identification and categorization, to identify outside entities further affecting the body's response to the external situation.[64] This then leads the brain to create a finely tuned system of visual neurons, creating one output from several inputs.[64,74] From this, the output is generated through the connection of interneurons and motor neurons in the spinal cord.[64,74] Within the motor areas of the frontal lobe, neurons that encompass similar preferred directions are interwoven with mini-columns.[64,74] Thus, during the visual-motor connection, the primary motor cortex, supplementary motor cortex, and dorsal premotor areas, adapt to stimuli from neuronal activity from exposure to mechanical loads.[64,74]

One of the most common musculoskeletal injuries that occur in athletics is the anterior cruciate ligament (ACL) rupture, thus it is widely used as a model for motor control in musculoskeletal injuries.[6] Within the United States, the lifetime burden of ACL injuries ranges from $7.6 to $17.7 billion per year.[6] As the injury is at such a high incidence, the ACL has prompted numerous studies to use this structure as a model to investigate the loss of motor control and coordination to the musculoskeletal system during injury.[65,66] Furthermore, this injury is accompanied by potential decreased lifelong physical activity and work productivity due to the likelihood of osteoarthritis.[6] In addition, there is also a 30% re-tear rate after an individual is cleared to return to sport, due to the difficulty in returning to pre-injury activity status.[6] Currently, ACL reconstruction rehabilitation targets neuromuscular training which overall seeks to reestablish biomechanical factors such as strength, balance, and plyometric capability.[6] However, little consideration is typically given to the cognitive and neurological components of the individual that are affected post-injury.[6] Recently, studies have demonstrated how unresolved neuroplastic alterations after a musculoskeletal injury can in turn limit the potential of gaining optimal function when an athlete is returning to sport.[6] Thus, improvements specific to the sensorimotor system can help restore the decreased neurological function, improving the overall neuromuscular network.[6]

Neuroplasticity

In a functional athletic environment, the interaction between dynamic muscle motor patterns is constantly being adjusted through the changing visual surroundings.[6] Therefore, although the internal focus of ACL rehabilitation including muscle contraction and control of excessive knee valgus is necessary, so is the need for an external focus of control where attention is directed to the ever-changing environment through the automatic motor control.[6] Through this evolving environment, there are three primary afferent pathways mentioned earlier, including the vestibular, visual, and somatosensory, in order for the body to maintain necessary stability during movement.[6] The visual system specifically plays an integral part in this connection through providing sufficient afferent input to the central nervous system in order to properly regulate motor control from outside environmental interaction.[6] This then exhibits the prominence of visual feedback from the closed-loop processing of the sensory-to-motor feedback loop.[6] This has been studied in ACL reconstruction patients, as trauma to the ACL has been shown to actually alter how the nervous system processes those sensory-motor connections.[6] By pin-pointing the injury induced sensory motor plasticity, a unique opportunity is presented in order to improve the overall translation of the neuromuscular system.[6]

This has also been studied in animal models with ACL ruptures, where the ACL mechanoreceptor and afferent connection traced from the spinal cord to brain stem, to cerebral cortex, are interrupted, thus interrupting proprioception and reflex function.[6] In human models, this loss of afferent connection is further revealed through altered, or even absent, somatosensory-evoked potentials when the common peroneal nerve or the ACL directly, is stimulated.[6] This loss of connection, in addition to pain, compensations that begin to develop, and the overall inflammatory process, contribute to altering to the foundation of the somatosensory feedback that begins in the knee.[6] These alterations further disrupt the gamma motor neuron function, effecting the perturbation reflexes that the body relies on to properly maintain neuromuscular control to when the environment stimuli is changed.[6] Thus, just like when any other body part is injured, compensations arise, so when this neural pathway is interrupted, alpha motor neurons begin to demonstrate a driving force in engaging in supplementary mechanisms such as an increase in utilization of enhanced visual feedback, to make up for the loss of resources that once helped the central nervous system maintain awareness of the joint's stability.[6]

Though, what may patients are unaware of during their ACL rehabilitation is that the neural deficits that are lost when a rupture occurs, are not repaired during surgery, in fact, these deficits can actually begin to extend bilaterally.[6] This is due to the fact hat the body operates in a highly complementary movement; such that the motor control, reflex, and proprioception can be affected bilaterally due to the alterations is supraspinal and spinal mechanisms.[6] The altered neuroplasticity, mechanical function, and biological function of the joint creates a disconnect in the body's overall joint position sense, movement detection, and force sense.[6] This was further proved when electroencephalography[67] was used to evaluate fore and joint-sense tasks in individuals with ACL reconstruction.[6] In these patients, there was a notable increase in brain activation in the attentional and sensory areas due to less neural efficiency and increased neural load, but still creating a decrease in proprioception ability.[6] Thus, this draws the conclusion that ACL reconstructions create an overall deafferentation of the nervous system that cannot be repaired through surgical interventions.[6] The theory of partial deafferentation has been further evaluated through transcranial magnetic stimulation of the efferent pathways between the relationship of the brain and quadriceps.[6] Results showed increased cortiocmotor excitability in individuals with ACL injuries, leading to an increased excitability in the resting motor cortex from affected sensory feedback processing.[6] When this mechanism is increased, there is risk of increase in the potential feed forward processing pathways through decreasing the threshold of connections with lowered altered motor planning areas of the plain, allowing for input from other sensory sources.[6]

Additionally during movement, there is an increased level in cortical drive in ACL reconstruction patients, demonstrating the greater amount of co-contraction and muscle guarding noticed after the injury occurs.[6] This neuromuscular control strategy is consistent with an increase in internal focus of control due to conscious awareness and awareness of the injured joint opposed to the external environment.[6] Typically the early stages of a rehabilitation protocol are focused on restoring muscle function, and the only internally focused feedback is thinking about maintain “quad contraction,” “keeping knees over toes,” and “bend your knee,” in order to better restore the muscle function and movement.[6] When these motor learning principles are specifically applied to neuromuscular during rehabilitation, the motor control and focus factors are normally subconsciously transferred to the athletic field, therefore conscious attention can now be focused on the surrounding environment.[6]

Thus, if subconscious changes can be made during rehabilitation through muscle memory to allow the muscle to function at a level that the individual is not thinking about, the visual, and somatosensory system should be able to also stimulate a neuroplastic effect to induce the visual feedback system to regulate stability through memory.[6] Through neurocognitive testing, researchers have developed the ability to prepare the neuromuscular system to be able to anticipate high-risk events or opposing players in a sports environment.[6] Therefore, this topic has been discussed that if clinicians begin to incorporate visual-motor related activities where dual-task function is required during rehabilitation, there is the belief that an individual could progress towards a cognitive autonomous stage of exercise where environmental stimuli is not a conscious threat to the individual.[6] Methods that have been studied to help develop this theory include incorporating other non-injured players into the rehabilitation process to help stimulate sudden direction changes and target acquisition.[6]

Additionally, virtual reality stimulations have demonstrated have become a growing vision-based intervention for improving the interconnected visual, motor, and somatosensory relationship during rehabilitation, enhancing the overall visual processing system.[6] Furthermore, Deutsch reported that virtual reality and gaming systems allow for improved multi-sensory feedback about the performance and also the results.[68] Both the hardware that is available as well as the stimulus for the goal directed movement help promote positive changes to the motor behavior system.[68] Custom built lab systems as well as off the shelf commercial systems have both been trialed and have demonstrated positive effects.[68] These tools have allowed individuals with multiple different types of musculoskeletal injuries to navigate through a virtual reality while engaging and developing their visual, auditory, and haptic effects by means of realism, increased difficulty in mobility, as well as sensory input.[68]

However, there is an additional concept that affects the sport participating individual that also tends to have little recognition during the return to play process. Recently, there has been an exponential growth in the level of training intensity that is associated with youth athletes for non-athletic related reasons.[69, 46] Youth athletes have reported that they continue to compete because they feel almost compelled to over-train by either a parent or coach.[70] Studies have also noted current trends towards early sports specialization that places a high demand of stress and burn-out, as these youth athletes are given minimal time to recover properly, and thus their physical and mental states suffer the consequences at an early age.[70] Moreover, when this mindset of "pushing through," develops at such an early age, athletes begin to believe that ignoring pain, sacrificing their health, and searching for performance success, becomes a normative culture that is carried throughout their athletic career.[70] Additionally, this socio-culture can cause consequences of not just orthopedic damage but also psychosocial inferences such anxiety, confidence, and interpersonal relationship.[70]

Wadey, et al, reported that although 90% of ACL reconstruction patients were found to have achieved normal knee function according to clinical indications, only 63% returned to pre-injury levels of participation, and only 44% retuned to playing competitively.[71] These findings indicate that there is a deeper contribution to the decrease in return to competitive sport following injury, such as psychological factors.[71] The

Integrated Model of Psychological Response to the Sport Injury and Rehabilitation Process,[69] suggested that there is a direct relationship between cognitive and behavioral responses as well as psychosocial and physical rehabilitation outcomes, which have been affected by pre-injury and post-injury factors.[71] Research has suggested that biological factors have a reciprocal relationship with psychological factors that are thus directly related to rehabilitation outcomes post-injury.[71] Brewer's research in 2010 showed findings of how cognitive, affective, and behavioral responses were highly correlated with measurable rehabilitation outcomes such as functional stability, knee laxity, and time to recovery.[71] Furthermore, this study reported how the addition of psychological skills such as goal-setting, imagery, and relaxation, when added into the rehabilitation process created desirable outcomes including reduced pain and increased overall muscle strength.[2,71]

Anxiety and Injury

However, one of the most commonly noticed psychological factors that affect rehabilitation outcomes is re-injury anxiety.[71] This emotional response has been proved to be a psychological barrier impeding the recovery process and one of the largest concerns of injured athletes returning to competitive sport.[71] Thus, when an athlete is coming to the end of their rehabilitation process, and becoming closer and closer to receiving full clearance, the re-injury anxiety creates an overall negatively toned emotional response, in addition to apparent cognitive and somatic symptoms.[71] These symptoms can include but are not limited to negative thoughts, negative images, the feeling of nausea, and an increase in feeling tense.[71] These feelings have been noticed to be especially heightened when the individual goes through the same type of motion that caused the injury or is playing in the same location where the injury occurred.[71] Furthermore, these implications have also been associated with the worry of repeating surgery, lack of confidence in the injured body part, and the overthinking of potential setbacks.[71] Re-injury anxiety has been since noted to be one of the largest reasons that athletes decide to reduce their competitive competition or end their participation altogether.[71]

Additionally, further research has discussed how re-injury anxiety has different dimensions that need to be individually assessed.[71] These dimensions include the intensity of the re-injury anxiety, the frequency of the anxiety, and the direction of the anxiety.[71] Intensity of the re-injury anxiety refers to the amount or level of symptoms the individual is experiencing, while frequency refers to how often the individual experiences the anxiety-related thoughts and feelings, and lastly direction refers to if the anxiety is either having a positive or negative impact on the individuals rehabilitation process.[71] Though, re-injury anxiety typically takes the direction of negatively impacting the individual, as the participant tends to become more aware of their potential limitations as they return to sport.[71] Therefore, it is important for clinicians to understand how each and every injured athlete responds to the various dimensions of re-injury anxiety, as they each can manifest themselves in emotionally and physically harmful ways throughout the rehabilitation process.[71] Thus, numerous coping strategies are encouraged to be utilized throughout rehabilitation post-injury and even through the beginning stages of returning an athlete to full clearance, such as cognitive reconstructing, social support, imagery, and relaxation techniques.[71]

Emotional Regulation in Response to Injury

Two emotions that are largely related are anxiety and worry.[4] These prevalent emotions are common with persistent pain, as individuals with persistent pain typically have higher rates of anxiety disorders.[4] Though there are a vast majority of psychological factors that also require rehabilitation after injury.[72] Thus, if us as clinicians are able to help the patient addresses these concerns by raising awareness, there can be hopes to effectively prevent adverse emotional responses to injury that can ultimately disrupt the physical rehabilitation process.[72] Typically when an athlete is injured, the emotional response that occurs includes tension, anger, depression, frustration, and boredom.[72] Studies show that when an athlete is asked to rank their post injury emotional response, frustration and boredom were ranked the highest.[72] Furthermore, these negative emotions that are experienced with injury can additionally fuel cognitions, attention, and overt behaviors.[4] Though, how these emotions are regulated, by the patient may have important implications on the impact of their pain and how their pain is perceived.[4] From this, clinicians learn how much of a key role negative affect plays in an athlete as well as how pain is associated with suffering.[4]

Moreover, the significant emotion that prepares an individual for the flight or fight response, is fear.[4] Fear is characterized by an extreme reaction to situations that is a form of anxiety that can have severe consequences to our cognitions, attention, and behavior, if the individual if it is not handled appropriately. [4] Though a major difference between fear and anxiety is how fear is time limited, it can expire after the incident or occurrence has happened.[4] On the other hand, the other more common aspect of anxiety that tends to linger is worry.[4] Worry is characterized by frequent cognitive disturbances where the "what if" possibilities linger with negative and aversive connotations.[4] Therefore, the term that tends to tie all of these concepts together is kinesiophobia.[4]

From this, Kori, Miller and Todd were the first to define kinesiophobia in 1990, as "an irrational and debilitating fear of physical movement resulting from a feeling of vulnerability to painful injury or reinjury."[2,73] This specialized type of fear as further been liked to an overall decrease in the level of performance and helps contribute to an athlete's reluctance to continue to engage in competitive sport after injury.[2] However, this can lead to physical consequences. When an athlete immediately injures themselves, decreased physical activity is necessary for the healing process to properly occur, however, a general lack of healing after tissue structures have physiologically healed, can lead to decreased strength and range of motion, making activities even more painful to participate in.[2] Therefore, when injury occurs to an athlete, it can make the return to play process a worrisome event for both physical and mental aspects of the athlete.

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APPENDIX A

Table A.1: Control vs. Experimental Group Statistics

	Control vs. Experimental	N	Mean	Std. Deviation	Std. Error Mean
Total Days Out	≤ 1 injury without season ending injury and surgery	270	2.89	4.565	.278
	≥ 1 injury including season ending injuries and/or surgery	870	44.24	85.593	2.902
Total Number of Injuries	≤ 1 injury without season ending injury and surgery	270	.67	.668	.041
	≥ 1 injury including season ending injuries and/or surgery	870	2.97	1.326	.045
Number of Injuries in Past 12 Months	≤ 1 injury without season ending injury and surgery	270	.67	1.250	.076
	≥ 1 injury including season ending injuries and/or surgery	870	1.00	1.051	.036
Sheehan Disability Score	≤ 1 injury without season ending injury and surgery	270	2.11	3.040	.185
	≥ 1 injury including season ending injuries and/or surgery	870	2.62	4.644	.157
Cognitive Anxiety Score	≤ 1 injury without season ending injury and surgery	270	16.89	6.019	.366
	≥ 1 injury including season ending injuries and/or surgery	870	17.86	6.413	.217
Somatic Anxiety Score	≤ 1 injury without season ending injury and surgery	270	11.89	2.028	.123
	≥ 1 injury including season ending injuries and/or surgery	870	16.72	6.584	.223
Self Confidence Score	≤ 1 injury without season ending injury and surgery	270	26.22	5.297	.322
	≥ 1 injury including season ending injuries and/or surgery	870	24.14	5.844	.198

Number of Fixations	≤ 1 injury without season ending injury and surgery	270	5.64	1.010	.061
	≥ 1 injury including season ending injuries and/or surgery	865	5.72	1.076	.037
Longest Duration of Fixation	≤ 1 injury without season ending injury and surgery	270	859.295	225.268	13.709
	≥ 1 injury including season ending injuries and/or surgery	850	886.219	189.742	6.508
Average Duration of Fixation	≤ 1 injury without season ending injury and surgery	270	503.515	163.594	9.956
	≥ 1 injury including season ending injuries and/or surgery	850	518.880	165.704	5.683
Average Pupil Diameter During Picture Viewing (image pixels)	≤ 1 injury without season ending injury and surgery	270	55.640	13.695	.833
	≥ 1 injury including season ending injuries and/or surgery	842	59.613	17.554	.604
Number of Blinks During Picture Viewing	≤ 1 injury without season ending injury and surgery	270	1.59	1.346	.082
	≥ 1 injury including season ending injuries and/or surgery	870	1.21	1.366	.046
Valance Score During Picture Viewing	≤ 1 injury without season ending injury and surgery	270	5.02	2.263	.138
	≥ 1 injury including season ending injuries and/or surgery	870	3.93	1.859	.063
Arousal Score During Picture Viewing	≤ 1 injury without season ending injury and surgery	270	3.10	2.407	.147
	≥ 1 injury including season ending injuries and/or surgery	870	3.90	2.544	.086
Fear Score During Picture	≤ 1 injury without season ending injury and surgery	270	2.93	2.504	.152

Viewing	≥ 1 injury including season ending injuries and/or surgery	870	3.44	2.621	.089

Table A.2: Control vs. Experimental Independent Samples T-Test Statistics

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Total Days Out	Equal variances assumed	150.905	.000	-7.933	1138	.000	-41.352	5.213	-51.580	-31.125
	Equal variances not assumed			-14.185	884.765	.000	-41.352	2.915	-47.074	-35.631
Total Number of Injuries	Equal variances assumed	60.524	.000	-27.414	1138	.000	-2.299	.084	-2.463	-2.134
	Equal variances not assumed			-37.923	908.985	.000	-2.299	.061	-2.418	-2.180
Number of Injuries in Past 12 Months	Equal variances assumed	.029	.864	-4.345	1138	.000	-.333	.077	-.484	-.183
	Equal variances not assumed			-3.969	394.222	.000	-.333	.084	-.498	-.168

Sheehan Disability Scale Score	Equal variances assumed	11.983	.001	-1.693	1138	.091	-.510	.301	-1.100	.081
	Equal variances not assumed			-2.097	687.988	.036	-.510	.243	-.987	-.033
Cognitive Anxiety Score	Equal variances assumed	4.031	.045	-2.210	1138	.027	-.973	.440	-1.837	-.109
	Equal variances not assumed			-2.284	473.726	.023	-.973	.426	-1.810	-.136
Somatic Anxiety Score	Equal variances assumed	316.464	.000	-11.890	1138	.000	-4.835	.407	-5.633	-4.037
	Equal variances not assumed			-18.955	1137.969	.000	-4.835	.255	-5.336	-4.335
Self Confidence Score	Equal variances assumed	.000	.989	5.231	1138	.000	2.084	.398	1.302	2.866
	Equal variances not assumed			5.509	489.083	.000	2.084	.378	1.341	2.828
Number of Fixations	Equal variances assumed	.202	.653	-1.059	1133	.290	-.078	.074	-.223	.067
	Equal variances not assumed			-1.095	475.090	.274	-.078	.072	-.219	.062

Longest Duration of Fixations	Equal variances assumed	12.673	.000	-1.938	1118	.053	-26.923	13.892	-54.182	.335
	Equal variances not assumed			-1.774	397.507	.077	-26.923	15.175	-56.758	2.911
Average Duration of Fixations	Equal variances assumed	.496	.481	-1.331	1118	.183	-15.365	11.540	-38.008	7.278
	Equal variances not assumed			-1.340	457.505	.181	-15.365	11.464	-37.8930	7.163
Average Diameter During Picture Viewing (image pixels)	Equal variances assumed	20.570	.000	-3.401	1110	.001	-3.972	1.168	-6.264	-1.680
	Equal variances not assumed			-3.857	575.955	.000	-3.972	1.029	-5.995	-1.949
Number of Blinks During Picture Viewing	Equal variances assumed	.206	.650	3.953	1138	.000	.375	.095	.189	.561
	Equal variances not assumed			3.983	453.892	.000	.375	.094	.190	.560
Valance Score During Picture Viewing	Equal variances assumed	4.125	.042	8.009	1138	.000	1.095	.137	.826	1.363
	Equal variances not assumed			7.227	388.146	.000	1.095	.151	.797	1.392

Arousal Score During Picture Viewing	Equal variances assumed	6.598	.010	-4.530	1138	.000	-.793	.175	-1.136	-.449
	Equal variances not assumed			-4.664	470.211	.000	-.793	.170	-1.127	-.459
Fear Score During Picture Viewing	Equal variances assumed	4.735	.030	-2.871	1138	.004	-.519	.181	-.873	-.164
	Equal variances not assumed			-2.942	466.397	.003	-.519	.176	-.866	-.172

Table A.3: Season Ending Injury Crosstab Results

			Season Ending Injury		
			Yes	No	Total
IV1	≤ 1 injury without season ending injury and surgery	Count	0	270	270
		% within IV1	0.0%	100.0%	100.0%
	≥ 1 injury including season ending injuries and/or surgery	Count	240	630	870
		% within IV1	27.6%	72.4%	100.0%
Total		Count	240	900	1140
		% within IV1	21.1%	78.9%	100.0%

Table A.4: Experimental Group Season Ending Injury Chi-Square Test Results

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	94.345[a]	1	.000		
Continuity Correction[b]	92.692	1	.000		
Likelihood Ratio	148.545	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	94.262	1	.000		
N of Valid Cases	1140				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 56.84.

b. Computed only for a 2x2 table

Table A.5: Experimental Group Surgery Crosstab Results

Crosstab

			Surgery Yes	Surgery No	Total
IV1	≤ 1 injury without season ending injury and surgery	Count	0	270	270
		% within IV1	0%	100%	100.0%
	≥ 1 injury including season ending injuries and/or surgery	Count	180	690	870
		% within IV1	20.7%	79.3%	100.0%
Total		Count	180	960	1140
		% within IV1	15.8%	84.2%	100.0%

Table A.6: Experimental Group Chi-Square Test Results

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	66.336[a]	1	.000		
Continuity Correction[b]	64.789	1	.000		
Likelihood Ratio	107.371	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	66.278	1	.000		
N of Valid Cases	1140				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 42.63.

b. Computed only for a 2x2 table

Table A.7: Experimental Group Concussion Crosstab Results

Crosstab

			Concussion			
			None	1 Concussion	More Than 1 Concussion	Total
IV1	≤ 1 injury without season ending injury and surgery	Count	120	150	0	270
		% within IV1	44.4%	55.6%	0%	100.0%
	≥ 1 injury including season ending injuries and/or surgery	Count	660	151	59	870
		% within IV1	75.8%	17.4%	6.8%	100.0%
Total		Count	780	301	59	1140
		% within IV1	68.4%	26.4%	5.2%	100.0%

Table A.8: Experimental Group Surgery Chi-Square Test Results

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	161.911[a]	2	.000
Likelihood Ratio	161.085	2	.000
Linear-by-Linear Association	37.192	1	.000
N of Valid Cases	1140		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 13.97.

Table A.9: Longest Duration of Fixation Control/Experimental vs. Picture Type Descriptive Statistics

Descriptive Statistics

Dependent Variable: Longest Duration of Fixation

Control vs. Experimental	Picture Type	Mean	Std. Deviation	N
Control	Neutral	838.317	213.066	90
	Fearful	837.078	226.6810	90
	Injury	902.491	231.874	90
	Total	859.295	225.268	270
Experimental	Neutral	876.370	186.280	284
	Fearful	866.605	197.067	284
	Injury	915.891	182.6070	282
	Total	886.219	189.742	850
Total	Neutral	867.213	193.455	374

	Fearful	859.500	204.659	374
	Injury	912.649	195.415	372
	Total	879.728	199.115	1120

Table A.10: Longest Duration of Fixation Control/Experimental vs. Picture Type Between Subject Effects Results

Tests of Between-Subjects Effects

Dependent Variable: Longest Duration of Fixation

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	785578.114[a]	5	157115.623	4.016	.001	.018
Intercept	624374857.800	1	624374857.800	15960.578	.000	.935
Control vs. Experimental	149306.863	1	149306.863	3.817	.051	.003
Picture Type	546792.435	2	273396.218	6.989	.001	.012
Control vs. Experimental * Picture Type	21405.884	2	10702.942	.274	.761	.000
Error	43579473.360	1114	39119.815			
Total	911158758.800	1120				
Corrected Total	44365051.470	1119				

a. R Squared = .018 (Adjusted R Squared = .013)

Table A.11: Longest Duration of Fixation Picture Type Post Hoc Test Results

Multiple Comparisons

Dependent Variable: Longest Duration of Fixation

Tukey HSD

(I) Picture Type	(J) Picture Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Neutral	Fear	7.712	14.463	.855	-26.231	41.656
	Injury	-45.436*	14.483	.005	-79.425	-11.446
Fear	Neutral	-7.712	14.463	.855	-41.656	26.231
	Injury	-53.148*	14.483	.001	-87.138	-19.159
Injury	Neutral	45.436*	14.483	.005	11.446	79.425
	Fear	53.148*	14.483	.001	19.159	87.138

Based on observed means.

The error term is Mean Square(Error) = 39119.815.

*. The mean difference is significant at the .05 level.

Table A.12: Average Duration of Fixation Control/Experimental vs. Picture Type Descriptive Statistics

Descriptive Statistics

Dependent Variable: Average Duration of Fixation

Control vs. Experimental	Picture Type	Mean	Std. Deviation	N
Control	Neutral	475.810	151.577	90
	Fear	510.954	175.475	90
	Injury	523.781	160.859	90
	Total	503.515	163.594	270
Experimental	Neutral	509.365	167.087	284

	Fear	503.643	167.449	284
	Injury	543.807	160.169	282
	Total	518.880	165.704	850
Total	Neutral	501.291	163.922	374
	Fear	505.403	169.206	374
	Injury	538.9622	160.349	372
	Total	515.176	165.255	1120

Table A.13: Average Duration of Fixation Control/Experimental vs. Picture Type Between Subject Effects Results

Tests of Between-Subjects Effects

Dependent Variable: Average Duration of Fixation

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	426260.801[a]	5	85252.160	3.152	.008	.014
Intercept	214215739.900	1	214215739.900	7919.406	.000	.877
Control vs. Experimental	48745.943	1	48745.943	1.802	.180	.002
Picture Type	238170.771	2	119085.386	4.403	.012	.008
Control vs. Experimental * Picture Type	59234.545	2	29617.272	1.095	.335	.002
Error	30133110.900	1114	27049.471			
Total	327814907.800	1120				
Corrected Total	30559371.700	1119				

a. R Squared = .014 (Adjusted R Squared = .010)

Table A.14: Average Duration of Fixation Picture Type Post Hoc Test Results

Multiple Comparisons

Dependent Variable: Average Duration of Fixation

Tukey HSD

(I) Picture Type	(J) Picture Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Neutral	Fear	-4.112	12.027	.938	-32.337	24.113
	Injury	-37.671*	12.043	.005	-65.934	-9.407
Fear	Neutral	4.112	12.027	.938	-24.113	32.337
	Injury	-33.559*	12.043	.015	-61.822	-5.295
Injury	Neutral	37.671*	12.0431	.005	9.407	65.934
	Fear	33.559*	12.043	.015	5.295	61.822

Based on observed means.

The error term is Mean Square(Error) = 27049.471.

*. The mean difference is significant at the .05 level.

Table A.15: Average Pupil Diameter During Picture Viewing Control/Experimental vs. Picture Type Descriptive Statistics

Descriptive Statistics

Dependent Variable: Average Pupil Diameter During Picture Viewing (image pixels)

Control vs. Experimental	Picture Type	Mean	Std. Deviation	N
Control	Neutral	54.115	14.216	90
	Fear	56.756	13.598	90
	Injury	56.048	13.271	90
	Total	55.640	13.695	270
Experimental	Neutral	57.109	16.538	281
	Fear	60.894	18.230	280
	Injury	60.839	17.648	281

	Total	59.613	17.554	842
Total	Neutral	56.383	16.039	371
	Fear	59.888	17.292	370
	Injury	59.677	16.801	371
	Total	58.648	16.780	1112

a. R Squared = .020 (Adjusted R Squared = .015)

Table A.16: Average Pupil Diameter During Picture Viewing Control/Experimental Between Subject Effects Results

Tests of Between-Subjects Effects

Dependent Variable: Average Pupil Diameter During Picture Viewing (image pixels)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	6206.895[a]	5	1241.379	4.478	.000	.020
Intercept	2715754.137	1	2715754.137	9795.434	.000	.899
Control vs. Experimental	3229.140	1	3229.140	11.647	.001	.010
Picture Type	1680.045	2	840.023	3.030	.049	.005
Control vs. Experimental * Picture Type	112.742	2	56.371	.203	.816	.000
Error	306635.115	1106	277.247			
Total	4137731.351	1112				
Corrected Total	312842.010	1111				

a. R Squared = .020 (Adjusted R Squared = .015)

Table A.17: Average Pupil Diameter During Picture Viewing Picture Type Post Hoc Test Results

Multiple Comparisons

Dependent Variable: Average Diameter During Picture Viewing (image pixels)

Tukey HSD

(I) Picture Type	(J) Picture Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Neutral	Fear	-3.505*	1.223	.012	-6.376	-.634
	Injury	-3.293*	1.222	.020	-6.163	-.424
Fear	Neutral	3.505*	1.223	.012	.634	6.376
	Injury	.211	1.223	.984	-2.659	3.082
Injury	Neutral	3.293*	1.222	.020	.424	6.163
	Fear	-.211	1.223	.984	-3.082	2.659

Based on observed means.

The error term is Mean Square(Error) = 277.247.

*. The mean difference is significant at the .05 level.

Table A.18: Valance Score During Picture Viewing Control/Experimental vs. Picture Type Descriptive Statistics

Descriptive Statistics

Dependent Variable: Valance Score During Picture Viewing

Control vs. Experimental	Picture Type	Mean	Std. Deviation	N
Control	Neutral	6.14	1.700	90
	Fear	3.61	2.378	90
	Injury	5.31	1.888	90
	Total	5.02	2.263	270

Experimental	Neutral	5.06	1.573	290
	Fear	2.60	1.578	290
	Injury	4.13	1.530	290
	Total	3.93	1.859	870
Total	Neutral	5.31	1.667	380
	Fear	2.84	1.847	380
	Injury	4.41	1.696	380
	Total	4.19	2.016	1140

Table A.19: Valance Score During Picture Type Control/Experimental vs. Picture Type Between Subject Effects Results

Tests of Between-Subjects Effects

Dependent Variable: Valance Score During Picture Viewing

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1438.406[a]	5	287.681	102.305	.000	.311
Intercept	16504.624	1	16504.624	5869.375	.000	.838
Control vs. Experimental	246.898	1	246.898	87.802	.000	.072
Picture Type	879.234	2	439.617	156.337	.000	.216
Control vs. Experimental * Picture Type	1.024	2	.512	.182	.834	.000
Error	3188.797	1134	2.812			
Total	24611.000	1140				

Corrected Total	4627.203	1139				

a. R Squared = .311 (Adjusted R Squared = .308)

Table A.20: Valance Score During Picture Viewing Picture Type Post Hoc Test Results

Multiple Comparisons

Dependent Variable: Valance Score During Picture Viewing

Tukey HSD

(I) Picture Type	(J) Picture Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Neutral	Fear	2.47*	.122	.000	2.19	2.76
	Injury	.91*	.122	.000	.62	1.19
Fear	Neutral	-2.47*	.122	.000	-2.76	-2.19
	Injury	-1.57*	.122	.000	-1.85	-1.28
Injury	Neutral	-.91*	.122	.000	-1.19	-.62
	Fear	1.57*	.122	.000	1.28	1.85

Based on observed means.

The error term is Mean Square(Error) = 2.812.

*. The mean difference is significant at the .05 level.

Table A.21: Arousal Score During Picture Viewing Control/Experimental vs Picture Type Descriptive Statistics

Descriptive Statistics

Dependent Variable: Arousal Score During Picture Viewing

Control vs. Experimental	Picture Type	Mean	Std. Deviation	N
Control	Neutral	1.42	1.060	90
	Fear	4.81	2.476	90
	Injury	3.08	2.111	90
	Total	3.10	2.407	270

Experimental	Neutral	1.97	1.630	290
	Fear	5.58	2.266	290
	Injury	4.14	2.238	290
	Total	3.90	2.544	870
Total	Neutral	1.84	1.531	380
	Fear	5.40	2.338	380
	Injury	3.89	2.252	380
	Total	3.71	2.534	1140

Table A.22: Arousal Score During Picture Viewing Control/Experimental vs. Picture Type Between Subject Effect Results

Tests of Between-Subjects Effects

Dependent Variable: Arousal Score During Picture Viewing

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2569.740[a]	5	513.948	122.916	.000	.351
Intercept	10097.316	1	10097.316	2414.886	.000	.680
Control vs. Experimental	129.526	1	129.526	30.978	.000	.027
Picture Type	1690.649	2	845.324	202.169	.000	.263
Control vs. Experimental * Picture Type	9.343	2	4.672	1.117	.328	.002
Error	4741.572	1134	4.181			
Total	22992.000	1140				
Corrected Total	7311.312	1139				

a. R Squared = .351 (Adjusted R Squared = .349)

Table A.23: Valance Score During Picture Viewing Picture Type Post Hoc Test Results

Multiple Comparisons

Dependent Variable: Arousal Score During Picture Viewing

Tukey HSD

(I) Picture Type	(J) Picture Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Neutral	Fear	-3.56*	.148	.000	-3.91	-3.22
	Injury	-2.05*	.148	.000	-2.40	-1.70
Fear	Neutral	3.56*	.148	.000	3.22	3.91
	Injury	1.51*	.148	.000	1.16	1.86
Injury	Neutral	2.05*	.148	.000	1.70	2.40
	Fear	-1.51*	.148	.000	-1.86	-1.16

Based on observed means.

The error term is Mean Square(Error) = 4.181.

*. The mean difference is significant at the .05 level.

Table A.24: Fear Score During Picture Viewing Control/Experimental vs. Picture Type Descriptive Statistics

Descriptive Statistics

Dependent Variable: Fear Score During Picture Viewing

Control vs. Experimental	Picture Type	Mean	Std. Deviation	N
Control	Neutral	1.19	.701	90
	Fear	4.83	2.712	90
	Injury	2.76	2.084	90
	Total	2.93	2.504	270
Experimental	Neutral	1.48	1.209	290
	Fear	5.36	2.558	290
	Injury	3.50	2.253	290
	Total	3.44	2.621	870
Total	Neutral	1.41	1.116	380
	Fear	5.24	2.601	380
	Injury	3.32	2.234	380
	Total	3.32	2.602	1140

Table A.25: Fear Score During Picture Viewing Control/Experimental vs. Picture Type Between Subject Effects Results

Tests of Between-Subjects Effects

Dependent Variable: Fear Score During Picture Viewing

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2848.130[a]	5	569.626	132.784	.000	.369
Intercept	8362.955	1	8362.955	1949.462	.000	.632
Control vs. Experimental	55.482	1	55.482	12.933	.000	.011
Picture Type	1949.015	2	974.508	227.164	.000	.286
Control vs. Experimental * Picture Type	7.089	2	3.545	.826	.438	.001
Error	4864.721	1134	4.290			
Total	20293.000	1140				
Corrected Total	7712.852	1139				

a. R Squared = .369 (Adjusted R Squared = .366)

Table A.26: Fear Score During Picture Viewing Picture Type Post Hoc Test Results

Multiple Comparisons

Dependent Variable: Fear Score During Picture Viewing

Tukey HSD

(I) Picture Type	(J) Picture Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Neutral	Fear	-3.83*	.150	.000	-4.18	-3.48
	Injury	-1.91*	.150	.000	-2.27	-1.56
Fear	Neutral	3.83*	.150	.000	3.48	4.18
	Injury	1.92*	.150	.000	1.56	2.27

Injury	Neutral	1.91*	.150	.000	1.56	2.27
	Fear	-1.92*	.150	.000	-2.27	-1.56

Based on observed means.

The error term is Mean Square(Error) = 4.290.

*. The mean difference is significant at the .05 level.

Table A.27: Experimental Group With Season Ending Injuries Group Statistics

Group Statistics

	Season Ending Injury	N	Mean	Std. Deviation	Std. Error Mean
Total Days Out	Yes	240	70.25	109.309	7.056
	No	630	34.33	72.284	2.880
Total Number of Injuries	Yes	240	2.00	.709	.046
	No	630	3.33	1.322	.053
Number of Injuries in the Past 12 Months	Yes	240	.88	.929	.060
	No	630	1.05	1.091	.043
Sheehan Disability Scale Score	Yes	240	4.25	5.344	.345
	No	630	2.00	4.189	.167
Cognitive Anxiety Score	Yes	240	20.88	6.445	.416
	No	630	16.71	6.022	.240
Somatic Anxiety Score	Yes	240	18.63	7.745	.500
	No	630	16.00	5.933	.236
Self Confidence Score	Yes	240	21.38	6.814	.440
	No	630	25.19	5.053	.201
Number of Fixations	Yes	240	5.66	1.039	.067
	No	625	5.74	1.090	.044
Longest Duration of Fixations (ms)	Yes	237	882.659	189.515	12.310
	No	613	887.595	189.966	7.672
Average Duration of Fixations (ms)	Yes	237	517.771	167.968	10.910
	No	613	519.309	164.956	6.662

Average Pupil Diameter During Picture Viewing (image pixels)	Yes	240	62.717	13.758	.888
	No	602	58.375	18.722	.763
Number of Blinks During Picture Viewing	Yes	240	1.24	1.357	.088
	No	630	1.20	1.370	.055
Valance Score During Picture Viewing	Yes	240	4.10	1.758	.113
	No	630	3.86	1.893	.075
Arousal Score During Picture Viewing	Yes	240	3.77	2.402	.155
	No	630	3.95	2.596	.103
Fear Score During Picture Viewing	Yes	240	3.23	2.449	.158
	No	630	3.53	2.681	.107

Table A.28: Experimental Group With Season Ending Injuries Independent T-Test Results

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Total Days Out	Equal variances assumed	81.483	.000	5.629	868	.000	35.917	6.381	23.393	48.441
	Equal variances not assumed			4.713	321.868	.000	35.917	7.621	20.923	50.910

Total Number of Injuries	Equal variances assumed	96.546	.000	-14.826	868	.000	-1.333	.090	-1.510	-1.157
	Equal variances not assumed			-19.110	775.345	.000	-1.333	.070	-1.470	-1.196
Number of Injuries in the Past 12 Months	Equal variances assumed	87.089	.000	-2.170	868	.030	-.173	.080	-.329	-.016
	Equal variances not assumed			-2.331	503.304	.020	-.173	.074	-.318	-.027
Sheehan Disability Score	Equal variances assumed	38.688	.000	6.538	868	.000	2.250	.344	1.575	2.925
	Equal variances not assumed			5.872	356.596	.000	2.250	.383	1.496	3.004
Cognitive Anxiety Score	Equal variances assumed	17.785	.000	8.932	868	.000	4.161	.466	3.246	5.075
	Equal variances not assumed			8.664	407.305	.000	4.161	.480	3.217	5.105
Somatic Anxiety Score	Equal variances assumed	37.947	.000	5.338	868	.000	2.625	.492	1.660	3.590
	Equal variances not assumed			4.747	351.129	.000	2.625	.553	1.537	3.713

Self Confidence Score	Equal variances assumed	23.423	.000	-8.993	868	.000	-3.815	.424	-4.648	-2.983
	Equal variances not assumed			-7.888	343.877	.000	-3.815	.484	-4.767	-2.864
Number of Fixations	Equal variances assumed	1.101	.294	-1.029	863	.304	-.084	.082	-.244	.076
	Equal variances not assumed			-1.051	452.792	.294	-.084	.080	-.241	.073
Longest Duration of Fixation	Equal variances assumed	.581	.446	-.340	848	.734	-4.935	14.520	-33.437	23.565
	Equal variances not assumed			-.340	429.950	.734	-4.935	14.505	-33.446	23.575
Average Duration of Fixation	Equal variances assumed	.005	.946	-.121	848	.903	-1.538	12.682	-26.430	23.353
	Equal variances not assumed			-.120	422.177	.904	-1.538	12.784	-26.666	23.590
Average Diameter During Picture Viewing (image pixels)	Equal variances assumed	15.183	.000	3.259	840	.001	4.342	1.332	1.727	6.958
	Equal variances not assumed			3.709	593.515	.000	4.342	1.170	2.042	6.642

Number of Blinks During Picture Viewing	Equal variances assumed	.014	.906	.417	868	.677	.043	.104	-.160	.247
	Equal variances not assumed			.419	435.669	.675	.043	.103	-.160	.246
Valance Score During Picture Viewing	Equal variances assumed	8.901	.003	1.731	868	.084	.244	.141	-.033	.520
	Equal variances not assumed			1.790	462.527	.074	.244	.136	-.024	.512
Arousal Score During Picture Viewing	Equal variances assumed	3.235	.072	-.930	868	.353	-.179	.193	-.558	.199
	Equal variances not assumed			-.962	464.062	.336	-.179	.186	-.546	.187
Fear Score During Picture Viewing	Equal variances assumed	7.515	.006	-1.528	868	.127	-.304	.199	-.694	.086
	Equal variances not assumed			-1.591	469.763	.112	-.304	.191	-.679	.071

Table A.29: Experimental Group With Surgery Group Statistics

Group Statistics

	Surgery	N	Mean	Std. Deviation	Std. Error Mean
Total Days Out	Yes	180	121.67	152.282	11.350
	No	960	18.09	31.430	1.014

Total Number of Injuries	Yes	180	2.17	.689	.051
	No	960	2.47	1.659	.054
Number of Injuries in the Past 12 Months	Yes	180	.67	.747	.056
	No	960	.97	1.159	.037
Sheehan Disability Score	Yes	180	2.33	3.359	.250
	No	960	2.53	4.481	.145
Cognitive Anxiety Score	Yes	180	18.17	6.406	.477
	No	960	17.53	6.318	.204
Somatic Anxiety Score	Yes	180	18.33	8.057	.601
	No	960	15.06	5.626	.182
Self Confidence Score	Yes	180	22.33	7.223	.538
	No	960	25.06	5.370	.173
Number of Fixations	Yes	180	5.93	.737	.055
	No	955	5.66	1.106	.036
Longest Duration of Fixation	Yes	179	893.484	184.872	13.818
	No	941	877.112	201.697	6.575
Average Duration of Fixations	Yes	179	509.881	160.296	11.981
	No	941	516.183	166.246	5.419
Average Pupil Diameter During Picture Viewing (image pixels)	Yes	179	63.665	14.842	1.109
	No	933	57.685	16.965	.555
Number of Blinks During Picture Viewing	Yes	180	1.50	1.470	.110
	No	960	1.26	1.348	.043
Valance Score During Picture Viewing	Yes	180	4.08	1.612	.120
	No	960	4.21	2.083	.067
Arousal Score During Picture Viewing	Yes	180	3.27	2.391	.178
	No	960	3.79	2.552	.082
Fear Score During Picture Viewing	Yes	180	2.83	2.346	.175
	No	960	3.41	2.639	.085

Table A.30: Experimental Group With Surgery Independent T-Test Results

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Total Days Out	Equal variances assumed	2549.038	.000	19.051	1138	.000	103.573	5.437	92.906	114.240
	Equal variances not assumed			9.089	181.869	.000	103.573	11.396	81.088	126.058
Total Number of Injuries	Equal variances assumed	162.106	.000	-2.404	1138	.016	-.302	.126	-.549	-.056
	Equal variances not assumed			-4.072	638.607	.000	-.302	.074	-.448	-.156
Number of Injuries in the Past 12 Months	Equal variances assumed	38.569	.000	-3.366	1138	.001	-.302	.090	-.478	-.126
	Equal variances not assumed			-4.501	363.143	.000	-.302	.067	-.434	-.170
Sheehan Disability Score	Equal variances assumed	1.180	.278	-.564	1138	.573	-.198	.351	-.887	.491

	Equal variances not assumed			-.684	311.902	.494	-.198	.289	-.767	.371
Cognitive Anxiety Score	Equal variances assumed	.044	.834	1.236	1138	.217	.635	.514	-.374	1.644
	Equal variances not assumed			1.224	248.707	.222	.635	.519	-.387	1.658
Somatic Anxiety Score	Equal variances assumed	40.446	.000	6.631	1138	.000	3.271	.493	2.303	4.239
	Equal variances not assumed			5.213	212.895	.000	3.271	.627	2.034	4.508
Self Confidence Score	Equal variances assumed	28.038	.000	-5.893	1138	.000	-2.729	.463	-3.638	-1.821
	Equal variances not assumed			-4.825	217.585	.000	-2.729	.566	-3.844	-1.614
Number of Fixations	Equal variances assumed	44.555	.000	3.224	1133	.001	.277	.086	.108	.445
	Equal variances not assumed			4.222	351.446	.000	.277	.066	.148	.406
Longest Duration of Fixation (ms)	Equal variances assumed	1.757	.185	1.008	1118	.314	16.371	16.236	-15.485	48.229

	Equal variances not assumed			1.070	265.158	.286	16.371	15.302	-13.758	46.502
Average Duration of Fixations (ms)	Equal variances assumed	.021	.884	-.468	1118	.640	-6.302	13.480	-32.752	20.146
	Equal variances not assumed			-.479	256.261	.632	-6.302	13.149	-32.198	19.592
Average Pupil Diameter During Picture Viewing (image pixels)	Equal variances assumed	.043	.835	4.403	1110	.000	5.980	1.358	3.315	8.644
	Equal variances not assumed			4.820	275.126	.000	5.980	1.240	3.537	8.422
Number of Blinks During Picture Viewing	Equal variances assumed	2.827	.093	2.147	1138	.032	.239	.111	.021	.456
	Equal variances not assumed			2.023	238.711	.044	.239	.118	.006	.471
Valance Score During Picture Viewing	Equal variances assumed	14.606	.000	-.791	1138	.429	-.130	.164	-.451	.192
	Equal variances not assumed			-.941	303.107	.348	-.130	.138	-.400	.141
Arousal Score During Picture	Equal variances assumed	2.822	.093	-2.525	1138	.012	-.518	.205	-.921	-.116

Viewing	Equal variances not assumed			-2.640	261.398	.009	-.518	.196	-.905	-.132
Fear Score During Picture	Equal variances assumed	11.465	.001	-2.753	1138	.006	-.580	.211	-.994	-.167
Viewing	Equal variances not assumed			-2.983	271.154	.003	-.580	.194	-.963	-.197

Table A.31: Experimental Group Out of Activity for Ten or More Days Group Statistics

Group Statistics

	Total Days Out of Activity	N	Mean	Std. Deviation	Std. Error Mean
Total Days Out	<10 days	360	1.75	2.746	.145
	≥ 10 days	510	74.24	101.607	4.499
Total Number of Injuries	<10 days	360	2.75	1.165	.061
	≥ 10 days	510	3.12	1.411	.062
Number of Injuries in the Past 12 Months	<10 days	360	1.08	1.189	.063
	≥ 10 days	510	.94	.938	.042
Sheehan Disability Score	<10 days	360	2.00	3.769	.199
	≥ 10 days	510	3.06	5.132	.227
Cognitive Anxiety Score	<10 days	360	18.67	6.494	.342
	≥ 10 days	510	17.29	6.301	.279
Somatic Anxiety Score	<10 days	360	18.17	7.079	.373
	≥ 10 days	510	15.71	6.013	.266
Self Confidence Score	<10 days	360	22.33	5.095	.269
	≥ 10 days	510	25.41	6.006	.266
Number of Fixations	<10 days	355	5.65	1.142	.061
	≥ 10 days	510	5.77	1.026	.045

Longest Duration of Fixations (ms)	<10 days	345	892.647	176.430	9.498
	≥ 10 days	505	881.827	198.375	8.827
Average Duration of Fixations (ms)	<10 days	345	528.149	173.905	9.362
	≥ 10 days	505	512.548	159.726	7.107
Average Pupil Diameter During Picture Viewing (image pixels)	<10 days	341	56.288	18.566	1.005
	≥ 10 days	501	61.876	16.469	.735
Number of Blinks During Picture Viewing	<10 days	360	1.29	1.438	.076
	≥ 10 days	510	1.15	1.310	.058
Valance Score During Picture Viewing	<10 days	360	3.73	2.171	.114
	≥ 10 days	510	4.07	1.589	.070
Arousal Score During Picture Viewing	<10 days	360	4.04	2.779	.146
	≥ 10 days	510	3.79	2.360	.105
Fear Score During Picture Viewing	<10 days	360	4.00	2.920	.154
	≥ 10 days	510	3.05	2.311	.102

Table A.32: Experimental Group Out of Activity for Ten or More Days Independent T-Test Results

Independent Samples Test

Levene's Test for Equality of Variances		t-test for Equality of Means						
							95% Confidence Interval of the Difference	
F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper

Total Days Out	Equal variances assumed	346.897	.000	- 13.530	868	.000	-72.485	5.357	-83.000	-61.970
	Equal variances not assumed			- 16.102	510.053	.000	-72.485	4.502	-81.329	-63.641
Total Number of Injuries	Equal variances assumed	46.699	.000	-4.062	868	.000	-.368	.091	-.545	-.190
	Equal variances not assumed			-4.197	846.794	.000	-.368	.088	-.540	-.196
Number of Injuries in the Past 12 Months	Equal variances assumed	88.025	.000	1.968	868	.049	.142	.072	.000	.284
	Equal variances not assumed			1.891	654.833	.059	.142	.075	-.005	.290
Sheehan Disability Score	Equal variances assumed	38.968	.000	-3.331	868	.001	-1.059	.318	-1.683	-.435
	Equal variances not assumed			-3.508	866.640	.000	-1.059	.302	-1.651	-.466
Cognitive Anxiety Score	Equal variances assumed	.001	.969	3.125	868	.002	1.373	.439	.510	2.235
	Equal variances not assumed			3.108	758.411	.002	1.373	.442	.506	2.239

Somatic Anxiety Score	Equal variances assumed	5.925	.015	5.521	868	.000	2.461	.446	1.586	3.336
	Equal variances not assumed			5.369	691.358	.000	2.461	.458	1.561	3.361
Self Confidence Score	Equal variances assumed	12.595	.000	-7.919	868	.000	-3.078	.389	-3.841	-2.315
	Equal variances not assumed			-8.145	839.212	.000	-3.078	.378	-3.820	-2.337
Number of Fixations	Equal variances assumed	3.461	.063	-1.689	863	.092	-.126	.074	-.271	.020
	Equal variances not assumed			-1.657	708.465	.098	-.126	.076	-.274	.023
Longest Duration of Fixations (ms)	Equal variances assumed	5.904	.015	.816	848	.415	10.820	13.256	-15.198	36.838
	Equal variances not assumed			.834	791.724	.404	10.820	12.967	-14.635	36.274
Average Duration of Fixations (ms)	Equal variances assumed	1.034	.309	1.349	848	.178	15.602	11.589	-7.105	38.308
	Equal variances not assumed			1.327	696.795	.185	15.601	11.755	-7.478	38.681

Average Pupil Diameter During Picture Viewing (image pixels)	Equal variances assumed	16.881	.000	-4.588	840	.000	-5.587	1.218	-7.978	-3.197
	Equal variances not assumed			-4.485	670.846	.000	-5.587	1.245	-8.034	-3.142
Number of Blinks During Picture Viewing	Equal variances assumed	5.966	.015	1.527	868	.127	.143	.094	-.041	.328
	Equal variances not assumed			1.503	726.694	.133	.143	.095	-.044	.331
Valance Score During Picture Viewing	Equal variances assumed	49.300	.000	-2.711	868	.007	-.346	.127	-.596	-.095
	Equal variances not assumed			-2.573	619.463	.010	-.346	.134	-.609	-.082
Arousal Score During Picture Viewing	Equal variances assumed	26.605	.000	1.442	868	.150	.252	.175	-.091	.596
	Equal variances not assumed			1.402	691.230	.161	.252	.180	-.101	.606
Fear Score During Picture Viewing	Equal variances assumed	62.042	.000	5.358	868	.000	.952	.178	.603	1.300
	Equal variances not assumed			5.150	656.190	.000	.952	.185	.589	1.315

APPENDIX B

University of Delaware *IRB Approved From: 11/22/2017 to: 11/22/2018*

INFORMED CONSENT TO PARTICIPATE IN RESEARCH

Title of Project: The Relationship Between Eye Tracking, Emotion Regulation and Injury

Principal Investigator(s): Samantha Schlageter, ATC

You are being invited to participate in a research study. This consent form tells you about the study including its purpose, what you will be asked to do if you decide to take part, and the risks and benefits of being in the study. Please read the information below and ask us any questions you may have before you decide whether or not you want to participate.

WHAT IS THE PURPOSE OF THIS STUDY?

The purpose of this study is to learn more about how a person's visual attention and emotions may relate to injury. By asking about your anxiety and history of injuries, as well as observing your eye movement while you see pictures specifically chosen to cause different emotions, researchers can search for a relationship to the number and severity of past musculoskeletal injuries. This may help explain why some people have repeated injuries. We will examine eye movement, pupil dilation, emotion, and heart rate while you are viewing emotional images. We measure these while showing you different kinds of pictures chosen to cause emotion (neutral, fear-related, and injury-related pictures). You will be one of approximately 50 participants in this study.

WHY ARE YOU BEING ASKED TO PARTICIPATE?

You are being asked to participate if you are (have)…

- Between the age 18 and 30 years AND
- Participate on one of the University of Delaware's Division I athletic teams or club sports teams

You will not be able to participate in this study if you are (have)…

0. History of an injury or surgery on the eye or face within the past 12 months
1. Has an implanted cardiac pacemaker
2. History of neurologic disease or surgery
3. History of recurring or severe headaches/migraine
4. Current signs and symptoms of a concussion
5. History of heart or brain surgery
6. History of seizures or epilepsy
7. Pregnant
8. Currently undergoing medical treatment for any psychiatric disorders

WHAT WILL YOU BE ASKED TO DO?

As part of this study you will be asked to report to the Neuromechanics Laboratory Human Performance Lab located on the south campus and the Carpenter Sports Building

located on the north campus at the University of Delaware for one testing session lasting approximately 1 hour.

Following completion of this consent form, you will be asked to complete the demographic form, including an injury history questionnaire, and competitive state anxiety inventory questionnaire. After you have completed the forms, the investigator(s) will record your eye movement and heart rate while you watch three sets of pictures. There will be a small sensor to track your eye movement just below the screen you will view the images on. Prior to viewing images, you will go through a calibration process to accurately track your eye movement that lasts approximately 30 seconds. Three sensors will be attached to both your shoulders and hip to record your heart rate changes.

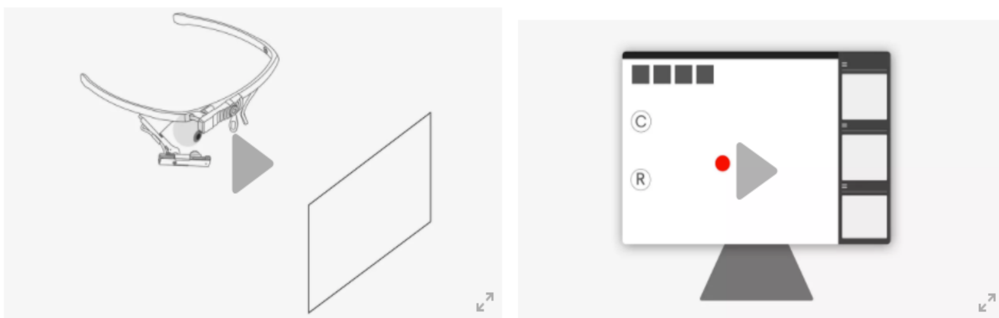


Figure 1. Pupil Labs System

After the completion of the calibration phase, participants will have two testing blocks. Each testing block will be composed of 30 randomly ordered trials of images. The selected picture will be presented on 24-inch LCD monitor. Subjects will have practice trials with two neutral pictures prior to the first testing block. From here, each trial will include a 2-sec black screen prior to picture onset (baseline), a 6-sec picture presentation, and a 12-sec emotional rating interval in which the picture will not be displayed. Subjects will be asked to sit and watch the screen in a comfortable, seated position, for the entire time during the baseline and picture presentation. Some images may cause strong emotions and you can stop the testing at any point during a picture presentation.

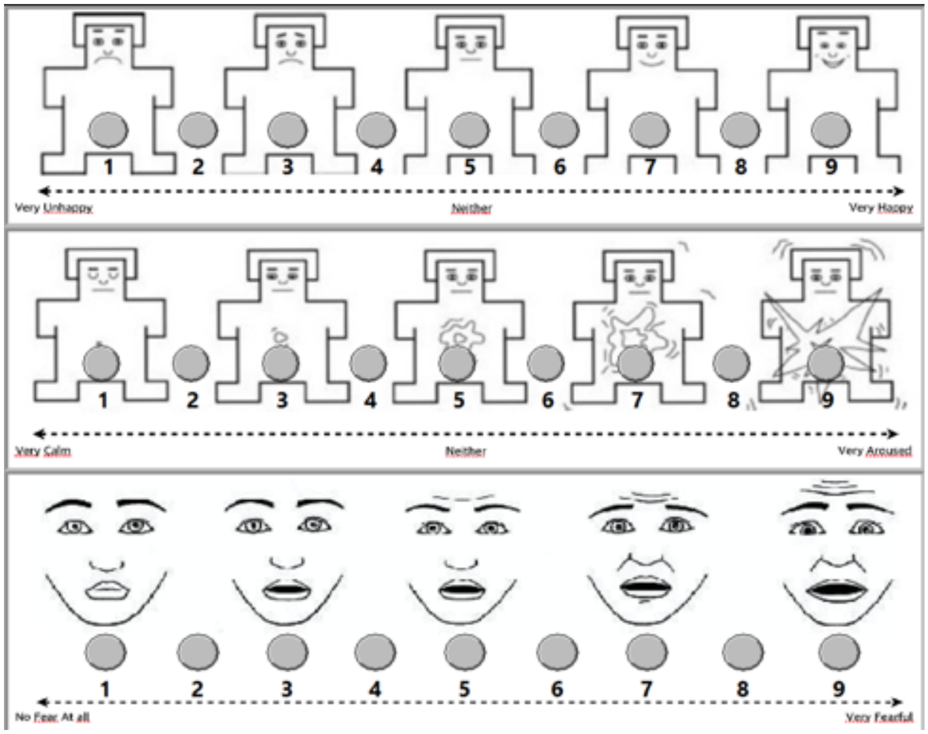


Figure 2. Emotion Rating Scales (***Top***; Valence, ***Middle***; Arousal, ***Bottom***; Level of Fear)

Sixty injury-related pictures will be added to elicit fear associated with musculoskeletal injury history will be evaluated with psychophysiological responses, ratings of valence and arousal domains, level of fear and ocular tracking regulation strategies compared to the selected pictures from IAPS. The injury-related pictures were specifically selected if pictures were sport-related. Overall, six picture presentation sets will be constructed and equally distributed such that each picture presentation set will have distributed condition of 10-pictures from each neutral and fear-related regarding type and the ranges of the valence and arousal domains in addition to 10 sport injury-related pictures (figure 3). You will be familiarized with two pictures prior to the first testing block. The investigator(s) will record eye movements and heart rate during all picture presentations. During the tests, you will be asked to keep your eyes open, but blinking comfortably.

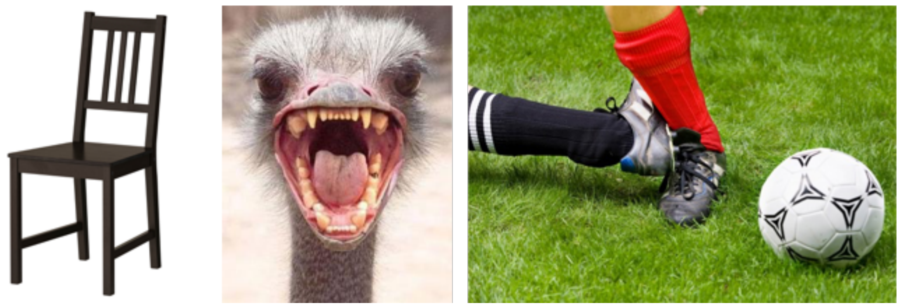


Figure 3. Example of emotional evocative pictures:
(***Left***; Neutral, ***Middle;*** Fear-related, ***Right***; Sport Injury-related)

WHAT ARE THE POSSIBLE RISKS AND DISCOMFORTS?

All experimental techniques are not invasive, but there are few mild possible risks of participating in this research including headaches from looking at a computer screen for an extended period of time and potential change in heart rate. There is minimal chance of experiencing redness or discomfort under the area where the pad is placed to measure heart rate. There is also a risk that you may feel uncomfortable or have anxiety with the fear-related or injury-related images. **You have the right to withdraw from this study at any time during testing.**

ECG testing

There is a possibility of skin redness and discomfort around the site of pad placements associated with ECG testing, these effects are usually mild and short lasting.

Images

Some images used in this study may cause strong emotional responses and you may feel uncomfortable or anxiety viewing them. Resting period between trials will minimize the unpleasant feeling. There is also a possibility you may experience headaches due to viewing a computer screen for an extended period of time.

WHAT IF YOU ARE INJURED DURING YOUR PARTICIPATION IN THE STUDY?

Close supervision will be provided throughout the entirety of the testing period by a certified athletic trainer. If you are injured during research procedures, you will be offered first aid at no cost to you. If you need additional medical treatment, the cost of this treatment will be your responsibility or that of your third-party payer (for example, your health insurance). By signing this document, you are not waiving any rights that you may have if injury was the result of negligence of the university or its investigators.

WHAT ARE THE POTENTIAL BENEFITS?

There are no direct benefits to participating in this study. However, the knowledge gained from this study may contribute to the understanding of eye movement and fear of injury and help improve future patient oriented rehabilitation strategies.

NEW INFORMATION THAT COULD AFFECT YOUR PARTICIPATION:
During the course of this study, we may learn new information that could be important to you. This may include information that could cause you to change your mind about participating in the study. We will notify you as soon as possible if any new information becomes available.

HOW WILL CONFIDENTIALITY BE MAINTAINED? WHO MAY KNOW THAT YOU PARTICIPATED IN THIS RESEARCH?
We will make every effort to keep all research records that identify you confidential to the extent permitted by law. The primary researcher will keep all paper data including your consent form in locked file cabinets as well as we will keep all electronic data on a secure password protected server. Names and contact information will only be used to contact you for the purpose of data collection. Your personal information will not be saved and shared. When you begin participation, you will be assigned a code number that will not use your name or contact information. Only one computer file will contain information that could link your name with your code number, and this file will be encrypted and stored on a secure password protected-server as well as all other computer data. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared. Completely de-identified data will be stored indefinitely for future research. Your research records may be viewed by the University of Delaware Institutional Review Board, which is a committee formally designated to approve, monitor, and review biomedical and behavioral research involving humans. Records relating to this research will be kept for at least three years after the research study has been completed.

WILL THERE BE ANY COSTS TO YOU FOR PARTICIPATING IN THIS RESEARCH?
There are no costs associated with participating in this study.

WILL YOU RECEIVE ANY COMPENSATION FOR PARTICIPATION?
There is no compensation associated with participating in this study.

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 choose to participate it will have no effect on your status with your corresponding team or affect any classroom or school-related responsibilities and/or 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 decision to stop participation, or not to participate, 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?

University of Delaware *IRB Approved From: 11/22/2017 to: 11/22/2018*

If you have any questions about this study, please contact the Principal Investigator, Samantha Schlageter at (732) 343-1885 or sschlag@udel.edu or Buz Swanik at (302) 831-2306 (cswanik@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 hsrb-research@udel.edu or (302) 831-2137.

Your signature on this form means that: 1) you are at least 18 years old; 2) you have read and understand the information given in this form; 3) you have asked any questions you have about the research and those questions have been answered to your satisfaction; 4) you accept the terms in the form and volunteer to participate in the study. You will be given a copy of this form to keep.

________________________________ ________________________________ __________

Printed Name of Participant Signature of Participant Date

________________________________ ________________________________ __________

Person Obtaining Consent Person Obtaining Consent Date

(PRINTED NAME) (SIGNATURE)

OPTIONAL CONSENT TO BE CONTACTED FOR FUTURE STUDIES:

Do we have your permission to contact you regarding participation in future studies? Please write your initials next to your preferred choice.

________ YES ________ NO

APPENDIX C

Permission to Contact Form

We are asking for permission to contact for future studies or follow-up studies involving male and female subjects between the ages of 18 and 30 years old, who have a musculoskeletal injury, with or without a concussion, or healthy controls, assessing anxiety and history of injuries, as well as observing your eye movement while you see pictures specifically chosen to cause different emotions. From this, researchers can search for a relationship to the number and severity of past musculoskeletal injuries. If you are interested in participating in this research, please provide your name and contact information so that (an) investigator(s) of the University of Delaware Athletic Training Research Lab can contact you. Thank you for your consideration.

_______ I am not interested in participating. Do NOT contact me.
(No further information needed)

_______ I am interested in participating and also certify that I have agreed to receive further information for a future follow-up research project associated with this project and will participate in the follow-up testing. Please contact me.
(Complete the following)

First Name: ______________________ Last Name: ______________________

Email Address: ____

Home Phone Number (with area code): ( ) _________ - _________

Cell Phone Number (with area code): ( ) _________ - _________

Prefer to contact you by: Email ______________, or Call _____________

Best time to call (if preferred): ___________________________

Please Return This Form Before You Leave

Contact Information:

Samantha Schlageter, BS, ATC	**C. Buz Swanik, PhD, Associate Professor**
(732) 343-1885	**(302) 831-2306**
sschlag@udel.edu	**cswanik@udel.edu**

THANK YOU.

APPENDIX D

D.1 Competitive State Anxiety Inventory-Version 2

QUESTIONNAIRES

CSAI-2

Instructions: Complete the following scale on two separate occasions: during a quiet time before practice when you are fairly relaxed, and during a competitive situation that you feel is highly stressful. If you are not currently active in competition, recall such situations as clearly as possible and record your responses.

The following are several statements that athletes use to describe their feelings before competition. Read each statement and circle the appropriate number to indicate how you feel right now, at this moment. There are no right or wrong answers. Do not spend too much time on any one statement.

	Not at all	Somewhat	Moderately so	Very much so
1. I am concerned about this competition.	1	2	3	4
2. I feel nervous.	1	2	3	4
3. I feel at ease.	1	2	3	4
4. I have self-doubts.	1	2	3	4
5. I feel jittery.	1	2	3	4
6. I feel comfortable.	1	2	3	4
7. I am concerned I may not do as well in this competition as I could.	1	2	3	4
8. My body feels tense.	1	2	3	4
9. I feel self-confident.	1	2	3	4
10. I am concerned about losing.	1	2	3	4
11. I feel tense in my stomach.	1	2	3	4
12. I feel secure.	1	2	3	4
13. I am concerned about losing.	1	2	3	4
14. I am concerned about choking under pressure	1	2	3	4
15. I'm confident I can meet the challenge.	1	2	3	4
16. I'm concerned about performing poorly.	1	2	3	4
17. My heart is racing.	1	2	3	4
18. I'm confident about performing well.	1	2	3	4

19. I'm worried about reaching my goal.	1	2	3	4
20. I feel my stomach sinking.	1	2	3	4
21. I feel mentally relaxed.	1	2	3	4
22. I'm concerned that others will be disappointed with my performance.	1	2	3	4
23. My hands are clammy.	1	2	3	4
24. I'm confident because I mentally picture myself reaching my goal.	1	2	3	4
25. I'm concerned I won't be able to concentrate.	1	2	3	4
26. My body feels tight.	1	2	3	4
27. I'm confident of coming through under pressure.	1	2	3	4

Scoring: This scale is called the Competitive State Anxiety Inventory-2 (CSAI-2), a sport-specific state anxiety scale developed by Martens, Vealey, and Burton (1990). The scale divides anxiety into three components: cognitive anxiety, somatic anxiety, and a related component-self-confidence. Self-confidence tends to be the opposite of cognitive anxiety and is another important factor in managing stress. To score the CSAI-2, take all the scores for each item at face value with the exception of item 14, where you "reverse" the score. For example, if you circled 3, count that as 2 points (1 = 4; 2 = 3; 3 = 2; 4 = 1). Total your scores in the following manner:

___ Cognitive state anxiety: Sum items 1, 4, 7, 10, 13, 16, 19, 22, and 25.
___ Somatic state anxiety: Sum items 2, 5, 8, 11, 14, 17, 20, 23, 26.
___ Self-confidence: Sum items 3, 6, 9, 12, 15, 18, 21, 24, and 27.

Your scores for each will range from 9 to 36, with 9 indicating low anxiety (confidence) and 36 indicating high anxiety confidence.

D.2: Concussion History Questionnaire

Directions: Please answer the following questions regarding your collegiate athletic career to
the best of your knowledge. Your answers will remain confidential and will NOT be shared with
your coaches or athletic training staff.
Demographics
Gender: M / F Age: _______ Academic year in school: FR SO JR SR
5th Other_____
Sport(s): __________________________________ Position in sport:________________________________
How many years did you participate in your sport at the collegiate level? ________
Which Division? NCAA I NCAA II NCAA III NJCAA
Other_______________________________
Injury History
1. Have you ever sprained your ankle? YES NO
a. Was the ankle sprain reported to a healthcare provider? YES NO
b. Did you complete a rehabilitation program, either on your own or with a healthcare provider? YES NO
i. If no, why not?
____
2. Have you ever injured a ligament or cartilage in your knee? YES NO
a. If yes, which one(s)? Meniscus Cartilage MCL ACL LCL PCL
3. Have you ever sprained any other joints (shoulder, wrist, etc.) while playing sports? YES NO
a. If yes, what body part(s)?
____
4. Have you ever suffered a concussion? YES NO
a. If yes, how many? _____
b. If yes, approximately when were they? (Month and year to the best of your memory)
____
c. If yes, when was your last concussion?
____
5. Did you ever suffer a concussion and not tell anyone? YES NO
a. If yes, why? (check all that apply)
____ 1. Did not think it was serious
____ 2. Did not know it was a concussion
____ 3. Did not want to be pulled out of the game/practice
____ 4. Did not want to be pulled from future games/practices
____ 5. Did not want to let your teammates down
____ 6. Would have if it was a less important game/practice
____ 7. Other:____
6. Have you ever hurt your back? YES NO
a. If yes, please explain:____
7. Have you ever broken a bone? YES NO

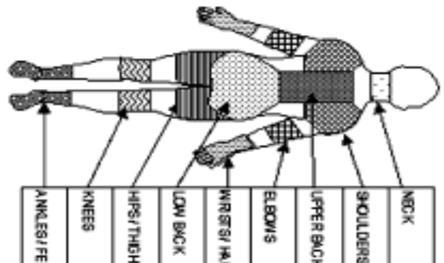
a. If yes, which bone(s)?____
8. Have you ever dislocated your shoulder? YES NO
9. Have you ever pulled, strained, or torn your rotator cuff or any other structure in your shoulder?
YES NO
a. If yes, briefly explain:____
10. Have you ever been knocked out while playing sports? YES NO
a. If yes, how many times?____
b. If yes, how many were diagnosed as concussions?____
11. Have you ever pulled, badly strained, or torn a muscle? YES NO
a. If yes, which muscle(s)?____
12. Have you ever been "knocked silly/seen stars" (confused/disoriented) while playing sports?
YES NO
a. If yes, how many times?____
b. If yes, did you tell your coach, athletic trainer, or parent? Which one?_________________
c. If yes, how many were diagnosed as a concussion?______________________________
13. Have you had multiple ankle sprains? YES NO
a. If yes, how many?__________
14. Have you had any episodes of your ankle giving way? YES NO
a. If yes, how many times?__________
15. Do you have any current residual (lingering) symptoms regarding your ankle sprains?
YES NO
a. If yes, what are they?____
16. Have you ever experienced any season ending injuries? YES NO
a. If yes, what was/were your injury/injuries?________________________________
b. If yes, did you have surgery on any of these injuries? Which ones?
____
17. During your collegiate athletic career, did you ever have any orthopedic surgeries? YES NO
a. If yes, on what?__________________________________
18. Following a blow to the head, if you had experienced a headache, dizziness, or confusion, would you report it to your athletic trainer? YES NO
a. If no, why not?____
19. Have you ever had injuries that you did not tell your athletic trainer about? YES NO
a. If yes, what injuries?____
20. Have you ever been hit so hard you lost your memory while playing sports? YES NO
a. If yes, how many times?_______________________________
b. If yes, did you tell your coach, athletic trainer, or parent? Which one?_______________
c. If yes, how many were diagnosed as a concussion?________________________
21. During your collegiate athletic career, do you feel like you had a good relationship with your athletic trainer? YES NO

D.3: Extended Version of the Nordic Musculoskeletal

Extended Nordic Musculoskeletal Questionnaire (NMQ-E)

How to answer the questionnaire:

Please answer by putting a cross in the appropriate box - one cross for each question. Answer every question, even if you have never had trouble in any part of your body. Please answer questions from left to right before going down to the next body region. This picture shows how the body has been divided. Limits are not sharply defined and certain parts overlap. You should decide for yourself which part (if any) is or has been affected.



	Have you **ever** had trouble (ache, pain or discomfort) in:	**If 'No', go on to the next body region. If 'Yes', please continue**	At the time of initial onset of the trouble, what was your age?	Have you **ever** been hospitalised because of the trouble?	Have you **ever** had to change jobs or duties (even temporarily) because of the trouble?	Have you had trouble (ache, pain, discomfort) at any time during the **last 12 months?**	**If 'No', go on to the next body region. If 'Yes', please continue**	Have you had trouble (ache, pain, discomfort) at any time during the **last month (4 weeks)?**	Have you had trouble (ache, pain, discomfort) **today?**	During the **last 12 months** have you at any time: been prevented from doing your normal work (at home or away from home) because of the trouble?	seen a doctor, physio-therapist, chiropractor or other such person because of the trouble?	taken medication because of the trouble?	taken sick leave from work/studies because of the trouble?
NECK	□ No □ Yes		___ years	□ No □ Yes	□ No □ Yes	□ No □ Yes		□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes
SHOULDERS	□ No □ Yes		___ years	□ No □ Yes	□ No □ Yes	□ No □ Yes		□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes
UPPER BACK	□ No □ Yes		___ years	□ No □ Yes	□ No □ Yes	□ No □ Yes		□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes
ELBOWS	□ No □ Yes		___ years	□ No □ Yes	□ No □ Yes	□ No □ Yes		□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes
WRISTS/ HANDS	□ No □ Yes		___ years	□ No □ Yes	□ No □ Yes	□ No □ Yes		□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes
LOW BACK	□ No □ Yes		___ years	□ No □ Yes	□ No □ Yes	□ No □ Yes		□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes
HIPS/THIGHS	□ No □ Yes		___ years	□ No □ Yes	□ No □ Yes	□ No □ Yes		□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes
KNEES	□ No □ Yes		___ years	□ No □ Yes	□ No □ Yes	□ No □ Yes		□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes
ANKLES/ FEET	□ No □ Yes		___ years	□ No □ Yes	□ No □ Yes	□ No □ Yes		□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes	□ No □ Yes

Appendix 1. The Extended Nordic Musculoskeletal Questionnaire (NMQ-E).

Questionnaire (NMQ-E

D.4: Sheehan Disability Scale

Sheehan Disability Scale

A brief, patient rated, measure of disability and impairment.

Please mark ONE circle for each scale.

WORK* / SCHOOL

The symptoms have disrupted your work / school work:

Not at all — Mildly — Moderately — Markedly — Extremely

0 1 2 3 4 5 6 7 8 9 10

☐ I have not worked / studied at all during the past week for reasons unrelated to the disorder.

* Work includes paid, unpaid volunteer work or training

SOCIAL LIFE

The symptoms have disrupted your social life / leisure activities:

Not at all — Mildly — Moderately — Markedly — Extremely

0 1 2 3 4 5 6 7 8 9 10

FAMILY LIFE / HOME RESPONSIBILITIES

The symptoms have disrupted your family life / home responsibilities:

Not at all — Mildly — Moderately — Markedly — Extremely

0 1 2 3 4 5 6 7 8 9 10

Days Lost

On how many days in the last week did your symptoms cause you to miss school or work or leave you unable to carry out your normal daily responsibilities? ______

Days Unproductive

On how many days in the last week did you feel so impaired by your symptoms, that even though you went to school or work, your productivity was reduced? ______

APPENDIX E

November 21st, 2017

Dear Reviewers:

Thank you for your attention to my documents. Below are the respected answers to the questions you had regarding some of the details of my package. The questions you had, have been addressed and changed, and new copies have been resubmitted.

1. Is the custom built ECG machine grounded for use with humans?
-Yes. This was not a machine, but a circuit with 3 channels including a ground to capture/detect isolated bioelectric signals. The signals were then passed to a standard A/D board, which was also grounded.

2. Permission to contact form: Why does this need to be completed by those who do not want to be contacted? What is the other study you are referring to? If they consent to your study and agree to be contacted you can already contact them. They can't consent to follow up testing with this form.
-The "Permission to contact form" does not need to be completed by those who do not wish to be contacted. We are in the planning stages for similar, follow-up studies and seek the subject's permission to be contacted if/when they are initiated.

3. What kind of training do investigators have in handling psychological discomfort?
- The investigators are Athletic Trainers who receive professional education in a competency-based approach through progressive re-assessment of a patients' injury status to include, psychosocial issues and strategies. These certification and licensing competencies state:

"Athletic trainers must be able to recognize clients/patients exhibiting abnormal social, emotional, and mental behaviors. Coupled with recognition is the ability to intervene and refer these individuals as necessary. Additionally, athletic trainers appreciate the role of mental health in injury and recovery and use interventions to optimize the connection between mental health and restoration of participation."
- We have also conducted many previous studies on injury proneness using various stressors because of the neuro-mechanical relationship to errors in coordination and musculoskeletal trauma.

4. Consent form: should a statement be added that student athletes are not required to participate and will not have an effect on status with team as has been done for students in class?
- We agree with the reviewers and have added this to the consent form.

5. Concussion history questionnaire asks lots of unrelated questions. (e.g. ankle spains, etc). Also, why do you need to know if they had a good relationship with

their athletic trainer?

- Although there is some minimal overlap between particular musculoskeletal questions, the Concussion History Questionnaire has proven to be a timely, reliable and valid source specific to previous mild brain injuries. However, the Nordic Musculoskeletal Questionnaire is also needed to quantify previous injuries numbers and severity for statistical analysis.
- We agree with the reviewers and do not need to know if the subject "had a good relationship with their Athletic Trainer." We will modify the questionnaire and delete this question.

Thank you again for your attention to my materials.

Sincerely,
Samantha Schlageter

HUMAN SUBJECTS PROTOCOL
University of Delaware

Protocol Title: The Relationship Between Ocular Tracking and Emotion Regulation Related to Injury History

Principal Investigator
Name: Samantha Schlageter, ATC
Department/Center: Kinesiology & Applied Physiology/Biomechanics & Movement Science
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Email Address: sschlag@udel.edu

Advisor (if student PI):
Name: C. Buz Swanik, PhD, ATC/FNATA
Contact Phone Number: (302) 831-2306
Email Address: cswanik@udel.edu

Other Investigators:
Dr. Tom Buckley, PhD, ATC
Yong Woo An, PhD, ATC
Andrea DiTrani, PhD, ATC

Investigator Assurance:

By submitting this protocol, I acknowledge that this project will be conducted in strict accordance with the procedures described. I will not make any modifications to this protocol without prior approval by the IRB. Should any unanticipated problems involving risk to subjects occur during this project, including breaches of guaranteed confidentiality or departures from any procedures specified in approved study documents, I will report such events to the Chair, Institutional Review Board immediately.

1. **Is this project externally funded?** ☐ YES **X** NO

If so, please list the funding source:

2. Research Site(s)

X University of Delaware

☐ Other (please list external study sites)

Is UD the study lead? **X** YES ☐ NO (If no, list the institution that is serving as the study lead)

3. **Project Staff**
Please list all personnel, including students, who will be working with human subjects on this protocol (insert additional rows as needed):

NAME	ROLE	HS TRAINING COMPLETE?
Samantha Schlageter	PI	Yes
C. Buz Swanik	Advisor	Yes
Tom Buckley	Co-investigator	Yes
Yong Woo An	Co-Investigator	Yes
Andrea DiTrani	Co-Investigator	Yes

4. **Special Populations**
Does this project involve any of the following:

Research on Children? No

Research with Prisoners? No

If yes, complete the Prisoners in Research Form and upload to IRBNet as supporting documentation

Research with Pregnant Women? No

Research with any other vulnerable population (e.g. cognitively impaired, economically disadvantaged, etc.)? please describe No

5. **RESEARCH ABSTRACT** Please provide a brief description in LAY language (understandable to an 8th grade student) of the aims of this project.

Growing evidence suggests muscle, skeletal, and joint injuries, as well as concussions, can be related to psychological factors. It is becoming a problem in sports but has yet to be discussed thoroughly within the literature. The ability of a person to quickly assess a situation using their vision and then make quick decisions in the brain, can potentially affect the way an individual reacts to certain situations. Within athletics, this may cause errors in the way an individual controls their emotions, coordinates body movements, and visually plans their next move. Some images can also create a heightened emotional response and reaction, which can change a person's focus, and thus affect decision-making. Eye tracking helps researchers observe the relationship between the person's attention and brain function. Athletes with past injuries tend to get hurt again despite physical rehabilitation, and the cause may be due to changes in the persons brain that affect their emotions, such as anxiety or fear, and attention to things they see. Therefore in the future, there is hope that researchers can incorporate visual attention and emotional regulation into screening, prevention, and rehabilitation programs in order reduce injuries. The purpose of this study is to examine the relationship between eye tracking and the body's emotional regulation when an athlete views different types of images**.**

6. **PROCEDURES** Describe all procedures involving human subjects for this protocol. Include copies of all surveys and research measures.

Each subject will report to the Neuromechanics Lab at the Human Performance Lab located on the south campus of the University of Delaware for a single testing session lasting approximately 1 hour in duration. Subjects will be informed that the purpose of this study is to investigate the relationship between eye tracking and injury-related images. Subjects will then be asked to complete the informed consent form, approved by the university's Institutional Review Board (IRB) **(**Appendix A**),** followed by completion of a demographic form, including an injury history questionnaire, and competitive state anxiety inventory questionnaire (Appendix B).

Procedure:

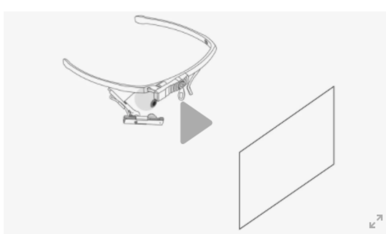
Each subject will report to the Neuromechanics Lab at the Human Performance Lab located on the South Campus and/or the Carpenter Sports Building of North Campus of the University of Delaware for a single testing session lasting approximately one hour. Subjects will be informed, before participating, that the purpose of this study is to investigate the relationship between previous injury, eye tracking, emotion and a variety of images**.** After completion of the consent form, Competitive State Anxiety Inventory-2 (CSAI-2), Extended Version of the Nordic Musculoskeletal Questionnaire, and Concussion History Questionnaire, subjects will complete the viewing of unpleasant, neutral, and injury related images with a Pupil Labs headset device and Pupil Capture software. The subject's cognitive awareness, fear perception, and emotion regulation will then be measured while viewing the images. The participant's heart rate, fear, and fixations of gaze patterns will be measured using a predetermined rating scale, a custom-built electrocardiography machine, and the custom Pupil Labs program. For this research experiment, we will be focusing on the total number of fixations, time to initial fixation of the image, and the time of each fixation to determine when the subject fixated the longest on certain images. In addition, each participant will be fitted with electrodes and electrocardiography (ECG) sensors in order to record increased or decreases in heart rate.

Subjects will first be asked to sit in a chair for a calibration phase of the equipment. Each participant will be comfortably fitted with the Pupil Labs headset. To begin, the headset and software must be calibrated relative to the monitor and focused on the participant's pupil. The calibration process requires the subject to look at a series of calibration targets distributed evenly throughout the screen. Each target will appear one at a time where they are only visible for a predetermined time period. The total calibration process usually takes about 20 seconds to complete. The Pupil Lab's algorithms will begin to automatically detect the participant's. Before calibration begins the researcher will make sure the pupil is properly detected. Calibration will then occur within the system while the participant is instructed to keep their head still. The Pupil Capture software will also be synchronized with a world view camera, viewing the International Affective Picture System and a block of sports injury pictures that will play on the screen, while the Pupil Capture detects the subject's pupil gaze pattern and tracks the path of their pupils.

After the completion of the calibration phase, participants will have two testing blocks. Each testing block will be composed of 30 randomly ordered trials of images. The selected picture will be presented on 24-inch LCD monitor. Subjects will have practice trials with two neutral pictures prior to the first testing block. From here, each trial will include a 2-sec black screen prior to picture onset (baseline), a 6-sec picture presentation, and a 12-sec emotional rating interval in which the picture will not be displayed. Subjects will be asked to sit and watch the screen in a comfortable, seated position for the entire time during the baseline and picture presentation. Additionally, subjects will then be asked to rate valence (unhappy/happy), arousal, and level of fear regarding each picture. During the viewing, continuous heart rate (HR) data will be collected by using a single channel of ECG during baseline and a picture presentation, synchronized with ocular tracking data via a custom IAPS program, and rating scores will be separately reported for each trial. Participants will be asked to keep their eyes open, but blinking comfortably and normally, and to look only to the screen during testing. Subjects will be monitored and encouraged to minimize body or facial muscle movements to limit errors to accurately assess pupil tracking.

<u>Pupil Labs:</u>

The Pupil Labs (Berlin, Germany) headset and software consist of a 3D printed eye-glass frame with built in cameras that record eye movements and gaze patterns. The software is downloaded onto the computer that will be used throughout the research study while the frames are plugged into the computer via USB cable. The Pupil Capture aspect of the Pupil Labs software that receives the video and audio stream, tracks the participants gaze pattern on the computer, identifies markers within the computer screen, streams data through the network to be recorded in real time, and overall detects the activity of the pupil. Each participant will be comfortably fitted with the lightweight Pupil Labs headset. The headset's center camera (world camera) will be capturing what the participant sees in real time, while the side camera (focus eye camera) detects and focuses on the pupil.



Electrocardiography (ECG):

A custom-build, single channel surface ECG system will be used in the analysis of heart rate differences between the participant's rest and picture presentation periods for determination of the psychophysiological fear response. This is accomplished by placing the Ag/ACI bipolar self-adhesive electrodes at both sides of the participant's shoulders with the hip as a reference location. Prior to the placement of electrodes, the area being used will be shaved, abraded, and wiped clean with an alcohol pad (70% ethanol solution) to remove debris in order to allow for maximal signal input. An A/D card will convert the signal from analog to digital data (NI DAQ, National Instruments, Austin, TX), and then the signal will be passed to a computer that samples the raw EMG data at 1,000Hz. The transmitted signal will be band-pass filtered at a 20-400Hz and LabVIEW software (National Instruments, Austin, TX) will be used to analyze the signal further. In order to create a linear envelope, the signal will then be rectified and low-pass filtered at 5 Hz. Then, inter-beat R-wave intervals will be detected to the nearest millisecond and 500-ms intervals will be calculated into heart rate in beat per minute (bpm).

International Affective Picture System (IAPS), Self-Assessment Manikin (SAM), and level of fear:

The IAPS is a series of pictures that has been developed to induce a variety of emotions regarding judgments on two major dimensions of the SAM: affective valence, and arousal. The SAM, which consists of a 9-point rating scale, represents 1 as a low rating and 9 as a high rating on each dimension. The valence dimension is a ranging from 1=very unpleasant to 9=very pleasant, whereas the arousal dimension is a ranging from 1=very calm to 9=very aroused. Preselected pictures (122) from the IAPS (62 pictures for neutral, 60 pictures for fear-related) will be utilized to represent the targeted neutral and fearful emotion. The neutral pictures, which consist of neutral objects such as plants, office supplies, or a neutral human, were chosen from the range of valence (4.03-5.20) and arousal (1.72-3.46), while the fear-related pictures, which include severely injured animal or human, attacking by animals, threatening by other people, or accident-related pictures, were chosen from the range of valence values (1.31-4.32) and arousal (5.9-7.15).

Sixty injury-related pictures will be added to elicit fear associated with ankle, knee, back, shoulder, or hand, and will be evaluated with psychophysiological responses, ratings of valence and arousal domains, level of fear and ocular tracking regulation strategies compared to the selected pictures from IAPS. The injury-related pictures were specifically selected if pictures were sport-related. The criteria of sport selection will be categorized into 3 common sport types according to the general injury rate and the sports supported in intercollegiate and club athletics at the University of Delaware. A picture was excluded if a resolution of the picture was lower than 1024 X 768 pixels. Overall, six picture presentation sets will be constructed and equally distributed such that each picture presentation set will have distributed condition of 10-pictures from each neutral and fear-related regarding type and the ranges of the valence and arousal domains in addition to 10 sport injury-related pictures.

The order of picture presentation sets between blocks will be counterbalanced using *Latin Square* and pictures within the set will be randomized across participants. A participant's level of fear to each emotionally evocative picture will be evaluated by using a 9-point Likert scale ranging from 1=not at all fearful to 9=extremely fearful.

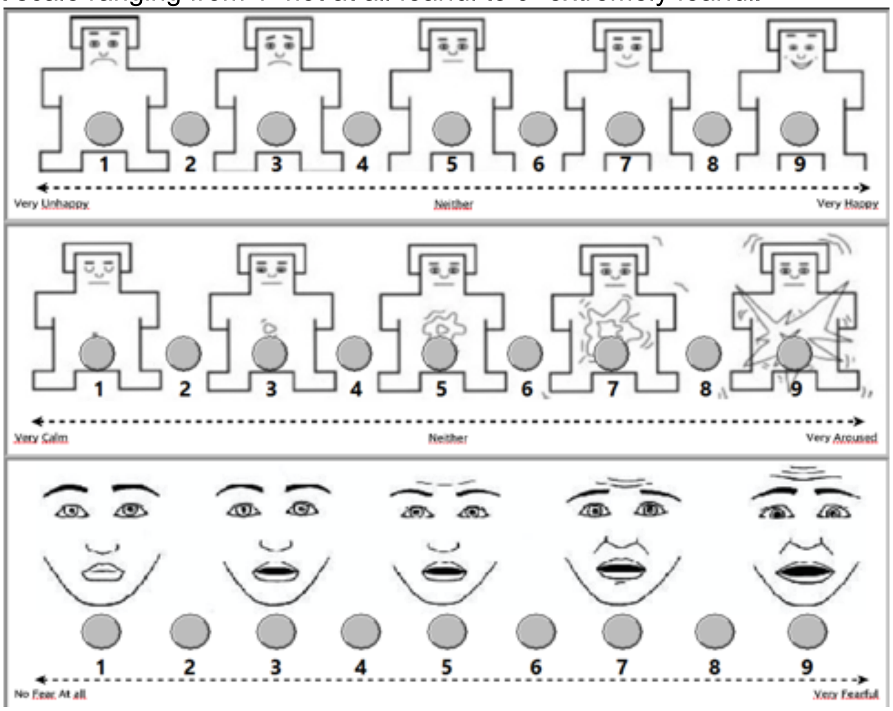


Figure 2. Emotion Rating Scales (***Top***; Valence, ***Middle***; Arousal, ***Bottom***; Level of Fear)

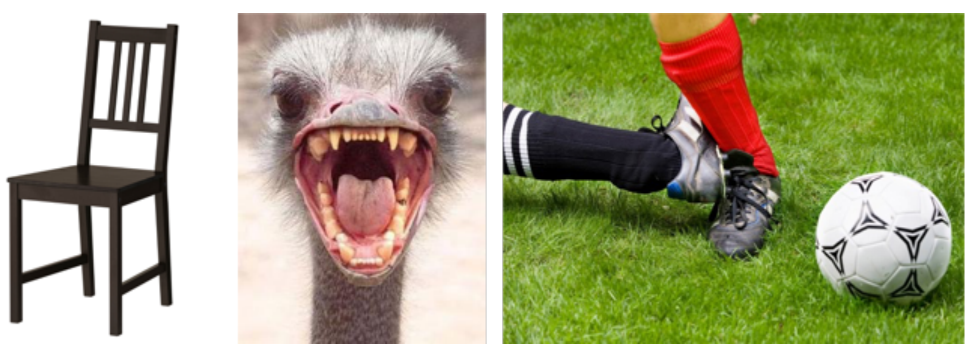


Figure 3. Example of emotional evocative pictures: (***Left***; Neutral, ***Middle;*** Fear-related, ***Right***; Sport Injury-related)

<u>Competitive State Anxiety Invetory-2 (CSAI-2):</u>

A 27-item questionnaire that assess a multitude of different aspects of anxiety. The CSAI-2 also has three subcategories, which include cognitive anxiety, somatic anxiety, and self-confidence, with 9 questions within each subcategory. The questionnaire is assessed on a 4-point likert scale, which ranges from “1=not at all” to “4=very much so.” The scores of each subcategory are then totaled and then demonstrate the level anxiety within each component. The values help researchers evaluate whether or not the athlete has a pre-established level of anxiety that is associated with their level of performance and if it in turn affects their performance outcomes. Extensive research has been done in order to establish the reliability and validity of the CSAI-2.

History Questionnaires Addressing Musculoskeletal Injuries and Concussions Over Time:

A 21-item Concussion History Questionnaire will assess the concussion history of an athlete including the quantity, severity, and treatment of the concussion using “yes” or “no” responses and open-ended responses. The questionnaire also assesses in depth history of musculoskeletal injuries including the possibility of past fractures and surgeries also using “yes” or “no” responses and open-ended responses. The Concussion History Questionnaire further includes a demographics section to assess the participant’s academic year in school, gender, and sport. The extended version of the Nordic Musculoskeletal Questionnaire (NMQ-E) is a musculoskeletal screening tool that is used to assess past musculoskeletal injuries of the neck, shoulders, upper back, elbows, wrists/hands, hips/thighs, knees, and ankles/feet, using “yes” or “no” responses to further assess the participant’s injuries over time, specifically within the last 12 months. Extensive research has been done on both questionnaires in order to establish reliability and validity.

7. **STUDY POPULATION AND RECRUITMENT**

Describe who and how many subjects will be invited to participate. Include age, gender and other pertinent information.

> Fifty volunteer participants within the range of 18-30 years of age will be recruited from the University of Delaware’s Division I and Club Sports teams. Subjects will be recruited through word of mouth throughout the upcoming summer and fall months of 2017. The college age participants are required to be regularly physically active at least three times a week for at least thirty minutes a day. The participants must also have played at least one year of varsity athletics in high school and must be currently participating on an athletic team. There will be no limitations on sex/gender or ethnicity/race. The control group is expected to be 25 healthy subjects, a mixture of males and females, with very minimal past history of musculoskeletal injuries. The experimental group is expected to be 25 healthy subjects, a mixture of males and females, with a varied history of musculoskeletal injuries. The Investigator(s) will provide written information that explains to prospective subject groups as following information; (1) the criteria for participation, (2) the purpose of the research and the procedures, (3) participant’s right to withdraw the testing at any time without any penalty, and (4) potential benefits by participating, (5) potential risks from the research, (6) assurance of confidentiality. All participants will be asked to sign an informed consent form approved by the Human subjects Review Board of the University of Delaware and completed a demographic form prior to participation. Personal information will be protected using a random identification number and only approved investigators in this study will have access to the data.

Attach all recruitment fliers, letters, or other recruitment materials to be used. If verbal recruitment will be used, please attach a script.

Appendix D

Describe what exclusionary criteria, if any will be applied.

1. History of an injury or surgery on the eye or face within the past 12 months
2. Has an implanted cardiac pacemaker
3. History of neurologic disease or surgery
4. History of recurring or severe headaches/migraine
5. Current signs and symptoms of a concussion
6. History of heart or brain surgery
7. History of seizures or epilepsy
8. Is pregnant
9. Currently undergoing medical treatment for any psychiatric disorders

Describe what (if any) conditions will result in PI termination of subject participation.

A subject will be terminated from participating in this research study if they are unable to complete any portions of the testing protocol described above. Subject participation may also be interrupted or terminated by the investigators if the subject's condition is deemed to place him/her at increased risks beyond those described in the protocol. Participation may also be terminated if the subject does not cooperate with the study procedures or instructions that are specified in the consent form.

8. **RISKS AND BENEFITS**
List all potential physical, psychological, social, financial or legal risks to subjects (risks listed here should be included on the consent form).

It is very unlikely that subjects will experience any side effects from participating in this study because all experimental techniques are non-invasive, and there are few mild potential risks from each technique.

IAPS
The emotional images associated with IAPS may produce an uncomfortable feeling, increased/decreased heart rate, or anxiety. If this should occur, the subject may request to terminate the study session.

Electrocardiography (ECG)
The electrodes from the ECG may produce temporary, mild redness or minor discomfort at the site of pad placement.

Pupil Labs
There may be minor discomfort or headaches from viewing a computer screen for an extended period of time.

In your opinion, are risks listed above minimal* or more than minimal? If more than minimal, please justify why risks are reasonable in relation to anticipated direct or future benefits.
*(*Minimal risk means the probability and magnitude of harm or discomfort anticipated in the research are not greater than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests)*

Risks that may be related with experiments are minimal.

What steps will be taken to minimize risks?

In order to minimize risk, if an individual is too disturbed by a picture, they may choose to not complete the study and will be excluded. Additionally, all data collections will have (an) investigator(s) present, who are trained in first aid, emergency management, and handling psychological discomfort .

Describe any potential direct benefits to participants.

There are no direct benefits to participating in this study.

Describe any potential future benefits to this class of participants, others, or society.

The finding of this study will provide subjects, clinicians and researchers with information concerning the influence of previous injuries on visual attention and emotional regulation, which may influence functional ability during physical activity and may help improve future injury prevention/rehabilitation strategies. We may learn why some athletes could be more prone to re-injury due to these characteristics

If there is a Data Monitoring Committee (DMC) in place for this project, please describe when and how often it meets.

N/A

9. **COMPENSATION**
Will participants be compensated for participation?

You will not receive compensation for participation in this study.

If so, please include details.

N/A

10. **DATA**
Will subjects be anonymous to the researcher?

Participants will not be anonymous to the researcher.

If subjects are identifiable, will their identities be kept confidential? (If yes, please specify how)

Yes, research records are kept separate from the subject identity. All paper data including consent forms will be kept in locked file cabinets under the control of the researchers. Names and contact information will only be used to contact subjects for the purpose of data collection. When subjects begin participation, they will be assigned a code number that will not include names or contact information. Only one computer file will contain information that could link subjects' name with their code number, and this file will be encrypted and stored on a secure password protected server. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared.

How will data be stored and kept secure (specify data storage plans for both paper and electronic files. For guidance see http://www.udel.edu/research/preparing/datastorage.html)

All paper data including consent forms will be kept in locked file cabinets under the control of the researchers. All computer data will be encrypted and stored on a secure password protected hard drive.

How long will data be stored?

In compliance with 45 CFR 46.115(b), all identifying records relating to IRB approved research will be retained for 3 years after the completion of this study. After 3 years following the completion of this study, all identifying information will be destroyed. Completely de-identified research data will be only stored indefinitely for future research.

Will data be destroyed? YES **X** NO (if yes, please specify how the data will be destroyed)

All paper documents (informed consent, demographic questionnaire, and etc…) will be shredded following 3 years from the completion of the research study. De-identified data may be retained indefinitely for future use, but data is considered to be completely de-identified when ALL links between individual identify and the data are destroyed.

Will the data be shared with anyone outside of the research team? ☐ YES **X** NO (if yes, please list the person(s), organization(s) and/or institution(s) and specify plans for secure data transfer)

How will data be analyzed and reported?

This study will analyze data using the Statistical Package for Social Sciences (SPSS, Chicago, IL). Group means will be calculated and will be compared between and within groups (male, female) using Analyses of Variance for each dependent variable. Correlation coefficients between dependent variables will be calculated for all relevant dependent variables. All subject data will be compiled on an excel spreadsheet and imported into SPSS 22.0 (SPSS, Chicago, IL) for statistical analysis. Data will be disseminated through group discussions, presentations and publications.

11. **CONFIDENTIALITY**

Will participants be audiotaped, photographed or videotaped during this study?

No.

How will subject identity be protected?

Approved investigator(s) will only have access to each subject's identity. All paper data including consent forms will be kept in locked file cabinets under the control of the primary researcher. Names and contact information will only be used to contact subjects for the purpose of data collection. When subjects begin participation, they will be assigned a code number that will not include names or contact information. Only one computer file will contain information that could link subjects' name with their code number, and this file will be encrypted and stored on a secure password-protected server. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared. All data will be analyzed using subject case numbers. In compliance with 45 CFR 46.115(b), all identifying records relating to IRB approved research will be retained for 3 years after the completion of this study. All paper documents (informed consent, demographic questionnaire, and etc…) will be shredded following 3 years from the completion of the research study. Data may be retained indefinitely for future use, but data is considered to be completely de-identified when ALL links between individual identify and the data are destroyed.

Is there a Certificate of Confidentiality in place for this project? (If so, please provide a copy).

No.

12. **CONFLICT OF INTEREST**

(For information on disclosure reporting see: http://www.udel.edu/research/preparing/conflict.html)

Do you have a current conflict of interest disclosure form on file through UD Web forms?

Yes

Does this project involve a potential conflict of interest*?

No.

* As defined in the University of Delaware's Policies and Procedures ,a potential conflict of interest (COI) occurs when there is a divergence between an individual's private interests and his or her professional obligations, such that an independent observer might reasonably question whether the individual's professional judgment, commitment, actions, or decisions could be influenced by considerations of personal gain, financial or otherwise.

If yes, please describe the nature of the interest:

13. **CONSENT and ASSENT**

_X__ Consent forms will be used and are attached for review (see Consent Template under Forms and Templates in IRBNet)

____ Additionally, child assent forms will be used and are attached.

____ Waiver of Documentation of Consent (attach a consent script/information sheet with the signature block removed).

____ Waiver of Consent (Justify request for waiver)

14. **Other IRB Approval**
Has this protocol been submitted to any other IRBs?
Yes.

If so, please list along with protocol title, number, and expiration date.

813901-2 Eye Tracking during viewing of fear-related images in athletes, closed 05/17/2017
Data was not collected from this study.

15. **Supporting Documentation**
Please list all additional documents uploaded to IRBNet in support of this application.

Appendix A – Informed Consent Form
Appendix B – Demographic/Injury History Questionnaire
Appendix C – Permission to Contact Form.
Appendix D - Recruitment Script