ASSESSMENT OF CONCUSSION AWARENESS IN UA STUDENTS

By

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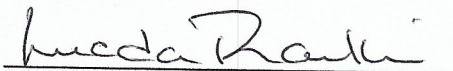
Approved by:



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Abstract:

A concussion is defined by a rapid movement of the head that results in characteristic symptoms. Most concussions resolve without any treatment, but risky behavior, such as returning to play, while the brain is in a vulnerable state can result in worsened outcomes. Concussion education is commonly provided to sports players, as it is known that contact sports offer a risk of concussions. However, non-sports players sustain head injuries as well who may not be within the reach of current education. This thesis seeks to assess the awareness of concussions in the general population. A survey was provided to various classes and sports teams that gathered information on concussion incidence and assessed participants' awareness of concussions. It was found that concussions occur outside of sports to individuals without concussion education. When offered a scenario, both educated and non-educated populations were found to choose risky decisions following concussions, indicating both groups are unaware of the gravity of concussions and rehabilitation guidelines. Inappropriate responses from individuals with prior education support the conclusion that current education is ineffective. Future implications include widespread concussion education that reaches all populations and conveys the severity of concussions and the importance of following proper treatment.

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I would like to acknowledge the following people:

- The professors and team captains who worked hard to make my thesis a success by distributing my survey and encouraging their respective groups to participate.

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Introduction:

The Centers for Disease Control and Prevention estimate that between 1.6 and 3.8 million sports-related concussive injuries occur annually in the United States (CDC). The likelihood of sustaining a concussion when playing a contact sport is estimated to be 19% (University of Pittsburgh, n.d.). Concussions are a serious injury, and while athletes usually recover from the first concussion they sustain within a day (CDC), multiple concussions, particularly those that are closed spaced in time, can result in chronic headaches, memory loss, confusion, impaired judgment, impulse control problems (Lin et al, 2015), behavioral changes, and aggression (Goswami et al, 2015). This thesis seeks to assess the awareness of these risks in the general student population at the University of Arizona.

The reported incidence of concussion by the CDC is an extremely wide range due to the frequent reliance on a concussion being self-reported. In order for parents, coaches, teammates and medical care providers to be aware of the sustained concussion, an athlete must be aware of the symptoms that define a concussion. In one study of high school football players, only 47.3% of players reported a concussive injury (Dimou & Lagopoulos, 2014). While most athletes have received some concussion education and are likely aware of the basic symptoms of a concussion (i.e, headache, nausea, cognitive impairment, memory loss (CDC)), it is unknown whether or not athletes understand the gravity of the condition. If an athlete is not aware of the severity of a concussion and the potential to sustain long term consequences, they may not be likely to report their symptoms in order to remain in play, which could be dangerous.

Robbins, et al suggests that providing athletes with an accepted definition of a concussion could “improve the reliability of self reported concussion history across multiple individuals” (Robbins et al, 2014). In order to accurately self-report a concussion, an athlete needs to know

the definition and the associated symptoms of a concussion. In one study, 36.1% of players that did not report concussive injuries did so because they did not realize their symptoms could be attributed to a concussion. (Dimou & Lagopoulos, 2014). While players may know the accurate definition, they may consciously choose not to self-report, since they are unaware of the risks of continued play. In the same study, 66.4% of players that did not report their concussion did not think their symptoms were serious enough to report, and 41% chose not to report symptoms because they did not want to be held from play (Dimou & Lagopoulos, 2014). Continued play while experiencing symptoms is a risk to player's health: athletes undergoing symptoms of a concussion who experience additional impact are at risk of magnified and potentially catastrophic neurologic sequelae (Kroshus & Baugh, 2015). Therefore, this thesis also seeks to assess the awareness of athletes of the severity and risks of concussions.

Kroshus & Baugh state that "in U.S. collegiate sport, decisions about content and delivery of concussion education are left up to the individual institution" (Kroshus & Baugh, 2015). In 2011, Arizona Governor Jan Brewer signed Senate Bill 1512 that mandates concussion education in high school sports (*Arizona Revised Statutes; Relating To School District Governing Boards*, 2011). This bill mandates that parents and students must be aware of the risks of concussions and must give signed consent that they are aware of these risks before their child may engage in play (*Arizona Revised Statutes; Relating To School District Governing Boards*, 2011). The NCAA has also established a concussion protocol. The protocol mandates that annual concussion education be provided to all parties in the NCAA: "student-athletes, coaches, team physicians, athletic trainers, and athletics directors" ("Concussion guidelines | NCAA.org," n.d.). The protocol also illustrates guidelines for pre-participation concussion baseline testing,

concussion management, and conditions for athletes to return to play after sustaining a concussion.

Kroshus & Baugh state that "concussion education for athletes has the potential to play a role in reducing the health burden of concussions from sport by modifying individual risk-related behaviors" (Kroshus & Baugh, 2015). However, there is currently no government mandate that requires concussion education to be provided for those that fall outside of high school or NCAA regulations, i.e., the general college student and more specifically, the collegiate intramural athlete. The effectiveness of the concussion education currently in place for intramural sports is unknown, emphasizing the need for an assessment of these players' knowledge of concussions.

However, concussions can also occur as a result of everyday activities outside of sports. One study found that most ER visits for mild traumatic brain injury (TBI) were not due to sports, but to falls, motor vehicle trauma, accidental hits, and assault (Bazarian et al, 2005). With everyday occurrences outside of sports constituting the four most common mechanisms of mild TBI in ER visits, the need for concussion education spans farther than just within the population of athletes. Head injuries do not solely occur during sports play, but occur in everyday life to individuals who lack concussion education regarding the seriousness of a concussion and treatment protocol. Therefore, the third aim of this thesis is to substantiate the need for widespread concussion education for the general population.

Physiological Background:

The central nervous system, composed of the brain and the spinal cord, is the control center of the body: it processes information, makes decisions, and initiates movement. Because it is a vital organ, the brain is heavily protected, being contained within the skull, a complex bony part of the skeleton. The brain is also surrounded by the cranial meninges: the dura mater, the

arachnoid mater, and the pia mater (see Fig 1). The dura mater is the most superficial layer and is similar to tough, impermeable plastic. It also serves to divide, the cranial cavity into compartments: the falx cerebri, which separates the two hemispheres of the cerebrum, and the falx cerebelli, which separates the two hemispheres of the cerebellum. The dura mater forms sinuses that carry blood from the brain back to the heart as well as the epidural and subdural spaces, where blood might collect if a head injury occurs. The arachnoid mater is the filmy collagenous middle layer, forming a thin meshwork between the dura and the pia layers. Between the arachnoid and pia maters exists the subarachnoid space, which is filled with cerebrospinal fluid (CSF) that serves as another means of protection to the brain. The CSF is a colorless, nutrient containing liquid that bathes the brain, serving as a cushion to protect against physical and chemical injuries. The arachnoid layer also contains villi that project into the sinuses formed by the dura mater and carry CSF back into systemic circulation. (Tortora & Derrickson, 2012).

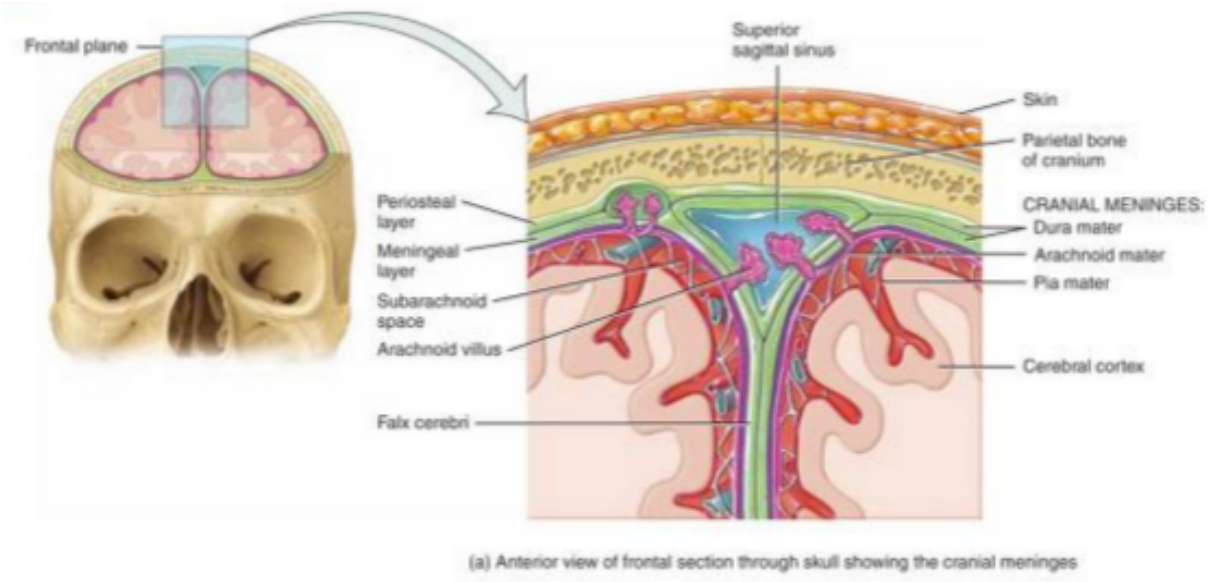


Figure 1: Anterior view of frontal section through the skull showing the cranial meninges (Tortora & Derrickson, 2012).

The brain is comprised of only 2% of the body's weight, but consumes 20% of the ATP (generated primarily from glucose) and oxygen used by the body, so nutrient rich blood is preferentially shunted to the brain. The CSF also contains essential nutrients for brain function, such as sodium, potassium, calcium, chloride and glucose and serves as a second key source for maintaining homeostasis for neural function. The pia mater is the deepest layer, and is a thin layer that adheres to the brain. Its primary function is serving as a barrier to the nutrient filled CSF.

One additional form of chemical protection to the brain is the blood brain barrier (BBB) which is comprised of tight junctions that seal together endothelial cells of blood vessels in the brain. The BBB is highly selective and semi-permeable: it permits the transport of ions and nutrients into the brain, while excluding toxins. It is essential in sustaining the neural activity of the brain, actively pumping in and out ions that enable synaptic activity and restore the membrane resting potential (Tortora & Derrickson, 2012).

Pathophysiology of concussions:

Historically, the term "concussion" has been defined by a brief loss of consciousness resulting from a head injury (Poirier, 2003). However, recently, the term has become more broad, generally used to describe any injury to the head ("Concussion: MedlinePlus," n.d.). The Committee of Head Injury Nomenclature of the Congress of Neurological Surgeons defined concussion as "a clinical syndrome characterized by immediate and transient post traumatic impairment of neural function due to brainstem involvement" (Poirier, 2003). The terms "concussion" and "mild traumatic brain injuries" (mTBI) have been used interchangeably, as a clear distinction between the two terms does not exist. A mTBI constitutes some form of intracranial trauma that can be seen on neuroimaging (Dimou & Lagopoulos, 2014), whereas a

concussion does not indicate any abnormalities on a lab test or neurological image (Clay, Glover, & Lowe, 2013). A concussion can be considered a form of mTBI, but not all mTBI diagnoses constitute concussions.

Concussions occur as a result of biomechanical forces, where there is a force or blow to the head or body that transmits a force that leads to a "shaking" of the brain (Dimou & Lagopoulos, 2014). Concussions often result in a brief impairment of neurological function that sometimes evolves over minutes to hours (Marchi et al, 2013). A concussion cannot be seen on a neurological image because it does not cause evident structural harm, but rather harm to the fine structure of the brain, such as the blood brain barrier.

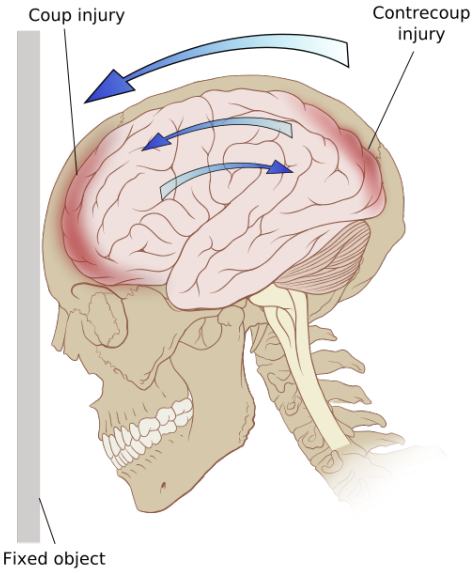


Figure 2: Impact of a concussion on the brain ("Coup contrecoup injury - Wikipedia, the free encyclopedia," n.d.)

Neuronal cell membrane disruption and axonal stretching occurs after the initial head trauma, which leads to channels opening, causing uncontrolled ion flux. This uncontrolled ion flux leads to dysregulation of ionic channels and membrane potential, which results in further ion

flux and an uncontrolled release of neurotransmitters, especially glutamate. Glutamate then acts on several receptors, which results in further depolarization and calcium influx into the neuron (Dimou & Lagopoulos, 2014). To compensate for the ionic dysregulation, ATP-dependent pumps are relied on to restore the ionic balance in the cell, which then leads to ATP exhaustion. All of these cellular events cause a cascade of physiological disorder in the brain that lead to the presentation of symptoms typically associated with concussions (Dimou & Lagopoulos, 2014). For example, ionic imbalance leads to action potential irregularities, axonal degeneration and dysfunction which causes confusion, a hallmark symptom of a concussion (Choe, Babikian, DiFiori, Hovda, & Giza, 2012).

The metabolic dysfunction caused by a concussive hit could potentially lead to permanent brain damage, especially if the individual has sustained multiple concussions. The theory of Second Impact Syndrome (SIS) states that the brain is in a state of metabolic vulnerability after a concussion until it has time to properly heal. If an individual in this state were to sustain another concussion, the second incident would have a synergistic effect, leading to an increased response. This increased swelling could lead to a fatal cerebral edema (Dimou & Lagopoulos, 2014). Multiple concussions can also result in long term changes of plasticity: one study found evidence of suppressed tong term potentiation and long term depression in college football players that have sustained at least two concussions (Choe et al, 2012). The theory of SIS is debated, but emphasizes the importance of concussion education. If a concussed individual continues playing, they both delay their recovery and put themselves at risk for more serious repercussions if another hit is sustained.

Proper recovery procedures are also debated. Most guidelines instruct the concussed individual to restrict activity during this time of post-concussive vulnerability. Evidence has

shown that drastic inactivity in neural circuitry can actually result in increased apoptosis and neurological and learning impairments. While extreme neural activity following a concussive event can lead to worsened neural impairment, there is data to show that voluntary exercise a week after sustaining a concussion can expedite recovery and increase the release of neurotropic molecules (Choe et al, 2012).

Concussion Management Protocol:

Current concussion emphasizes not returning to play until proper steps have been taken to prevent second impact syndrome. Historically, concussions were graded on a scale of severity and return to play timelines differed based on the grade of the concussion sustained (figure 3).

Grade	**First Concussion**	**Second Concussion**	**Third Concussion**
Grade I—mild	May return to play if asymptomatic for 1 week	May return to play in 2 weeks if asymptomatic for 1 week	Terminate season, although patient may return to play next season if asymptomatic
Grade 2—moderate	May return to play after asymptomatic for 1 week	Minimum of 1 month out of competition, may return to play then if asymptomatic for 1 week and consider termination of season dependent on symptoms	Terminate season, although patient may return to play next season if asymptomatic
Grade 3—severe	Minimum of 1 month, may return to play if asymptomatic for 1 week	Terminate season, although may return to play next season if asymptomatic	

Figure 3: Return to play guidelines based on concussion grade scale (Cantu, 2001).

Concussion grading and severity scales have since been deemed inappropriate tools to utilize when assessing a players' readiness to return to play. Because concussion symptoms vary and reporting cannot be standardized, these concussion scales may be inaccurate. Players may potentially return to play too quickly and be at risk for sustaining another concussion. Currently, healthcare professionals have favored a more conservative approach to return to play guidelines.

Electronic baseline testing addresses the unreliability of athletes' self-reporting of concussions and allows for an individualized standard of "healthy neurological function" to be established. There are a variety of computerized neurological tests (CNT), but the ImPACT test is the most widely used. These evaluate aspects of neurocognitive function including attention span, working memory, working attention time, and reaction time ("The ImPACT Test" n.d.). Players take a series of tests when they start a career at an institution or at the beginning of a new season. When the player sustains a head injury, regardless of severity, they take the CNT. The CNT is electronic which allows for increased accessibility and administration. A trained CNT overseer administers the CNT and interprets the results. If the athlete shows significantly worsened performance on the current CNT compared to the initial test, they will be removed from play and concussion recovery protocol will be followed (MacDonald & Duerson, 2015).

In reality, 70-80% of concussions resolve within 7-10 days without treatment, but some populations, such as those under the age of 18, require more time and stricter steps to recover. The 4th International Conference on Concussion in Sport was held in Zurich in November 2012 and established new guidelines for concussion management to replace those proposed by Cantu (figure3). As previously mentioned, historically, concussions were treated using a passive (non-active) recovery. The Consensus Statement from the Zurich Conference highlights a functional recovery plan.

Rehabilitation stage	Functional exercise at each stage of rehabilitation	Objective of each stage
1. No activity	Symptom limited physical and cognitive rest	Recovery
2. Light aerobic exercise	Walking, swimming or stationary cycling keeping intensity <70% maximum permitted heart rate No resistance training	Increase HR
3. Sport-specific exercise	Skating drills in ice hockey, running drills in soccer. No head impact activities	Add movement
4. Non-contact training drills	Progression to more complex training drills, e.g., passing drills in football and ice hockey May start progressive resistance training	Exercise, coordination and cognitive load
5. Full-contact practice	Following medical clearance participate in normal training activities	Restore confidence and assess functional skills by coaching staff
6. Return to play	Normal game play	

Figure 4: Concussion rehabilitation guidelines from the Zurich Conference (McCrory et al, 2013).

Concussion research is ongoing and new innovations in diagnosis and treatment protocol are constantly being published. Currently, the Zurich guidelines are the most recent widespread accepted protocol for concussions, but the concussion conference in the summer of 2016 may present new data.

Materials and Methods:

125 students from PSIO489, PSIO380, MCB160, MCB411, the UA Club Women's Rugby Team and the UA Club Women's Ultimate Frisbee team were provided an online, anonymous survey by their instructor/team captain. The online survey was generated with Qualtrics software and included questions designed to assess respondents' awareness of concussion symptoms, severity of consequences and treatment protocol, in addition to sports involvement and concussion incidence (See appendix 1 for full survey).

Results:

The following results reflect participants' responses from the online survey. 125 students began the survey and 120 students completed the survey.

Population Statistics

Gender	Count	% of total
Male	26	21%
Female	97	79%

Table 1: Sex of population.

College	Count	% of total
Agriculture and Life Sciences	8	7%
Architecture	0	0%
Education	1	1%
Engineering	7	6%
Fine Arts	0	0%
Humanities	3	2%
Medicine	40	33%
Nursing	5	4%
Science: SLHS	1	1%
Pharmacy	0	0%
Science: Math	1	1%
Science: Psychology	3	2%
Social and Behavioral Sciences	16	13%
LASC	1	1%
Eller	6	5%
Public Health	1	1%
Science: Natural sciences	21	17%
Science: other	9	7%

Table 2: College of Participants.

Age	Count	% of total
under 18	0	0%
18	7	6%
19	19	15%
20	20	16%
21	37	30%
22	31	25%
over 22	9	7%

Table 3: Age of participants.

Grade	Count	% of population
Freshman	14	11%
Sophomore	19	15%
Junior	32	26%
Senior	55	45%
Graduate student	3	2%
Total	123	100%

Table 4: Grade of participants.

Sport	Count	% of total
High school sports	100	81%
Club collegiate sports at the UA	49	40%
Intramural sports at the UA	43	35%
NCAA sports	3	2%
None of these	8	7%
Unorganized sports (ie. recreational, pickup games)	89	72%

Table 5: Sports involvement of survey participants.

Sport	Count	% of total
Track	33	33%
Cross Country	28	28%
Soccer	26	26%
Basketball	25	25%
Swimming	23	23%
Volleyball	22	22%
Other	19	19%
Tennis	17	17%
Softball	16	16%
Football	14	14%
Baseball	8	8%
Cheerleading	5	5%
Golf	5	5%
Wrestling	4	4%

Table 6: specific high school sports involvement of population.

Sport	Count	% of total
Tennis	2	5%
Inner Tube Water Polo	4	10%
Basketball	6	14%
Ultimate	7	17%
Softball	7	17%
Flag Football	9	21%
Other	10	24%
Volleyball	11	26%
Soccer	23	55%

Table 7: specific intramural sports involvement of surveyed population of intramural sports players.

The survey population was primarily female, 21-22 years old, and senior status. Most participants were in the colleges of Medicine, Social and Behavioral Sciences or Science (three of the largest colleges at UA). The majority of the participants were involved in high school sports and non-organized sports, with a large population playing club and intramural sports. Popular intramural sports in this population were soccer and volleyball.

The UA Women's club Rugby and UA Women's club Ultimate Frisbee teams were recruited for participation, which may explain the primarily female population heavily involved in sports. In addition, students in a senior capstone Physiology class were recruited to partake in the survey, which explains the large amount of participants in the College of Medicine and also the large number of senior participants.

Concussion Incidence Profile:

The following results reflect the responses to questions asked to assess concussion incidence in the population.

Q7: Have you ever had a concussion?		
Answer	Count	%
Yes	41	33%
No	82	67%

Table 8: Response to question 7: "Have you ever had a concussion?"

33% of the population of survey participants reported sustaining a concussion (Table 8). This number may be disproportionately high because of response bias or because of the large population of sports teams surveyed.

Q8: What did you do following that concussion? Select all that apply.		
Answer	Count	%
Returned to play	12	29%
Saw a doctor	28	68%
Went home and rested	29	71%
Ignored it	3	7%
Other	2	5%

Table 9: Response to question 7: "What did you do following that concussion?"

Participants who reported having sustained a concussion were asked what they did to treat their concussion. The majority of respondents saw a doctor and went home and rested.

However, almost a third of the population with a history of concussion (HOC) returned to play following their concussion.

Q9. How many concussions have you had?		
Answer	Count	%
1-2	30	73%
2-3	8	20%
3-4	1	2%
more than 5	2	5%
Total	41	100%

Table 10: Response to question 9: "How many concussions have you had?"

Q10. How many of these concussions were during sports play outside of organized sports?		
Answer	Response	%
0	26	63%
1-2	12	29%
2-3	2	5%
more than 3	1	2%
Total	41	100%

Table 11: Response to question 10: "How many of these concussions occurred outside of organized sports?"

Q11. How many of these concussions were sustained while under the age of 18?		
Answer	Response	%
0	10	24%
1-2	26	63%
2-3	3	7%
more than 3	2	5%

Table 12: Response to question 11: "How many concussions occurred under the age of 18?"

Q12. How many of these concussions sustained under the age of 18 were NOT sustained during organized sports play? (ie. how many concussions were sustained around the house, at recess, riding a bike, etc.)		
Answer	Response	%
0	21	68%
1-2	10	32%
2-3	0	0%
more than 3	0	0%
Total	31	100%

Table 13: Response to question 12: "How many concussions occurred under the age of 18 outside of sports?"

Participants with a history of concussion (answered "yes" to question 7: "Have you ever had a concussion?") were asked how many concussions were sustained, if any, in various settings. These incidence statistics indicated where concussions occur therefore demonstrating where concussion education is needed.

	Count	%
Q14. I have received concussion education in a high school sport.		
Yes	51	52%
No	48	48%
Q15. I have received concussion education from the Campus Rec.		
Yes	6	14%
No	36	86%
Q16. I have received concussion education from my collegiate club sport.		
Yes	22	45%
No	27	55%
Q26. I have received concussion education of any sort.		
Yes	80	67%
No	39	33%

Table 14: Response to questions 14,15,16 and 26 regarding incidence of education.

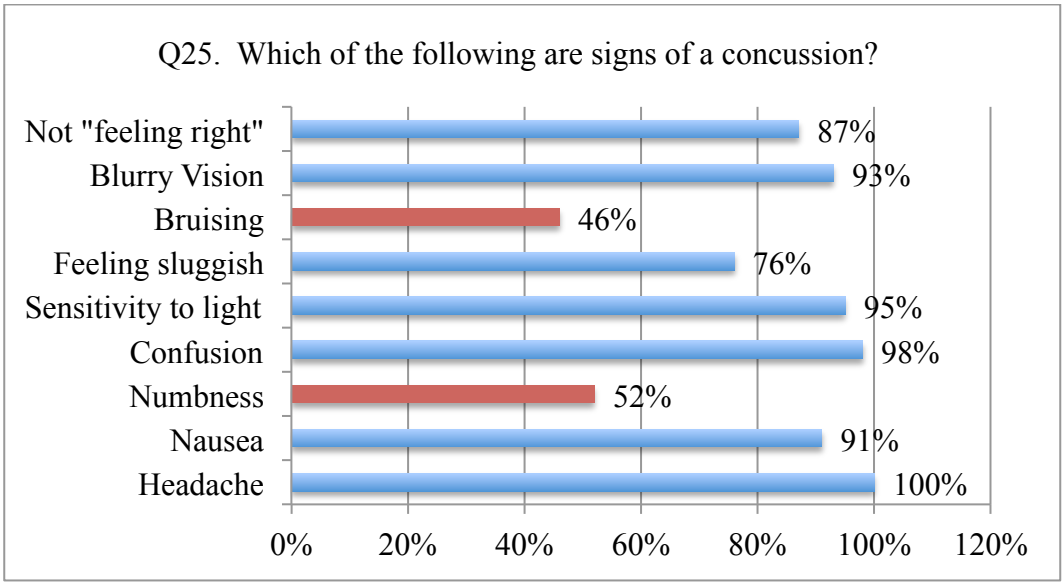
Q32. Do you feel the education you have received was adequate?		
Answer	Response	%
Yes	45	56%
No	35	44%
Total	80	100%

Table 15: Response to question 32: "Do you feel that the education you have received was adequate?"

Participants were asked to report whether or not they have received concussion education in various settings to shed light on how widespread education currently is.

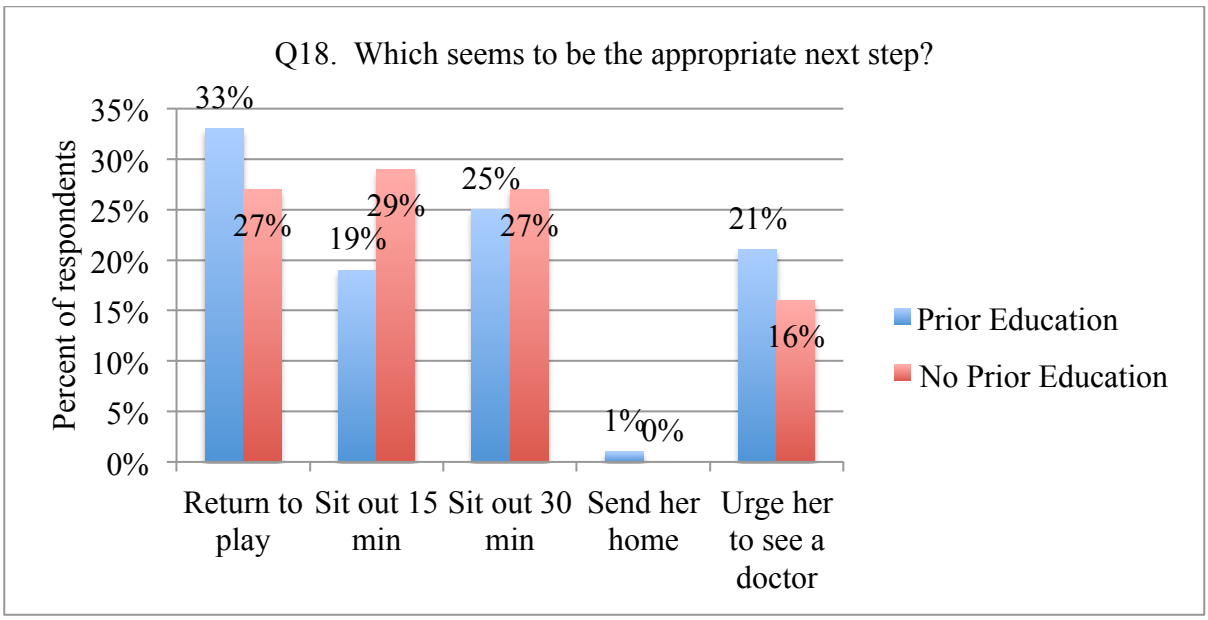
Concussion Education Effectiveness

The following questions were asked to assess the effectiveness of concussion education currently in place. These questions on the survey asked respondents questions regarding signs of a concussion and proper treatment protocol.

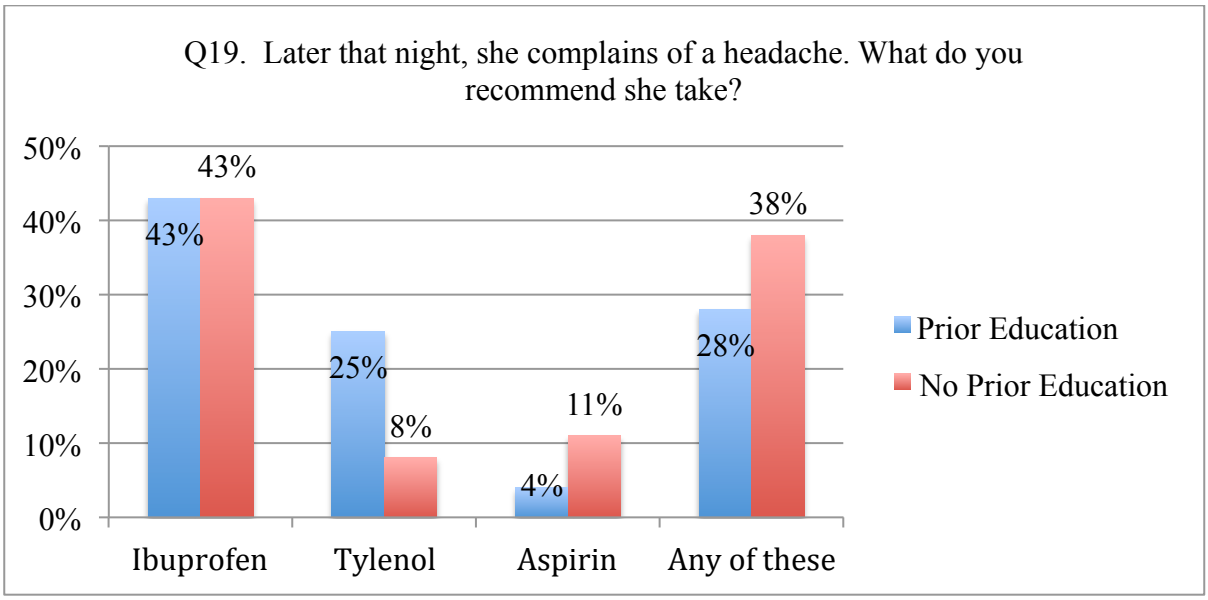


Graph 1: Responses to question 25: "Which of the following are signs of a concussion?"

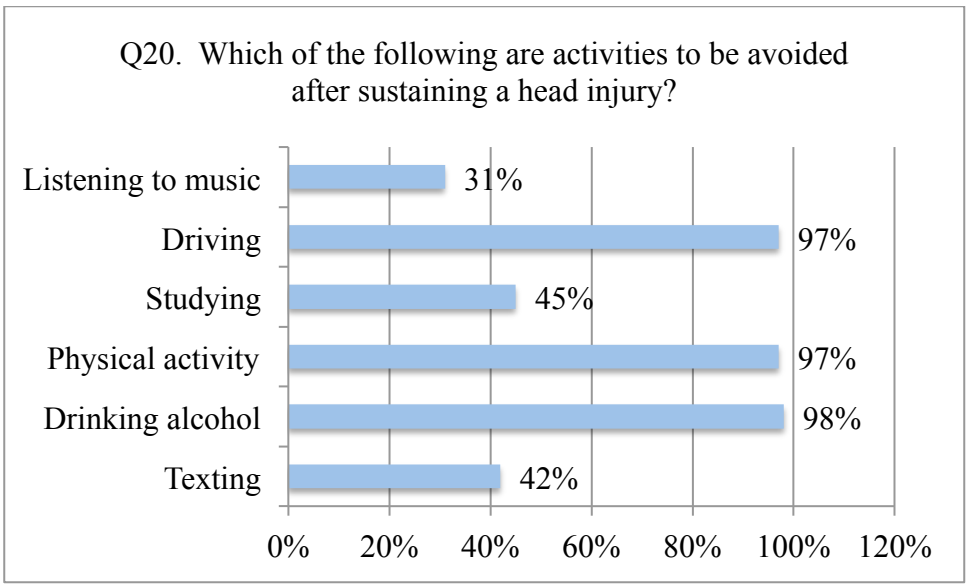
Participants were to consider the following situation when answering questions 18 and 19: "Suppose you are part of an organized soccer team and one of your teammates gets kneed in the face. She reports no symptoms and remarks that she is okay and to get back to the game."



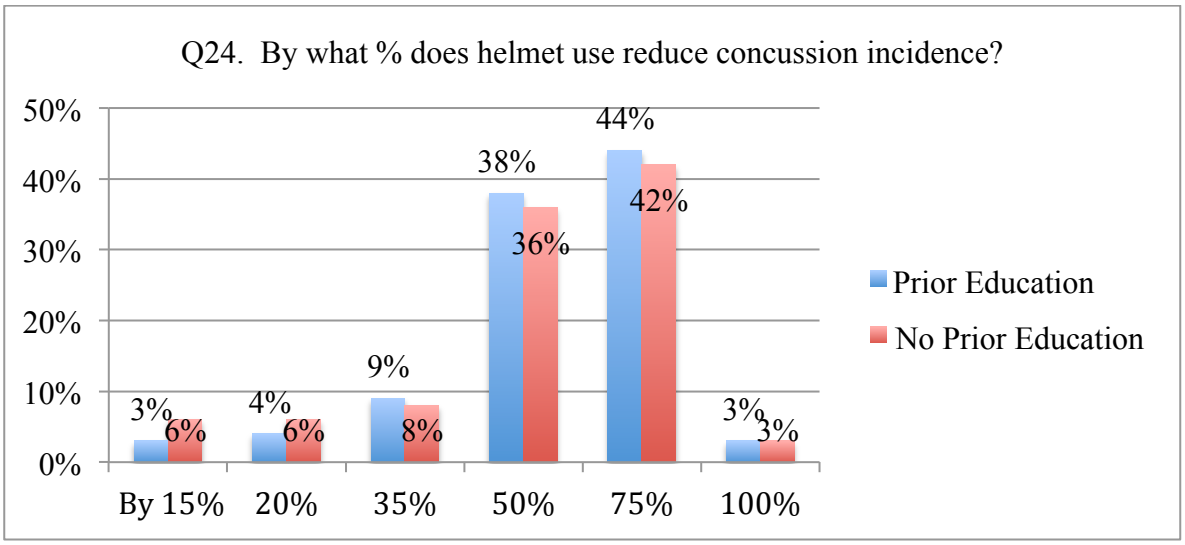
Graph 2: Responses to question 18: "Which seems to be the appropriate next step?"



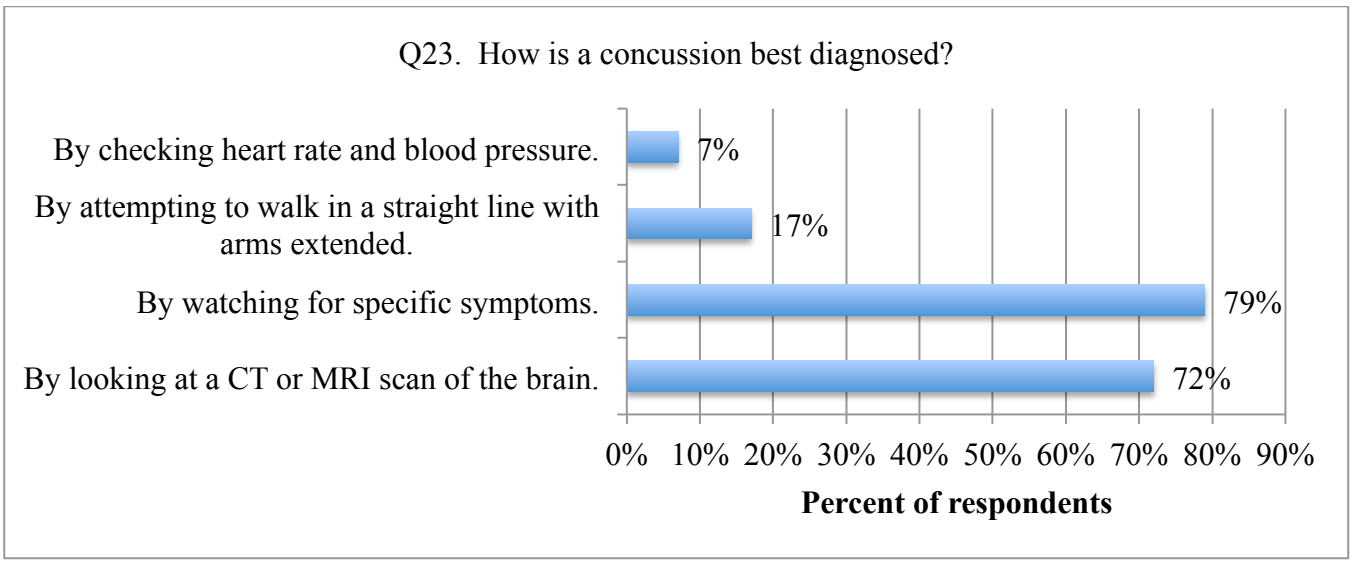
Graph 3: Responses to question 19: "Later that night, she complains of a headache. What do you recommend she take?"



Graph 4: Responses to question 20: "Which of the following activities are to be avoided after sustaining a head injury?"

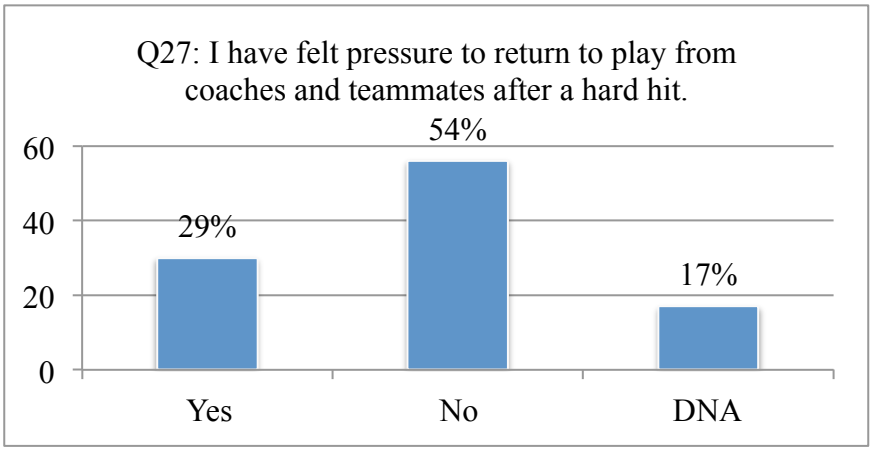


Graph 5: Responses to question 24: "By what % does helmet use reduce concussion incidence?"



Graph 6: Responses to question 23: "How is a concussion best diagnosed?"

Questions 18-25 were asked to all participants to gauge their knowledge of concussion diagnosis and concussion treatment protocol.



Graph 7: Responses to question 27: "I have felt pressure to return to play from coaches and teammates after a hard hit. Yes or no?"

Those who participated in any kind of organized sport were asked if they have ever felt pressure to return to play after a hard hit. 29% of this population affirmed that they have felt this type of pressure.

Discussion:

This thesis sought to assess the awareness of concussion symptoms and treatment protocol, in order to evaluate the effectiveness and the reach of concussion education currently in place.

33% of the surveyed population (41/123) (Table 8) reported sustaining at least one concussion and will serve as the "history of concussion" population (HOC). When asked they did following their concussion, 29% of the HOC population (12/41) report they returned to play following their head injury. This was a "multi-select" question; so the individual could have gone on to see a doctor after returning to play (i.e. selecting more than one activity in question 8) as 68% of the population (28/41) did report seeing a doctor following their concussion. Even if the individual did eventually see a doctor after finishing the game, returning to play following a concussion is dangerous and puts one at risk for second impact syndrome. Sustaining a concussion during a period of vulnerability increases recovery time and increases the risk for long-term consequences (Meehan, Zhang, Mannix, & Whalen, 2012).

Survey participants from the HOC population were then asked the various settings where their concussions occurred and if they had received education in those settings. 75% (31/41) of the HOC population reported sustaining at least one concussion under the age of 18 (Table 12). This is significant because the brain is under development until the early 20s (Carman et al, 2015), which puts the young brain at risk for long term consequences. Damage to parts of the brain that are still under development may result in problems later in life (Carman et al, 2015).

Second impact syndrome is also especially pertinent to the young brain. Because the brain is already in a vulnerable state of development, sustaining a second concussion while the brain is still recovering from the first puts one at risk for long-term consequences. Education for

individuals under the age of 18 should be emphasized because of the vulnerability of the brain during adolescence.

37% (15/41) of the HOC population reported sustaining at least one concussion outside of organized sports (Table 11). 24% of those who had sustained a concussion under the age of 18 (10/31) sustained at least one concussion outside of sports under the age of 18 (Table 13).

As previously mentioned, education is mandated in high school sports, club sports, and NCAA sports. These mandates assume that concussions only occur during organized sports play, or that mandated education given in sports leagues will reach all those at risk for a concussion. However, only 52% (51/99) of the total surveyed population that participated in a high school sport reported received concussion education during high school (Table 14) despite concussions occurring both inside and outside of sports. 33% (80/119) of the total surveyed population reported not ever receiving concussion education of any sort (Table 14). Evidence that concussions occur outside of organized sports play substantiates widespread concussion education, as everyone is at risk for a concussion, not just sports players. However, data collected on education incidence indicates a substantial gap in education reach.

Concussion education informs individuals how to recognize a concussion and properly treat it. If an individual does not know they have a concussion, or does not know what steps to follow in order to properly recover, they could be at risk for long term consequences.

Kroshus & Baugh state that "concussion education for athletes has the potential to play a role in reducing the health burden of concussions from sport by modifying individual risk-related behaviors" (Kroshus & Baugh, 2015). Without education, players are more likely to engage in risky behavior regarding concussion treatment protocol.

It is first important to note that individuals who took this survey are aware of the signs of a concussion. 80-90% of respondents chose the following correct symptoms as being signs of a concussion: not "feeling right" (87% indicated this as a symptom), blurry vision (93%), sensitivity to light (95%), confusion (98%), nausea (91%) and headache (100%) (Graph 1). Only 40-50% of respondents chose the incorrect signs: bruising (46%) and numbness (52%). In addition, participants were asked how a concussion is best diagnosed. 72% of participants selected "by looking at a CT or MRI scan of the brain" which is not technically correct, but there is debate regarding this. Some mTBIs result in abnormalities that can be seen on a neuroimaging scan (Dimou & Lagopoulos, 2014), but some institutions define a concussion as not displaying abnormalities on a brain scan. Nevertheless, 79% of respondents indicated that concussions are diagnosed by watching for specific symptoms, which is the correct choice (Graph 6). These two questions assessed the surveyed populations "textbook" knowledge of concussions. From this, it can be concluded that participants are aware of the basic symptoms and diagnosis criteria of a concussion, and that respondents were informed enough to answer questions regarding what to do following that concussion.

Although participants were able to answer basic questions correctly regarding concussion signs, the actual definition of a concussion is not universally known. Towards the end of the survey, participants were given the definition of a concussion, as provided by the CDC: "A concussion is defined by: 1. A forceful bump, blow, or jolt to the head or body that results in rapid movement of the head. -and- 2. Any concussion signs or symptoms, such as a change in the athlete's behavior, thinking, or physical functioning" ("What Is a Concussion? | CDC Injury Center," n.d.). After they were given the definition of a concussion, they were asked if this information changes the number of concussion previously reported. 24% (28/118) of respondents

affirmed that their reported concussion number had changed once they learned the true definition of a concussion. 70% (19/27) of those that designated a change in response indicated that their answer was now more than previously stated. This finding is consistent with what was found by Robbins et al. The definition of a concussion is not widely known so making individuals more aware of the definition of a concussion may aid in better concussion reporting and potentially better outcomes (Robbins et al, 2014).

Subsequent questions assessed participant's knowledge of treatment protocol. Question 20 asked, "Which of the following are activities to be avoided after sustaining a head injury?". 97-98% of respondents indicated driving (97%), physical activity (97%), and drinking alcohol (98%) should be avoided after a head injury (graph 4). However, only 30-45% of respondents indicated texting (42%), studying (45%), and listening to music (31%) as inappropriate activities to partake in following a head injury (graph 4). It is interesting to note that very recent concussion treatment protocol indicates physical activity should be rapidly incorporated into a concussion recovery plan (McCrory et al, 2013) to promote healing, but treatment protocol has consistently discouraged screen use (texting), listening to music and cognitive activities (studying). Responses reflected the antiquated treatment technique of heavily reduced physical activity, but also demonstrated a lack of understanding of either protocol, as the activities consistently discouraged across all protocols were popular choices among respondents (studying, listening to music, texting).

Participants were then asked what the appropriate next step would be following a teammate sustaining a knee to the face. Responses were grouped into those with no prior concussion education (NPE) and those with prior concussion education (PE). 33% of the educated population (PE) (26/80) indicated that the appropriate next step would be to have her

return to play, which was the most popular choice for this population (Graph 2). 29% (11/39) of the population with no prior education (NPE) indicated she should sit out 15 minutes and then return to play, which was the most popular choice, with "return to play" and "sit out 30 minutes" being tied for the second most popular choice in the NPE group. Only 21% of the PE group (17/80) and 16% (6/39) of the NPE group indicated that they would urge her to see a doctor. It is known that concussion education decreases risky behavior (Kroshus & Baugh, 2015), but the results indicate that the most risky choice to this scenario ("have her return to play") was most popular among those with prior concussion education. This indicates that concussion education currently in place is ineffective at preventing risky decision-making and all individuals do not understand the gravity of a concussion. Those without prior education did not choose the most risky choice but, still, the proper choice was not the most popular with this group. These findings indicate that proper treatment protocol for concussions is not inherent and widespread education is necessary to make the correct choices following a head injury.

Participants were asked which drug would be most appropriate to take to relieve a headache after a head injury. Although not intuitive, the correct answer would be Tylenol/acetaminophen, which was indicated by only 25% (20/80) of the PE group and 8% (3/39) of the NPE group (Graph 3). 43% of both the PE (34/80) and NPE (16/39) groups chose Ibuprofen, which was the most popular response, and also a risky choice (Graph 3). Aspirin and Advil/ibuprofen are anti-inflammatory drugs that have an anti-coagulant mechanism. Taking these drugs after sustaining a concussion would increase the risk of a subdural hematoma.

Participants were also asked how protective helmets are. 38%/36% of the PE/NPE populations (30/80)/(14/39), respectively, believed that helmets reduced concussion incidence by 50% (Graph 5). 44%/42% of the PE/NPE populations (35/80)/(16/39), respectively, thought that

helmets reduced concussion incidence by 75% (graph 5). Although specifics are debated, it is accepted that helmets reduce the potential for a concussion by 20-25% (National Research Council (U.S.) et al, 2014). This statistic depends on many factors, such as the angle of the injury-causing force, the material and thickness of the helmet, the presence of other preventative gear, helmet fit, etc. Despite all these factors, even the most protective, state of the art helmet would not reduce the risk of a concussion by more than 50%. The responses to this question indicate over-confidence in protective gear, which may have implications for protective gear causing increased aggressiveness in sports play.

Limitations

The primary limitation of this survey was time. Because it is an honors thesis project, it was to be completed in a 10-month school year. The IRB approval procedure demanded 6 of the 10 months, so for a more thorough analysis of concussion awareness, more time is required.

Another limitation of the project was the survey population. Respondents were primarily female and senior standing, which is not an accurate representation of the general population. In addition, only two sports teams, club rugby and club ultimate Frisbee were represented in the survey population. These two sports are particularly intense and aggressive, which may have influenced the results, especially the scenario questions regarding treatment protocol.

To better assess the general population's awareness of concussions, a more standardized recruitment procedure needs to be followed in order to recruit a representative population for a more accurate assessment.

Conclusion

Overall, the responses demonstrated a lack of effective education. Despite evidence of concussions occurring outside of sports, education does not reach populations of non-athletes. Responses also indicated a lack of knowledge of proper treatment protocol in both individuals with prior concussion education and no prior concussion education. This suggests that proper treatment protocol is not instinctive and needs to be taught. Responses also indicate that concussion education currently in place is not effective, as those with prior education still made risky and incorrect decisions regarding concussion recovery. Risky decisions chosen by respondents can indicate a decreased understanding of the severity of a head injury as well.

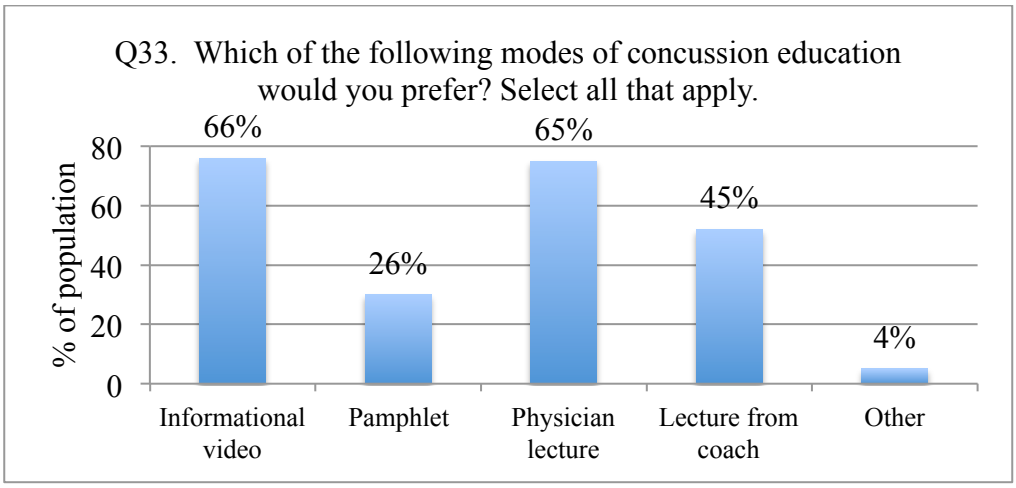
Future Implications

Concussions are a serious public health issue and are to be taken seriously, as the brain is a vital organ. It is currently unknown whether or not concussions can result in long-term consequences, but current research indicates that multiple head injuries may result in a neurodegenerative disease called chronic traumatic encephalopathy (CTE) that may cause dementia and behavioral changes later in life (Carr, 2012). Although the long-term impact of concussions is uncertain, it is evident that sustaining multiple concussions without allowing time for proper healing worsens outcomes. Those who sustain a concussion need to follow proper treatment protocol to decrease the risk of magnified neurologic sequelae (Kroshus & Baugh, 2015).

Findings from the survey responses illustrate a lack of awareness of proper treatment protocol in the general population, even in those with prior education, effectively rendering

current education ineffective. In fact, 44% (35/80%) of survey respondents who had received concussion education indicated that they felt that the concussion education they had received was inadequate (Table 15), further confirming a need for more effective education. Results from the survey also indicate that the general population, not just athletes, is at risk for concussions and current concussion education does not reach some vulnerable populations. Therefore, a need for more widespread, more effective education is substantiated.

Survey participants were asked what mode of concussion education they would prefer.



Graph 8: Responses to question 33: "Which of the following modes of concussion education would you prefer? Select all that apply."

An informational video and a lecture from a physician were the most popular choices, followed by a lecture from a coach. A pamphlet was the least preferred choice (graph 8).

My recommendation is for widespread, comprehensive concussion education, in the form of the modes listed in graph 8, to be implemented in the University of Arizona. Education must reach the general population that could experience a concussion while participating in virtually any everyday task that affords some risk. This education should contain a universally accepted definition of a concussion, signs and symptoms, as well as basic treatment protocol that emphasizes seeking the advice of a healthcare professional as well as encourages sports players

to abstain from sports play until symptoms do not persist. Most importantly, education must stress the severity of a concussion and the importance of taking suitable steps to recovery.

Effective education can promote adherence to proper treatment protocol only to a certain extent. While the general population may not follow steps to proper treatment due to being ill informed, sports players might experience pressure to minimize their head injury. 29% (30/104) of organized sports players surveyed indicated that they have felt pressure to return to play from coaches and/or teammates after a hard hit (graph 7). This response reveals the culture that exists in organized sports: disregarding an athlete's health to promote relentless commitment to the game. If concussions are to be taken seriously, all those involved in sports need to acknowledge the severity of head injuries and learn to prioritize athletes' health over the sport. It is important to know the signs and symptoms and what should be done following a concussion, but it is crucial to actually take action when a head injury occurs. Changing the entire dynamic of sports will be difficult, but effective education can be the first step in the development of a culture that is receptive and proactive regarding the risks of concussions.

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Appendices

Appendix 1: Concussion Survey

Q1 This is a consent form for research participation. It contains important information about this study and what to expect if you decide to participate. Please consider the information carefully.
This survey is part of an honors thesis completed to fulfill the requirement for graduation with honors in Physiology. Concussions are serious injuries that may cause long-term consequences. My thesis seeks to assess the knowledge of concussions and how it affects decision-making following a concussion in the population of students at the University of Arizona.
·This survey will be given to about 500-700 students across all majors.
·This study is part of an undergraduate physiology honors thesis.
·Inclusion in this study will contribute to the general assessment of knowledge and incidence of concussions, inside and outside of sports play.
·This survey will require about 10 minutes of your time.
·Your participation is voluntary. You may refuse to participate in this study.
·Some questions ask about activities that participants may feel uncomfortable being asked about. However, participants may choose not to answer any of the questions.
·Your information will allow for insight that could improve the knowledge and management of concussions in students across campus.
·You may choose not to participate without penalty or loss of benefits to which you are otherwise entitled.
·You will be provided with any new information that develops during the course of the research that may affect your decision whether or not to continue participation in the study.
·An Institutional Review Board responsible for human subjects research at The University of Arizona reviewed this research project and found it to be acceptable, according to applicable state and federal regulations and University policies designed to protect the rights and welfare of participants in research.
If you have any questions you may contact the PI, Courtney Holbrook at courtneyholbrook@email.arizona.edu or the advisor, Cindy Rankin, PhD at crankin@email.arizona.edu.
By choosing "I give my consent to take part in the survey"; below, you agree to the following statement: I have read (or someone has read to me) this form, and I am aware that I am being asked to participate in a research study. I have had the opportunity to ask questions and have had them answered to my satisfaction. I voluntarily agree to participate in this study. I am not giving up any legal rights by signing this form.

- ❍ I give my consent to take part in the survey. (1)
- ❍ I do not give my consent to take part in the survey. (2)

If I do not give my consent to... Is Selected, Then Skip To Thank you for your participation. Ple...

Q2 What is your gender?
- ❍ Male (1)
- ❍ Female (2)
- ❍ Other (3)

Q3 What is your primary college?
- ❍ Agriculture and Life Sciences (1)
- ❍ Architecture (2)
- ❍ Education (3)
- ❍ Engineering (4)
- ❍ Fine Arts (5)
- ❍ Humanities (6)
- ❍ Medicine (7)
- ❍ Nursing (8)
- ❍ Pharmacy (10)
- ❍ Social and Behavioral Sciences (13)
- ❍ LASC (14)
- ❍ Eller (15)
- ❍ Public Health (16)
- ❍ Science: Psychology (12)
- ❍ Science: SLHS (9)
- ❍ Science: Math (11)
- ❍ Science: Natural sciences (17)
- ❍ Science: other (18)

Q4 What is your age?
- ❍ under 18 (1)
- ❍ 18 (2)
- ❍ 19 (3)
- ❍ 20 (4)
- ❍ 21 (5)
- ❍ 22 (6)
- ❍ over 22 (7)

Q5 What is your grade? (by year, not by credits)
- ❍ Freshman (1)
- ❍ Sophomore (6)
- ❍ Junior (7)
- ❍ Senior (8)
- ❍ Graduate student (9)

Q6 Which of the following have you participated in? Select all that apply.

- ❑ High school sports (1)
- ❑ Club collegiate sports at the UA (2)
- ❑ Intramural sports at the UA (3)
- ❑ NCAA sports (4)
- ❑ Unorganized sports (ie. recreational, pickup games) (6)
- ❑ None of these (5)

Answer If Which of the following have you participated in? Select all that apply. High school sports Is Selected

Q7 Which high school sports have you participated in? Select all that apply.

- ❑ Football (1)
- ❑ Baseball (2)
- ❑ Basketball (3)
- ❑ Softball (4)
- ❑ Wrestling (5)
- ❑ Soccer (6)
- ❑ Cross Country (7)
- ❑ Track (8)
- ❑ Golf (9)
- ❑ Tennis (10)
- ❑ Swimming (11)
- ❑ Cheerleading (12)
- ❑ Volleyball (13)
- ❑ Other (14) _____

Answer If Which of the following have you participated in? Select all that apply. Intramural sports at the UA Is Selected

Q8 Which Intramural sports have you participated in? Select all that apply.

- ❑ Volleyball (1)
- ❑ Basketball (2)
- ❑ Flag Football (3)
- ❑ Ultimate (4)
- ❑ Inner Tube Water Polo (5)
- ❑ Soccer (6)
- ❑ Softball (7)
- ❑ Tennis (8)
- ❑ Other (9) _____

Q9 Have you ever had a concussion?

- ❍ Yes (1)

❍ No (2)

Answer If Have you ever had a concussion? Yes Is Selected

Q10 What did you do following that concussion? Select all that apply.

❑ Returned to play (1)
❑ Saw a doctor (2)
❑ Went home and rested (3)
❑ Ignored it (4)
❑ Other (5) _____

Answer If Have you ever had a concussion? Yes Is Selected

Q11 How many concussions have you had?

❍ 1-2 (1)
❍ 2-3 (2)
❍ 3-4 (3)
❍ more than 5 (4)

Answer If Have you ever had a concussion? Yes Is Selected

Q12 How many of these concussions were during sports play outside of organized sports? For this survey, an organized sport is considered to be affiliated with a high school, a club, an intramural league, or NCAA. An unorganized sport is considered to be a pick up game or recreational activity, for example.

❍ 0 (1)
❍ 1-2 (2)
❍ 2-3 (3)
❍ more than 3 (4)

Answer If Have you ever had a concussion? Yes Is Selected

Q13 How many of these concussions were sustained while under the age of 18?

❍ 0 (1)
❍ 1-2 (2)
❍ 2-3 (3)
❍ more than 3 (4)

Answer If How many of these concussions were sustained while under the age of 18? 1-2 Is Selected Or How many of these concussions were sustained while under the age of 18? 2-3 Is Selected Or How many of these concussions were sustained while under the age of 18? more than 3 Is Selected

Q14 How many of these concussions sustained under the age of 18 were NOT sustained during organized sports play? (ie. how many concussions were sustained around the house, at recess, riding a bike, etc.)

❍ 0 (1)

- 1-2 (2)
- 2-3 (3)
- more than 3 (4)

Answer If Have you ever had a concussion? Yes Is Selected And Which of the following have you participated in? Select all that apply. Intramural sports at the UA Is Selected

Q15 How many concussions have you sustained in intramural games?
- 0 (1)
- 1-2 (2)
- 2-3 (3)
- more than 3 (4)

Answer If Which of the following have you participated in? Select all that apply. High school sports Is Selected

Q16 I have received concussion education in a high school sport.
- Yes (1)
- No (2)

Answer If Which of the following have you participated in? Select all that apply. Intramural sports at the UA Is Selected

Q17 I have received concussion education from the Campus Rec.
- Yes (1)
- No (2)

Answer If Which of the following have you participated in? Select all that apply. Club collegiate sports at the UA Is Selected

Q18 I have received concussion education from my collegiate club sport.
- Yes (1)
- No (2)\

Q19 A concussion can result from a direct blow to the ____
- head (1)
- torso (2)
- leg (3)
- all of these (4)

Q20 Suppose you are part of an organized soccer team and one of your teammates gets kneed in the face. She reports no symptoms and remarks that she is okay and to get back to the game.

Q21 Which seems to be the appropriate next step?
- Let her return to play but remove her from play if she displays any abnormal behavior.
- Have her sit out 15 minutes and then let her return to play. (2)

- ❍ Have her sit out 30 minutes and then let her return to play. (3)
- ❍ Send her home to get some rest to be able to practice tomorrow. (4)
- ❍ Urge her to see a doctor. (5)

Q22 Later that night, she complains of a headache. What do you recommend she do?
- ❍ Take an Ibuprofen/Advil (1)
- ❍ Take a Acetaminophen/Tylenol (2)
- ❍ Take an aspirin (3)
- ❍ Any of these (4)

Q23 Which of the following are activities to be avoided after sustaining a head injury? Select all that apply.
- ❑ Texting (1)
- ❑ Drinking alcohol (2)
- ❑ Physical activity (3)
- ❑ Studying (4)
- ❑ Driving (5)
- ❑ Listening to music (6)

Q24 You always should see a doctor after sustaining a head injury with concussion symptoms.
- ❍ Yes (1)
- ❍ No (2)

Q25 Symptoms are most pronounced immediately after a head injury.
- ❍ True (1)
- ❍ False (2)

Q26 How is a concussion best diagnosed?
- ❑ By looking at a CT or MRI scan of the brain. (1)
- ❑ By watching for specific symptoms. (2)
- ❑ By attempting to walk in a straight line with arms extended. (3)
- ❑ By checking heart rate and blood pressure. (4)

Q27 By what % does helmet use reduce concussion incidence?
- ❍ 100% (1)
- ❍ 75% (2)
- ❍ 50% (3)
- ❍ 35% (4)
- ❍ 20% (5)
- ❍ 15% (6)

Q28 Which of the following are signs of a concussion? Select all that apply.

- ❑ Headache (1)
- ❑ Nausea (2)
- ❑ Numbness (3)
- ❑ Confusion (4)
- ❑ Sensitivity to light (5)
- ❑ Feeling sluggish (6)
- ❑ Bruising (7)
- ❑ Blurry Vision (8)
- ❑ Not "feeling right" (9)

Q29 I have received concussion education of any sort.
- ❍ Yes (1)
- ❍ No (4)

Answer If I have received concussion education of any sort. Yes Is Selected

Q30 Do you feel the education you have received was adequate?
- ❍ Yes (1)
- ❍ No (2)

Q31 Which of the following modes of concussion education would you prefer? Select all that apply.
- ❑ An informational video (1)
- ❑ A pamphlet (2)
- ❑ Lecture from health professional (3)
- ❑ Lecture from coach (4)
- ❑ Other (5) _____

Answer If Which of the following have you participated in? Select all that apply. Club collegiate sports at the UA Is Selected Or Which of the following have you participated in? Select all that apply. NCAA sports Is Selected Or Which of the following have you participated in? Select all that apply. High school sports Is Selected

Q32 I have felt pressure from coaches and/or teammates to return to play after a hard hit.
- ❍ Agree (1)
- ❍ Disagree (3)
- ❍ Does not apply (4)

Q33 A concussion is defined by: 1. A forceful bump, blow, or jolt to the head or body that results in rapid movement of the head. -and- 2. Any concussion signs or symptoms, such as a change in the athlete's behavior, thinking, or physical functioning.Does this change your previous answer of how many concussions you have had?
- ❍ Yes (1)
- ❍ No (2)

Answer If A concussion is defined by: 1. A forceful bump, blow, or jolt to the head or body that results in rapid movement of the head. -and- 2. Any concussion signs or symptoms, such as a cha... Yes Is Selected

Q34 How many concussions have you sustained?

Answer If A concussion is defined by: 1. A forceful bump, blow, or jolt to the head or body that results i... Yes Is Selected

Q35 Is your new answer more or less than previously stated?

- More (1)
- Less (2)

Q36 Have you seen the movie, "Concussion"?

- Yes (1)
- No (2)

Answer If Have you seen the movie, "Concussion"? Yes Is Selected

Q37 Did the movie change your perception of concussions in professional sports?

- Yes (1)
- No (2)

Q38 Thank you for your participation. Please click next to finish the survey.

Reflection:

When I began my honors thesis last April, I did not realize that the topic of concussions would explode throughout the media during the course of my writing. My original interest in concussions stemmed from my decision to pursue a Masters of Public Health after graduation. It made sense to integrate both my degree in physiology and the field I am entering into by exploring a public health topic for my thesis. I was unaware that so much research was being done regarding concussions, and that when I returned to school in August, I would find papers published weekly regarding exactly what I was studying, concussion awareness.

My first experience with concussions was hearing about a friend losing consciousness on the lacrosse field in high school. He ended up being okay, but had to take time off of school to recover. I wondered if everyone was as proactive as he was following a concussion.

I spent two summers of undergrad in Peru, volunteering for a non-profit that gives educational seminars in rural communities regarding public health issues such as parasitism and obesity. I was shocked how much these community members did not know about the causes of parasitic infection and how receptive they were to our seminars. When I came back to Peru the following summer, the non-profit had actual data on how educational outreach has decreased rates of parasitic infection in these communities. Experiencing how powerful and effective education can be is why I am pursuing an MPH in health policy.

If education can cause better health outcomes in rural Peruvian neighborhoods, I knew that it could make positive change in my own community as well. One can assume that those in rural communities lack education, but back in Tucson, I needed to substantiate making changes to concussion education currently in place by finding evidence that gaps in knowledge exist in populations at risk. I was successful in this. My findings are a small confirmation of what has been previously indicated in other studies: people do not know enough about concussions.

I would love to be able to pursue my interest in concussion education further. Researching head injuries has shown me that even common, every day injuries, like concussions, that do not seem like significant trauma can result in long-term consequences, substantiating the need for increased patient education. Concussions are certainly an example of how increased media coverage can bring about awareness and positive advancements in the field public health, despite pushback from the NFL. When I read this reflection 5 years down the line, I hope that there will be even more substantial improvements to concussion management in organized sports.

Writing this thesis has made me even more passionate about health policy and public health. I am not sure my findings from the next research study I facilitate will be as indicative and significant as they were in this study, but I've learned that the process is the most rewarding part of the journey. My honors thesis has truly been an integrative project of everything I have learned during undergrad, and it has been a wonderful experience.