PARTICIPATION WHILE SYMPTOMATIC: THE SPORT-RELATED CONCUSSION CONUNDRUM

by

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LIST OF ABBREVIATIONS

Abbreviation	Description
ADHD	Attention Deficit Hyperactivity Disorder
ANN	American Academy of Neurology
AT	Athletic Trainer
CTE	Chronic Traumatic Encephalopathy
HRQoL	Health Related Quality of Life
ImPACT	Immediate Post-Concussion Assessment and Cognitive Testing
LOC	Loss of Consciousness
mTBI	Mild Traumatic Brain Injury
NATA	National Athletic Trainer Association
NCAA	National Collegiate Athletic Association
NFL	National Football League
RIO	Reporting Information Online
RTP	Return-To-Play
SRC	Sport-Related Concussion
TBI	Traumatic Brain Injury

I. INTRODUCTION

Approximately 1.7 million people are diagnosed with a traumatic brain injury (TBI) annually in the United States.[1] It is estimated that 75% of these injuries are categorized as a mild traumatic brain injury (mTBI), better known as a concussion.[2] In 15-24 year-olds, sport-related concussions (SRC) are the second highest cause of TBI following motor vehicle accidents.[3] A concussion is a direct or indirect contact to the head, face, neck, or body, which results either in a collision between the brain and skull or in a strain on neural tissue and vasculature.[4] The majority of concussions cause immediate signs and symptoms; however, approximately 20% of concussions can produce a delayed onset of signs and symptoms occurring about 48 hours post injury.[5] Symptoms including temporary alterations in neurological and neurocognitive functioning typically resolve within 1-2 weeks post-injury in adults.[4] Study estimations have estimated that per 10,000 athletic exposures in a game or practice result in approximately 2.5 to 5 concussions diagnosed among male and female athletes of all sports.[6,7] One study found concussions represented 8.9% of all high school sports-related injuries.[8] Additionally, previous studies have determined that more concussion injuries happened during practice compared to games/competitions,[8-11] but more concussions are reported during games/competitions.[9] Specifically, Register-Mihalik et al. indicated that 73 (22.8%) of 320 concussive events during games were reported and 40 (11.5%) of 348 concussive events during practice were reported.[9] Additionally, concussion rates are higher among collegiate athletes in comparison to high school athletes and they occur more frequently during full contact/partial contact sports (e.g football, soccer, basketball, etc.) versus non-contact sports (e.g cross-country, track, swimming, tennis).[8]

Furthermore, high school athletes are shown to take longer during SRC recovery compared to collegiate athletes[12], it could be assumed that younger athletes would take even longer with recovery. Conversely, there is a dearth in concussion data concerning 3.6 million middle school students and 21.5 million club sport athletes.[13] Research lacks evidence whether these assumptions are the same among younger athletic populations such as middle school student-athletes or non-school affiliated club leagues.

The number of diagnosed concussions may not accurately represent the number of concussions occurring because many concussions go unreported and undiagnosed.[14] Concussions may not be reported or diagnosed for a variety of reasons such as, a lack of proper concussion education or delayed onset of concussion-related symptoms. Athletes may be unaware that the symptoms and head impact are related.[4] Some concussions may be associated with more obvious signs and symptoms such as loss of consciousness (LOC), disorientation, amnesia, balance disturbance, and nystagmus. More in-depth injury evaluation has detected additional neurocognitive symptoms such as decreased processing speed and decreased reaction time.[15] Conversely, a concussion may only result in unobservable symptoms (e.g. dizziness, headache, nausea, fatigue) that must be self-reported by the patient.[8,16,17] According to Gessel et al., headache, dizziness, and confusion are the most common symptoms reported after sustaining a concussion.[8] Athletes are generally more aware of the cognitive and somatic deficits (e.g headache, nausea, dizziness, balance disturbances) that may follow a concussive event, but may not associate psychiatric problems such as mood changes, irritability, anxiety, and depression with SRC.[18,19] Research shows that psychiatric changes are common in a variety of brain injuries.[20,21] In support of these findings, Kuehl and colleagues conducted a study that

suggested SRC may alter individual's health-related quality of life (HRQoL)[22], which is defined as physical, psychological, and social domains of health determined by an individual's beliefs, perceptions, values, and experiences.[23] It is important for athletes to be honest while reporting their SRC symptoms in order to receive appropriate medical attention. This will further benefit the athlete by preventing the individual from returning to activity before reaching a full recovery. Return-to-play (RTP) should be guided by a medical professional such as the athlete's athletic trainer (AT) and/or physician and involve a 5-day protocol that begins when the athlete is asymptomatic for 24 consecutive hours.[4] As discussed in many studies, premature RTP could ultimately lead to further, long-term complications such as post-concussion syndrome or second impact syndrome.[4,22,24-31]

A study by Wallace et al. determined several reasons why high school athletes did not report their concussions including: not thinking it was serious enough for medical attention; not wanting to lose playing time; not wanting to let their team down; not wanting to go to the doctor; or not having health insurance.[31] The lack of reporting concussions makes it necessary to continue to emphasize the importance of concussion education to encourage athletes to seek proper medical care after sustaining a concussion. Zuckerman et al. compared the frequency of SRCs during the 2009-2010 academic year with the 2013-2014 academic year in 25 National Collegiate Athletic Association (NCAA) sports.[11] The researchers determined that there has been an increase in the number of SRCs reported, but they were unable to determine whether this increase was the result of improved SRC reporting or an increase in SRC frequency.[11] Reporting differences between male and female student-athletes is frequently investigating and

some studies attribute these differences to the sport, style of play, biomechanical differences, and/or cultural explanations.[8] Among various high school sports, Gessel et al. indicated that the majority of football concussions come from running plays; female soccer players are at higher risk while heading the ball compared to male players; female basketball players are at greater risk while defending and ball control compared to male players; 'takedowns' during wrestling result in the highest risk; and baseball/softball have similar rates of concussion from getting hit with the ball.[8] It is hard to tell whether male or female athletes sustain more concussions or if the differences are attributed to under-reporting.[10,32,33] Torres et al. argue that male athletes and athletes with a history of previous concussions are more likely to under-report future concussions.[10,32,33]

Universities and high schools commonly employ an AT to oversee athletes and their injuries before, during, and after athletic events. An AT is a healthcare professional that collaborate with physicians and provide services including prevention, emergency care, clinical diagnosis, therapeutic intervention, and rehabilitation to injuries and medical conditions among active populations.[34] As of 2014, there were approximately 25,400 ATs employed in the United States; of this number 37% worked at educational-based locations such as secondary schools or universities.[35] According to the National Athletic Trainers' Association (NATA), in 2009 only 42% of high schools across the country had access to an AT.[36] The employment of ATs has expanded at the secondary school and collegiate level and in healthcare over the recent years.[35] It is suggested these jobs will continue to increase by 21% from 2014 to 2024 due to the higher demand for ATs and the increase in awareness of sports-related injuries.[35] Wallace et al. discovered student-athletes attending schools without an AT report fewer concussions compared to

student-athletes with an AT.[31] Related research has looked at schools that do not employ a full-time AT and how it affects concussion education, reporting, and injury care in those particular student-athletes.[37,38] Information about concussion understanding and awareness from school nurses, high school football coaches, and student-athletes has been collected in several studies, which all suggest that not having an AT or medical professional available has a negative influence on concussion reporting.[37-39] Guilmette et al. indicated that coaches answered concussion education questions relatively well, but many coaches also stated they did not have any or very few concussions throughout the entire previous season. It is important the coaches are educated on this topic, but having an AT present monitor the SRCs is preferred because the coaches are often not trained or qualified to properly evaluate them.[38-31] Their findings suggest future research to focus on younger age groups to determine the level of concussion education received among those athletes and coaches.[38] Weber et al. surveyed high school nurses across the country, 49.1% of the respondents said their school also employed an AT.[37] Nurses at schools with an AT tended to have more experience and knowledge about these injuries.[37] In support of ATs being valuable at schools, another study found that 19% of their nurse respondents were not aware there was a RTP protocol.[40] It has not yet been determined how likely a concussed athlete is to withhold themselves from athletic activities when experiencing SRC symptoms when an AT is not available. In a study investigating RTP behaviors during games involving Australian football players conducted by Fortington et al., the data indicated that 88% (n = 30) of the concussed athletes removed themselves immediately after a concussive event and the remaining 12% (n = 4) continued playing.[41] However, 47% (n = 14) of the 30 players removed from play for a concussion evaluation

returned to the same game despite being evaluated by a medical professional.[41] Therefore, these findings indicate that concussion education, specifically in Australian rugby, may not be sound or the evaluation process used in this study was not adequate enough to differentiate concussion injuries. Additionally, athletes may not be aware of the risks they were enduring by returning to play the same day of injury. Taking this into consideration, it is important to determine whether athletes, coaches, and parents have been thoroughly educated on how to recognize SRC signs and symptoms and the importance of seeking medical attention from someone they trust.[12,32,42,43]

The majority of previous concussion research has recruited high school[6,8-10,12,19,24,28,29,31,39,42,44-47] and collegiate student-athletes[5,8,17,18,22,26,29,32,48-51], thus data on younger athletes is lacking. Considering a large amount of athletes begin playing sports before high school, further research is necessary to determine the amount of concussion education and the awareness of concussion symptoms among younger age groups.[38] Likewise, Kerr et al. determined little concussion research has looked at the influence 'environment levels' has on student-athletes reporting concussions, this leaves a large number of club athletes unaccounted for in research.[52] The majority of research has utilized collegiate or high school student-athletes and there is little to show for the middle school student-athletes, this study would like to gain more information on this highly active age category and what they know about concussion injuries. This cross-sectional study is guided to focus on how concussion injury behavior in regards to participating while symptomatic may differ based on the presence of an AT and concussion education among student-athletes in middle school, high school, and college that play school and/or club affiliated sports. Information gathered on this topic can help future clinicians make a

better educated assumption if athletes are under-reporting and/or participating while symptomatic due to lack of knowledge or AT presence at certain academic levels. Seen in **Figure 1.1** is a guide to how the authors envisioned the breakdown of the contributing baseline variables, a concussive event, and the variables that might factor in after the injury.

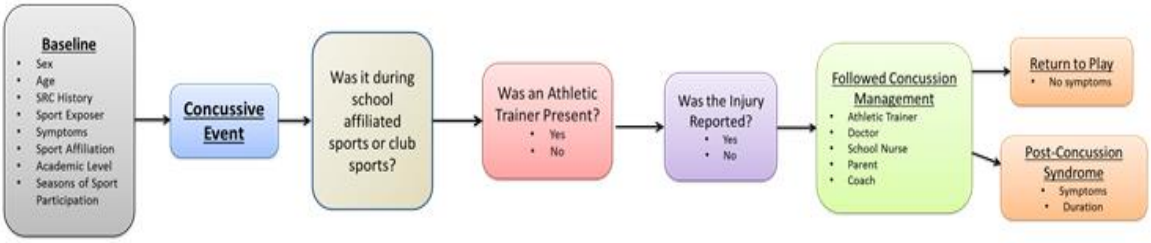

Figure 1 - Theoretical Model

Research Questions

Research Question 1: What is the relationship between sex and athletic participation while symptomatic after a SRC?

Hypothesis 1: Male student-athletes will be more likely to report participating in athletic events while still symptomatic after a SRC compared to female student-athletes.

Research Question 2: What is the relationship between AT presence and athletic participation while symptomatic after a SRC?

Hypothesis 2a: Student-athletes will be more likely to report participating in athletic activities while symptomatic after an SRC when an AT was not present compared to when an AT was present.

Hypothesis 2b: Student-athletes participating in club sports without an AT will be more likely to report participating in athletic activities while symptomatic after an SRC compared to student-athletes participating in school affiliated sports with

an AT.

Research Question 3: What is the relationship between concussion education and athletic participation while symptomatic after a SRC?

Hypothesis 3: Student-athletes who have received concussion education will be less likely to report participating in athletic activities while still symptomatic after a SRC compared to student-athletes who have not received concussion education.

Research Question 4: What is the relationship between SRC history and likelihood of voluntarily siting out of athletic activity while symptomatic after a future SRC?

Hypothesis 4: Student-athletes without a SRC history will be less likely to voluntarily sit out of athletic activity while symptomatic after a future SRC compared to student-athletes with a SRC history.

Operational Definitions

Concussion: A direct or indirect contact to the head, face, neck, or body, which results either in a collision between the brain and skull or in a strain on neural tissue and vasculature. Altered neurological and neurocognitive function typically recovers within 1-2 weeks post injury.[4]

Return-to-Play Protocol (RTP): Progression should occur in a step-wise fashion with gradual increments in physical exertion and risk of contact.[53] See **Appendix A**.

Academic Level:

Middle school/Junior high – a school intermediate between elementary school and high school and usually encompassing grades 6 through 8.

High school – a school consisting of students attending grades 9 through 12.

College – a school of higher education after graduating high school and/or earned

GED.

Sport Affiliation:

School – Athletic participation on a school-sponsored team. Typically categorized into Freshman, Junior Varsity, and Varsity teams.

Club – Competitive athletic leagues that are not affiliated with an academic institution, but typically have one or more coaches, scheduled practices, and competitions. They do not fall under the jurisdiction of state or national athletic associations (e.g., National Collegiate Athletic Association, National Federation of State High School Associations).

Assumptions

- The participants completed the questionnaire honestly and accurately.
- There were participants within all academic levels that had a SRC history.

Delimitations

- We only recruited participants in school athletic settings, due to increased participant access and availability compared to individual club teams.
- Our participants were only recruited from schools in central and south Texas, but represent a wide range of ages, athletic abilities, and both rural and urban settings.
- The number of questions was limited to meet time specifications set by the participating middle and high school administrators.

Limitations

- Limitations to the responses and cooperation of the student-athletes attending the selected secondary schools and universities recruited to participate in our study.

- Members of the research team could not be present during survey completion to answer questions, because of work affiliations with participating schools. Some participants may not have taken the survey seriously or read the questions and answers thoroughly, resulting in a few contradictory responses.

II. REVIEW OF RELATED LITERATURE

Introduction

A sport-related concussion (SRC) is direct or indirect hit to the head, face, neck, or body during athletic participation, that results in neurological and neurocognitive symptoms that typically recover in 1-2 weeks post-injury in adults.[4] This review of literature focuses on intrinsic and/or extrinsic factors that may contribute to concussion reporting among student-athletes. Additionally, the review of literature will look at male and female, high school and collegiate athletes of various sports to determine who is more likely to become non-compliant with concussion management guidelines after sustaining a concussion injury. This information is beneficial for athletic trainers (AT) to determine the common tendencies of high school and collegiate athletes on reporting behaviors and returning to play after a SRC.

Concussion Education

Knowledge Among Student-Athletes

Since 2009, the United States has passed student-athlete legislation that mandates the implementation and use of concussion protocols in all 50 states and the District of Columbia within high school and college athletics.[54] These laws require high school and collegiate athletes to receive some type of concussion education, however there is a wide variety of who may be presenting this information and the depth of information provided to these athletes. Although it is not required, baseline testing has been promoted as a Best Management Practice and is becoming a more common practice in the secondary schools.[55] In addition, the National Collegiate Athletic Association (NCAA) has passed mandates requiring universities and colleges to hold annual concussion education

sessions for their coaches and athletes, while the National Athletic Training Association (NATA) recommends pre-participation baseline testing.[54] However, Kroshus and colleagues have indicated in several studies that high school and collegiate participants did not recall receiving concussion information material on the same day they received it.[56,57] These results prompted Kroshus and Baugh to conduct a follow-up study to determine the most effective way to administer concussion education to athletes.[50] Data were collected from ATs (n = 789) associated with 276 schools and student- athletes (n = 325) associated with 4 NCAA Division I, II, and III institutions. The ATs were asked questions about who delivers the education, the educational format, what educational content areas are addressed, and if all athletes receive the same information at their school. As a result, 49% of the ATs said different teams at their institute received different forms of education. Additionally, multiple institutions had more than one AT respond to the survey. Their results showed inconsistent education techniques among ATs at the same school. It is concerning that inconsistencies were found among schools because it could be assumed that some athletes were not receiving adequate or correct concussion information. These differences could be the deciding factor between whether athletes from the same school report or do not report a concussion. The majority (91.3%) of ATs said an AT was involved in delivering the education, 9.7% said team physicians were involved with presenting the material, and 13.9% said athletic department administrators were involved with presenting the material. The lack of involvement from team physicians is not ideal because these are the medical professionals athletes will most likely be referred to if they sustain a SRC. The additional involvement from medical staff, coaches, and administrators can potentially create a more concussion aware and

positive environment across the athletic community for athletes. Athletes were asked similar questions about the presentation of concussion education along with certain topics regarding concussions such as symptoms, proper management, possible long-term consequences, impact on athletic performance, impact on academic performance, and importance of reporting. Responding athletes indicated that 77.9% received concussion education material through a formal lecture and 74.6% of athletes received written materials, suggesting that some schools may deliver the information using multiple methods. The high percentage of athletes receiving written material regarding concussion education is concerning because no one requires them to actually read and learn the information. Therefore, these athletes could say they received concussion education but never actually learned about a concussion which is ineffective. The written concussion education material method may have an impact on why student-athletes lack concussion knowledge despite receiving concussion education. Other educational techniques included showing a video (30.7%), online materials (21.5%), and posters (19.8%). Almost all concussion education provided by the participating schools included symptoms, importance of reporting, and information about proper management. Additionally, some schools stated they included possible long-term consequences, negative impact on athletic performance, post-concussion syndrome, second impact syndrome, psychiatric changes, association with depression, and chronic traumatic encephalopathy (CTE).[50] Although it is commended of those schools to include possible long-term consequences, it is unfortunate and concerning that other schools are not properly warning their student-athletes of the risks athletes are taking if they do no report a SRC. Furthermore, the variety in the amount of concussion education provided between

athletes can cause confusion and misunderstandings to occur, in which could decrease the severity some athletes think about SRCs. Kroshus and Baugh asked the athletes their recommendations for the most ideal concussion education design, who would deliver the education, and their preferred format of the education. The athletes indicated that a lecture or video were the preferred methods for receiving the information. Athletes commonly reported their AT was involved with concussion education, but 40% indicated they wanted their coach to be more involved in the process to ensure their education and to establish a healthy perception towards reporting concussions.[50] In correlation to Kroshus and Baugh's findings, coaches' attitudes have been found to have negative influences on concussion reporting in several other previous studies.[39,46] The athletes also rated the importance for all concussion education content areas at 82% or higher. The information gathered in this study is important because it gives insight on how athletes view concussion education and the positive changes that could be made to make it more beneficial and influential. As a result, athletes admitted that concussion education is important, however research still shows there is a lack in concussion reporting[9,12,32,33,42], therefore further adjustments should be made to concussion education methods to decrease the discrepancies seen between concussion education and reporting.

Several concussion reporting studies have determined that athletes under-report concussion symptoms because they do not want to let their team/coach down[9,12,19,32,33,39,42,46,47], but athletes seem to lack the knowledge that playing while symptomatic is letting their team down as well due to the physical and cognitive deficits of the injury.[50,57] Specifically, Eckner et al. determined athletes that play symptomatic have a slower reaction time.[58] Kroshus et al. have suggested educating athletes is

important in hopes of modifying a team's perception and social norms towards concussion reporting attitudes.[51] This could allow for teams as a whole to agree on values and expectations of concussion reporting, in addition to understanding that being a good teammate includes looking out for one another's health and safety both on and off the field.[51] Determining beneficial and influential modifications to concussion education methods provided at schools could be useful because previous research shows that participation in current educational interventions on concussions does not have a significant impact on increasing concussion reporting rates among high school and collegiate student-athletes.[10,31-33,42,47] Additionally, research should investigate whether younger athletic populations and student-athletes affiliated with club sports are receiving concussion education as well.

Knowledge Among Parents

Not only should student-athletes be educated on concussion information, but parents and guardians should value the knowledge for the safety of their child. Weerdenburg et al. conducted a survey in a Canadian emergency department to determine the parental concussion knowledge of children with a possible head injury.[43] The researchers recruited 495 parents to complete a questionnaire regarding their child's head injury prior to seeing a doctor for an official diagnosis. Overall, 200 (40%) of the children were diagnosed with a concussion by a medical professional and 203 (41%) parents reported self-diagnosing their child with a concussion before seeing a medical professional. It was determined that 118 (58.3%) of the parents were correct in their diagnosis according to the physician. This indicates that over 40% of the parents could not properly distinguish the signs and symptoms of a concussion. In regards to

concussion education, 371 (75%) of the parents knew a concussion was an injury to the brain and 453 (92%) said they would remove their child from activity immediately if they suspected a concussion. Unfortunately, only 145 (29%) of the parents that indicated they would prevent their child from playing also knew about concussion RTP guidelines. This suggests that parental knowledge concerning concussion management is lacking. It is possible that the lack of controlled activity for children following a concussion is a result of the parents being unaware of concussion severity and the required RTP treatment guidelines.[43] It is important to know who an athlete is most likely to report their concussion injury to in case it is someone other than an AT or medical professional. Further information may help clinicians properly educate parents and guardians on SRC signs and symptoms and appropriate care and referral practices for their children. This could especially be useful for parents of younger athletes that may not be able to grasp the full understanding and severity of concussions despite receiving concussion education. The inclusion of additional people that are aware and encourage the reporting of SRC will only benefit athletes' health and safety.

Concussion Reporting

Self-Reporting

It is recommended that all athletes report all concussion symptoms they experience, but several studies have found that this does not always happen.[9,12,32,33,42] The main factors found to have some type of influence on high school and collegiate student-athletes reporting their concussions are as follows: sex[10,12,33,42], concussion education[12,32,42], history of concussions[6,32,33], and athlete perception toward concussions.[9,48,50] So far in research, several studies have determined that female athletes

are more likely to report a concussion than male athletes regardless of age.[10,12,32,42] Additional differences have been found suggesting that older, male athletes[10,42] and athletes with a history of SRC[6,32,33] are less likely to report a concussion compared to their counterparts.

Register-Mihalik et al. recruited 167 high school football, soccer, lacrosse, and cheer athletes to complete a questionnaire regarding their concussion history.[9] These high school student-athletes were asked about prior concussions and having their "bell rung", results indicated most athletes did not associate a "bell-ringing" experience with a concussion.[9] According to responses, an accumulation of 584 "bell ringing" events had been sustained by the 89 participants, but only 71 (12.3%) of these injuries were reported to an AT or coach by 15 of the included athletes. These findings are consistent with other studies where participants indicated that their concussions were not reported because they did not think it was serious enough, did not want to be removed from the game, did not want to let down their teammates, or did not want to let down their coach.[9,19,39,46,47] Aside from having their 'bell rung", 84 participants said they had sustained a previous concussion and among this group there was a similar low reporting rate of 50% (n = 41). Concussion reporting may also be impacted by athletes' inability to identify prominent signs and symptoms including, sleep disturbances, difficulty concentrating, changes in behavior, nausea, and vomiting, as noted in several studies.[9,45,47] Register-Mihalik et al. revealed that 32 (37.7%) of the participants with a concussion history admitted to playing with symptoms. The athletes indicated they did not report the injury because they did not want to be held from participation in practice or games.[9] In agreement Bramley et al. found that concussion reporting was negatively impacted by game versus practice

situations, suggesting that athletes were less likely to report symptoms during a game.[44] These findings can be beneficial to clinicians in determining when high school athletes are more likely to try to hide concussion-related symptoms. If these decisions are situational, evaluations should not wait for athletes to self-report the injury but rather evaluate any athlete that is suspected to have a SRC.

Torres et al. conducted a study of 262 University of Pennsylvania collegiate athletes inquiring about their knowledge of concussions and personal concussion history.[32] Seventy (27%) of the participants reported having a concussion history. Of those participants, 45 (64%) student-athletes missed some athletic time and 42 (46%) said it negatively affected their schoolwork. Thirty (43%) student-athletes had hidden their concussion symptoms from their AT during some point in order to play in a game, and 15 (22%) said they would hide future concussion symptoms as well. Of the 15 student-athletes that said they would hide future concussions, 11 of them were male.[32] Overall, athletes with prior SRC history and male athletes in general tended to respond to the survey with "unlikely" or "extremely unlikely" in regards to reporting future concussions.[32] It continues to be concerning that student-athletes indicate they will not report future concussions, especially those with a history of SRC suggesting that concussion education and the severity of the injury is not being addressed properly. These findings pertain to college athletes at a university but should expand to include younger athletes and athletes that are not affiliated with a school to see if they differ.

A study conducted in Maine recruited 4,792 high school student-athletes to complete a concussion history questionnaire at preseason, one month later, and again an average of 20.7 months after the first questionnaire to indicate the consistency of

reporting one's concussion history.[33] At the end of the study, 80.3% of the participants reported the same number of concussions on both surveys, 15.9% reported additional concussions, and 3.8% reported an inconsistent concussion history. The article defines an inconsistent concussion history report as a decrease in the number of lifetime concussions reported on follow-up surveys, compared with the number reported at baseline.[33] If they had an increase in the number of concussions reported between the 2 questionnaires it was justified by the approximate 2 year time period between testing. Researchers found inconsistent SRC reporting was associated with being male, an increased history of previous concussions, and having Attention Deficit Hyperactivity Disorder (ADHD).[33] The authors concluded it is not well understood why under-reporting and inconsistent concussion reporting was seen among athletes, but it could be related to lack of knowledge. Consistent concussion education should be investigated in younger athletic populations to see if flawed reporting behaviors can be reduced by providing accurate and beneficial information at a younger age to encourage a positive concussion reporting behavior sooner among athletes.

Another preseason study was conducted by Kurowski et al. to determine the level of knowledge and attitude high school student-athletes had towards concussions.[42] Their survey questioned high school student-athletes (n = 496) about previous concussion education, current knowledge, self-reporting attitudes, and self-reporting behaviors.[42] There were 200 (40%) participants that indicated they would "always" tell a coach or AT if they were experiencing symptoms and 252 (50.9%) indicated they would "always" tell a coach or AT if they were experiencing symptoms even if it meant they would miss several days of practice or games. Only 116 (23.4%) of the participants reported already

having a concussion history, but it was undetermined by the article if these concussions were previously reported at the time of injury. Additionally, the older female athletes provided better knowledge about concussions, but there was an association between younger female athlete status and better self-reporting behaviors. Therefore, the authors concluded that better concussion education does not equate to better self-reporting behavior. Additionally, other studies have shown to support the conclusion about female athletes having more SRC knowledge.[12,42,47] Miyashita et al. conducted a similar survey style study that included 454 high school student-athletes from Connecticut. Their results were similar to previous research indicating female athletes were significantly more likely to report a concussion in general and more likely to report future concussions at the time of the injury.[12]

Finally, Meier et al. investigated the effect environment had on athletes self-reporting concussion-related symptoms.[59] They conducted a prospective study at a NCAA Division I university that examined the concussion-related symptoms being reported in different settings. Initially, 40 collegiate athletes were evaluated due to their recent concussive event. The participants were male and female athletes involved in soccer, basketball, volleyball, and football. Upon evaluation, they completed the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) Battery test at their athletic facilities (athletic environment). Then participants completed the Hamilton Anxiety rating scale and a Hamilton Depression rating scale at an average of 1.92 days and 9.14 days post-injury in a confidential environment. These rating scales looked at 4 symptom domains including sleep, psychiatric (e.g. depression, anxiety, change in mood), cognitive (e.g. memory loss, difficulty concentrating, feeling in a ‘fog’), and

somatic (e.g. headache, dizziness, balance disturbances). Twenty nine of the participants followed up 9.14 days after their injury in the confidential setting and of those participants 9 were already cleared to RTP by a medical professional. The results indicated that athletes reported a higher amount of symptoms in all 4 domains of the Hamilton Anxiety and Hamilton Depression rating scales immediately post-injury to approximately 9 days post-injury. Therefore, athletes that had been cleared by a doctor did not significantly differ from athletes that had not been cleared yet. At 9 days post-injury, about 60% of the athletes who were already cleared for RTP reported mild symptoms in at least 1 of the symptom domains. The authors concluded that concussion reporting still relies heavily on self-reporting psychiatric and somatic symptoms and implies that neurocognitive testing alone may lack identification of some symptomatic athletes. The authors mention these differences may be attributed to the Hamilton Anxiety and Hamilton Depression rating scales being more in depth because the interviewer is able to ask follow-up questions, whereas the ImPACT Battery test includes simple one-step questions that are answered and interpreted by the individual taking the test.[59] Although these scores are used in conjunction with other neurological and neurocognitive tests to determine an athlete's level of recovery, a more advanced RTP protocol should be considered to reduce the reliance on self-reported symptoms. Since it is suggested that some high school and collegiate athletes intended on hiding future concussions, it would be beneficial to determine a way to not have to rely on self-reported symptoms and distinguish between those athletes that are symptomatic despite what they tell their AT. This alternative could be useful for reducing pre-mature RTP and the risk of other long-term consequences.

What is Being Reported?

In addition to conducting research that helps determine concussion reporting behaviors, it is also important to know what an athlete is reporting when they say they have concussive symptoms. Covassin et al. recruited 1,616 high school and collegiate student-athletes to participate in a study where they completed the ImPACT and Beck Depression Inventory II at baseline measurements.[15] The researchers found high school athletes reported more somatic symptoms compared to college athletes who reported more emotional and sleep disturbances at baseline. Conversely, female athletes reported significantly more cognitive, emotional, and sleep disturbances than male athletes at baseline. This study also evaluated depression levels among the athletes and determined that those reporting severe depression had lower scores on visual memory and reported more total migraine and cognitive symptoms.[15] These findings provide good information regarding symptoms a clinician can expect male and female athletes to report at baseline and after a SRC. Continuing this research to include an additional age group of middle school student-athletes could be beneficial to be aware of the common symptoms reported in a younger population. Differences may exist between the middle school age population due lack of knowledge on all associated symptoms. It is suggested that even some high school and college athletes are not fully aware of all the concussion-related symptoms, therefore younger athletic populations could be at greater risk of not knowing all the concussion-related symptoms. Additionally, at a younger age and at a different stage in their development, younger athletic populations may report entirely different common symptoms compared to high school and collegiate student-athletes.

Perception of Injury

There is a vast variety of perceptions made about concussions that has influenced reporting behavior among student-athletes. In one study athletes stated they did not report concussions because they were "embarrassed",[9] in another study 27% of New Zealand high school rugby players thought athletes should not report concussions during important games.[60] The perception of concussions can vary among sports and communities for several reasons; for example some athletes have reported the desire for coaches to be more involved in concussion education to promote a better concussion reporting environment and to avoid a negative perception of concussions among their team[50] Results from Kroshus et al. found that athletes report having high intentions of reporting a concussion injury, but in fact do not report the majority of their concussions at the time of injury.[57] The hockey players that participated in this study stated they had a negative perception towards reporting concussions because they did not want to let down their teammates or coaches.[57] Baugh and Kroshus continued their research with other colleagues by conducting another 2-year study of 10 NCAA Division I college football teams investigating their individual perceptions of future risk of sustaining a concussion and health-related outcomes as a result of concussion.[48] During the first survey, 323 (40%) of the athletes believed they would sustain a concussion in the future. There were 81 (25%) players that assumed they would miss games due to a concussion and 32 (10%) thought they may develop dementia, Alzheimer's, and/or Chronic Traumatic Encephalopathy (CTE) as a long-term effect of concussion.[48] The athletes that were aware of these potential risk factors and thought there was a strong potential they would sustain a concussion in the future were more likely to have a history of concussions ($p <$

0.001). Two years later a follow-up study was conducted with the same participants and questions. Surprisingly, the results showed a significant decrease in the perception of risk of sustaining a concussion reported by the same athletes.[48] The authors believed that athletes who overestimated the short-term and underestimated long-term consequences of concussion should both be addressed with proper concussion education. However, they assumed that athletes who overestimated potential long-term health consequences were more likely to report a concussion to a medical professional. Additionally, the authors believed that a decrease in risk perception was due to the improvement of concussion education provided at the universities. The authors believed that the participation in college football influenced these athletes responses and allow them to better understand the injury and RTP protocols, which could have affected their perception of risk.[48] Athletes may have been influenced by how many seasons they had left in their athletic career; an athlete that is almost done with sports may perceive a decreased risk because they have less athletic exposures left compared to a teammate that still has several years. Additionally, the older athletes may consider themselves more skilled in tackling techniques therefore less at risk due to their experience playing. Kroshus et al. also implemented a study to determine team norms and overall perceptions.[61] The authors found that 77.5% of participants thought their own concussion reporting attitude was safer than their teammates. However, both male and female teams tended to have a negative misperception on how their teammates felt towards reporting concussions. Similar to other concussion study findings, male teams tended to have a less safe attitude towards concussion reporting compared to females.[61] This issue could be the result of a process known as the 'spiral of silence' meaning individuals do not voice their opinion

because they are afraid of disagreeing with or the disapproval of their teammates.[62] The idea of 'spiral of silence' has been tied into social norms, specifically male athletes who do not want to look weak if they report a concussion injury.[47] These perceptions throughout athletics should be further investigated among younger athletic populations and non-school affiliated teams to see if they differ in a positive or negative way. Research should determine the root of these misperceptions and use concussion education to recreate a more positive environment for student-athletes reporting concussions.

Compliance with Concussion Management

Variability with Compliance

The lack of compliance among high school and collegiate student-athletes with concussion management and mandated protocols is another topic of discussion seen throughout previous studies.[8,27,63,64] Concussion reporting is not perfectly correlated with RTP protocol compliance.[8,27] A variety of studies have been conducted to determine the likelihood of children and adolescents remaining compliant with concussion management protocols directed by medical health professionals.[8,27,63,64] A study using data from the High School Reporting Information Online (RIO) database analyzed 1,308 concussions from 100 high schools across the United States between 2005 and 2008.[10] The report used both the American Academy of Neurology (AAN) guidelines[65] which categorize concussions by grade (I, II, III) depending on loss of consciousness (LOC) and symptoms and the Prague guidelines[66] which categorized concussions by simple and complex depending on LOC and duration of symptoms; see **Appendix B**. In current concussion evaluations, it is no longer appropriate or encouraged to use the ANN grading scale I, II, or III based off LOC and symptoms. The study indicated that according to the AAN

guidelines, 530 of the athletes who experienced concussions had prematurely returned-to-play and 196 were considered premature RTP by the Prague guidelines.[10] Baseball players had the highest rate of non-compliance with the AAN guidelines. The researchers also found that 15.8% of male football players that experienced LOC during their concussive event RTP within less than 1 day.[10] These findings have prompted a number of jurisdictions to pass legislation that mandate the use of concussion protocols among high schools and universities.[54] Overall, male athletes (12.6%) were more likely to RTP sooner than female athletes (5.8%).[10] RTP protocol has changed drastically over the years; in reference to the 2012 Consensus Statement on Concussion in Sport International Conference, following a concussive injury there should be a 24 to 48 hour rest period. Once an athlete is asymptomatic for 24 consecutive hours, they can begin a 6-step RTP protocol that is estimated to take a week to complete.[4] The development and requirements put in place for RTP among high schools and universities has shown the desire to encourage a safe recovery for student-athletes with a SRC, however additional steps are still necessary to void the gaps that some athletes still slip through by returning to play still symptomatic. Further research should investigate the reasons student-athletes might RTP while symptomatic. Research could help distinguish if non-compliance is the result of lack of education specifically regarding RTP guidelines or the absence of an AT to help with the RTP guidelines. This additional information could help determine whether the combination of improving concussion education, an advanced RTP protocol, and/or the increase in AT employment could eliminate the non-compliance issue seen in high school and collegiate student-athletes in addition to younger athletic populations. Overall, it would be beneficial to clinicians and the safety of athletes to acquire a better

understanding of high school and collegiate student-athletes that do not comply with concussion management guidelines.

Long-Term Effects of Non-Compliance

Individuals with a history of 3 or more concussions or premature RTP after SRC may have an elevated risk of further long-term complications such as post-concussion syndrome or second-impact syndrome.[4,22,24-31] A study conducted by Ackery et al. investigated the potential long-term effects athletes had as a result of becoming non-compliant with concussion protocols.[27] The researcher administered a questionnaire to 23 former professional and junior league hockey players from the USA and Canada regarding their compliance with concussion management during their athletic careers and how their injuries may have affected them since retiring. Medical professionals advised 15 of the participants to never return to ice hockey due to the severity of their head injuries. However, 5 of these athletes did not follow medical advice and continued playing hockey while symptomatic. As a result, 4 of those players said they were still experiencing post-concussion syndrome symptoms at the time of the survey, which was an average of 2 years post-injury. Overall, 65% of these former ice hockey players reported having post-concussion syndrome for at least 2 years or longer regardless of when they ended their athletic career.[27] Unfortunately, these findings suggest that athletes that become non-compliant with concussion management guidelines tend to suffer from post-concussion syndrome symptoms as a result of their actions. This information could benefit ATs and other individuals that present concussion education to student-athletes and aim to influence athletes to report concussion symptoms so they avoid similar long-term consequences. Furthermore, this information should specifically be addressed to

those athletes that are shown to be more likely to hide future SRC because those are the athletes that are at greatest risk of sustaining additional SRC and developing long-term consequences. Research should continue to investigate which athletes are more likely to become non-compliant with concussion management guidelines and determine influential changes that will discourage this behavior among various age groups including a younger population.

Conclusion

The occurrence of SRCs in high school and collegiate student-athletes, specifically athletes involved in contact sports such as football, soccer, and hockey has increased over the years, potentially as a result of increase awareness and methods to encourage athletes to report symptoms.[6,8,67,68] Concussion reporting is important because research has found that individuals with a history of 3 or more SRC are three times more likely to be diagnosed with depression[25,26], 3 times more likely to sustain an additional concussion[26], and to experience prolonged recovery[26] compared to respective players that do not have a SRC history of 3 or more.[25,26] Research indicates that males and athletes with a history of SRCs are more likely to under-report symptoms and/or be non-compliant with RTP guidelines.[10,12,27,32,33,42] Additional research has determined specific reasons why athletes do not report concussions such as not thinking it is serious enough, not wanting to miss playing time, and/or not wanting to let their team or coach down.[9,12,19,31-33,39,42,46,47] Unfortunately, research suggests athletes still behave this way despite receiving concussion education, concluding that concussion educational meetings may not alter concussion reporting.[31-33,42] The progression seen in concussion research continues to develop and more research is being conducted to investigate areas that still

lack full understanding such as younger athletic populations including middle school athletes and non-school affiliated athletics. Research has not yet shown whether middle school student-athletes report their concussions, receive concussion education, RTP still symptomatic, or their likelihood of sitting out while symptomatic. Furthermore, there are few studies that specifically look at the relationship between AT presence and student-athletes returning to play still symptomatic after sustaining a SRC. The majority of SRC research focuses on school-sponsored athletics, therefore little is known about the relationships among club sport athletes and their SRC incidences, RTP compliance, and access to an AT. Due to the lack of research involving middle school and club sport student-athletes our study will include these athletic populations, in addition to high school and collegiate athletes. Our study will also investigate the relationships among sport affiliation, SRC education, SRC incidence, SRC reporting behaviors, RTP compliance, and AT access.

III. METHODS

Design

A cross-sectional survey was designed to collect information about student-athletes' prior concussions sustained during school affiliated sports and club sports and whether they reported these injuries or participated in athletic activity while symptomatic. A pilot study that included 8 high school and middle school student-athletes was conducted to establish test-retest reliability and ensure question validity for younger age groups. Adjustments such as rewording were made to 5 survey questions to assure understanding of the intended questions.

The independent variables analyzed within this survey included sex, academic level, sport affiliation, concussion education, and athletic trainer (AT) presence. The outcome measures included participation in athletic activities while symptomatic after a concussive injury and likelihood to hold themselves out of participation should they sustain a future concussion. All procedures were approved by the Texas State University Institutional Review Board.

Participants

This study specifically targeted male and female student-athletes that were currently participating on a middle school, high school, or university affiliated athletic team. Participants were recruited from 4 middle schools, 2 high schools, and 3 colleges in the central Texas area. Student-athletes that could not speak or write English were excluded from participation. All eligible student-athletes that attended the recruitment meetings at each of the respective middle schools and high schools were recruited for participation. All collegiate student-athletes attending one of the three participating

universities, who were eligible and had a working email address were sent a recruitment email.

Survey Instruments

The question design for this study included dichotomous (yes/no), ordinal and categorical questions. There were a total of 45 questions regarding previous concussions sustained by the participant. Questions obtained information about topics including reporting concussions, participation while symptomatic, access to an AT, and athletic involvement. Compliance with return-to-play (RTP) guidelines was evaluated based on whether the student-athlete followed mandated laws that require clearance from a physician after sustaining a concussion and returned asymptomatic. Several questions determined the trust student-athletes have towards their AT and those questions were obtained from the Trust in Physicians Scale.[69] This survey did not require any identifiable information about the participating student-athletes.

The survey (**Appendix C**) collected self-report responses from student-athletes over a variety of age groups and levels of athletic ability to improve generalizability of our study. The inclusion of such a wide range of age groups and schools allowed the research team to recruit a large number of participants. The survey style format was chosen because of the success other researchers have had using this format to determine concussion related research such as underreporting concussions in collegiate athletes and the consistency of self-reporting concussions in adolescent athletes.[12,42]

Data Collection

Potential schools, school districts, and universities to be included in the study were contacted by the research team for approval to recruit the student-athletes attending

their respective institution. The researcher team contacted the head AT, coaches (middle school and high school only), and athletic director/coordinator at each institution to determine their willingness to assist with recruitment, distribution, and collection of the surveys (when necessary). The research team received permission from 4 middle schools, 2 high schools, and 3 colleges to recruit their student-athletes for our study. Approval from the high school and middle schools' school district was obtained before any information was released to parents or students. All documents administered during this study were approved by the Texas State University Institutional Review Board.

The athletic director or administrative assistant for each middle school and high school sent out an email containing an overview of the study to all corresponding student-athletes' parents and guardians. Parental/guardian consent was obtained through passive parental consent. Notification of this was made clear in the email that was sent out to parents regarding the study. Parents and guardians had 2 weeks to contact the research team if they did not want their child to participate in the survey. If the research team did not hear from a child's parents or guardians after 2 weeks, then consent was assumed. After consent was obtained, the research team met with the schools and teams to collect assent forms from each student-athlete during their athletic periods. Athlete assent forms were later grouped into 'yes' or 'no' to determine who had permission to participate.

Following consent and assent of all interested middle school and high school athletes and their parents/guardians the distribution of surveys and data collection began. Each school had two months to administer the surveys. The middle school and high school surveys were completed in a pen and paper format similar to previous studies conducted.[31,70] At each school, the coaches administered the surveys to their teams during

the athletic periods. Some schools enlisted several coaches to help with the distribution depending on the team size and practice schedules. The coordinators were given a list of all the student-athletes that had enrolled in our study. Students were not allowed to participate if their parents did not give consent, if the student-athlete indicated they did not want to participate on their assent form, if they did not fill out an assent form, or if the student-athlete incorrectly completed the assent/consent form. Student-athletes that did not participate were not penalized in any way. Brief instructions were given to the site coordinator to read prior to survey completion to reassure the student-athletes that participation was voluntary, that this survey was not a test, and that the results would be reported as a group and not individually. The participants were told not to write their name on the survey and that they could stop filling out the form at any time.

The middle school and high school participants completed the surveys individually during their athletic periods and then placed their own survey in a folder labeled 'Completed Surveys'. Surveys from various teams were mixed into multiple 'Completed Surveys' folders to ensure the research team could not identify individual teams and/or athletes. When the group was finished completing their surveys, the coaches were instructed to return the survey folders and pens back to the storage bin that contained all the survey instrumentation provided by the research team. The bin was then returned to the appointed office. The on-site storage location was required to be a locked office. Once all interested participants at a location had finished completing the surveys, the research team was notified for pick up. The research team collected the storage container with all completed surveys from each site. The storage bins were moved to a locked office at Texas State University. One of the research team members then reviewed

all paper surveys for identifying information (e.g., names, school). The same individual removed all identifying information with a black Sharpie and then reorganized all of the paper surveys into random piles. This was done to ensure the research team member who hand-entered the data from the surveys into an excel document was blinded to the school, team, and study participants.

The collegiate participants completed the same survey via an Internet-based format (Qualtrics.com). The corresponding university's AT sent out an email inviting their student-athletes to participate in our study and then up to four reminder emails to the student-athletes encouraging them to participate in our survey. The research team was not in direct contact with any college participants to ensure anonymity of all participants. Collegiate student-athlete consent was obtained when they clicked on the link to the survey. They were informed in the invitation email that this was a voluntary study and they could stop completing the survey at any time.

Data Analysis

The data collected from high schools and middle schools were hand-entered into an Excel spreadsheet by one member of the research team and verified by a second researcher to avoid any errors in the data entry process. The collegiate data were collected through an Internet-based program (Qualtrics.com) allowing the research team to download their coded responses, eliminating experimenter data entry error. These data were manually cleaned to address any errors. Analyses were conducted using IBM SPSS statistical software version 24 using an a priori alpha level of 0.05. Participant demographics for the full dataset (all participants) and the participants that reported sustaining a SRC in school, club, or both sport affiliations (concussion participants) can

be found in **Tables 1 and 2**. Chi-square and post-hoc binomial tests were used to analyze our data.

IV. MANUSCRIPT

Participation While Symptomatic: The Sport-Related Concussion Conundrum

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Context: In 15-24 year-olds, sport-related concussions (SRC) are the second highest cause of traumatic brain injury (TBI) following motor vehicle accidents.[1] Little is currently known about the relationships among athletic trainer (AT) presence, sex, SRC education, reporting, and compliance for school vs. club teams and middle school student-athletes compared to high school, collegiate.

Objective: To determine relationships among sex, sport affiliation, academic level, AT presence, concussion education, and sport participation while symptomatic after a SRC.

Design: Cross-sectional retrospective study.

Setting: Survey

Participants: 1,225 male (n = 671) and female (n = 553) student-athletes (14.47±2.17 years) from 4 middle schools, 2 high schools, and 3 National Collegiate Athletic Association Universities in central and south Texas.

Interventions: Sex (M/F), sport affiliation (school, club), academic level (middle school, high school, college), concussion education (Y/N), and AT presence (Y/N).

Main Outcome Measures: Sport participation while symptomatic after a SRC (Y/N) and future SRC reporting behavior (Y/N).

Results: 282 (23%) participants reported a history of SRC while participating in school or club sports; 77 of these individuals sustained at least 1 or more concussions during school and club sporting events. The data collected from the 77 participants that sustained

concussions in both athletics settings were analyzed as individual concussive events (n = 359). Analyses determined no significant differences found between sex (χ^2 [1, N = 328] = 1.301, p = 0.25), AT presence (χ^2 [1, N = 329] = 0.038, p = 0.85), or concussion education (χ^2 [1, N = 315] = 0.009, p = 1.0) for athletes returning to play symptomatic. Additionally, no significant differences were found between SRC history and likelihood to sit one's self out while symptomatic (χ^2 [2, N = 1,167] = 0.282, p = 0.87). No other findings were statistically significant ($p \geq 0.05$).

Conclusions: There were no significant differences between sex or sport affiliation when returning to play while symptomatic. These results did not support our hypotheses, nor do they support previous literature. Our results suggest that current education programs are not discouraging athletes from returning to sport while still experiencing concussion symptoms and that AT presence is not a mitigating factor in student-athletes' reporting behavior. The inclusion of middle school and club athletes suggest these athletic populations might approach concussions differently and should be included in future research.

Introduction

Approximately 1.7 million people are diagnosed with a traumatic brain injury (TBI) annually in the United States.[2] It is estimated that roughly 75% of these injuries are categorized as a mild traumatic brain injury (mTBI), which includes concussion.[3] A concussion is a direct or indirect contact to the head, face, neck, or body, which results either in a collision between the brain and skull or in a strain on neural tissue and vasculature.[4] These temporary alterations in neurological and neurocognitive functions related to sport-related concussion (SRC) typically resolve in adults within 1-2 weeks post-injury.[4] Although there is a high number of SRCs diagnosed, this number does not accurately represent all SRCs sustained as research has found some high school and collegiate student-athletes do not report their concussions.[5]

SRC rates are higher among collegiate athletes compared to high school athletes.[6] Some SRCs may be associated with more obvious signs and symptoms such as loss of consciousness, disorientation, amnesia, balance disturbance, and nystagmus. With further evaluation, additional neurocognitive symptoms may be discovered including, decreased processing speed and decreased reaction time.[7] Conversely, a SRC may only result in unobservable symptoms (e.g., dizziness, headache, nausea, fatigue) that must be self-reported by the patient.[6,8,9] However, research suggests that high school and collegiate student-athletes do not always report these concussion-related symptoms despite receiving concussion education,[10-14] this can make it more difficult for clinicians to detect a SRC. More specifically, male athletes,[10-13,15,16] athletes with a history of concussions,[11-13,16-18] and older athletes[12,19,20] are less likely to report their concussion-related symptoms. Researchers have shown that student-athletes do not report concussions for several

reasons including, they do not think it is serious enough, they do not want to be removed from the game, or they do not want to let their teammates/coach down.[14,21-24] Those athletes who do choose to report their concussion symptoms when an athletic trainer (AT) is present, it is plausible that they would be less likely to report their concussion symptoms in the absence of an AT. Athletes may be influenced by the presence of an AT to report symptoms because it is encouraged, however if an AT is not around they may not think it is necessary. If an AT is not present student-athletes may not know who to report to, they may feel less guilty hiding their symptoms, or they may think similar to the idea of 'out of sight, out of mind'. Athletes who do not report symptoms put themselves in danger. Premature return-to-play (RTP) for athletes experiencing concussion symptoms may increase their chances of developing long-term complications such as Post-Concussion Syndrome or even death due to second-impact syndrome.[4,15,17,18,25-30] Due to the potentially serious consequences associated with unsupervised or premature return to sport, it is imperative that athletes of all ages are educated about all aspects of concussion. Unfortunately, little information is available concerning whether middle school student-athletes receive concussion education. Importantly, middle school student-athletes' rapidly developing brains are more vulnerable to injury compared to adult brains, and may be at greater risk for sustaining a SRC, experiencing more severe symptoms, or for a longer period of time[31] compared to their high school and collegiate counter parts. Subsequently, it is necessary to determine if middle school student-athletes are receiving SRC education to improve their SRC knowledge, self-reporting behaviors, and RTP compliance.

This cross-sectional study was designed to investigate SRCs sustained during

school and club affiliated sports among middle school, high school, and collegiate student-athletes. This study aimed to answer 4 research questions: (1) What is the relationship between sex and athletic participation while symptomatic after a SRC? (2) What is the relationship between AT presence and athletic participation while symptomatic after a SRC? (3) What is the relationship between concussion education and athletic participation while symptomatic after a SRC? (4) What is the relationship between SRC history and likelihood of voluntarily sitting out of athletic activity while symptomatic after a SRC in the future?

Methods

Participants

In total, the research team recruited student-athletes (n = 4,729) from 4 middle schools, 2 high schools, and 3 colleges in central and south Texas. Written consent and assent (minors) were obtained from all interested middle school and high school student-athletes (n = 1,477) prior to the study. Parental consent (minors) was obtained through passive parental consent. Inclusion criteria included all student-athletes participating in school affiliated sports that attended our consent and assent meeting at each respective location. Student-athletes that could not speak or write English were excluded. Collegiate student-athletes (n = 1,142) were recruited with the help of the head AT employed at each location. The head AT forwarded an email from the research team to all of their current athletes regarding the details and consent information related to the study. The email contained a link to the online version of the survey that was identical to the paper version. Collegiate participant consent (n = 91) was assumed when they clicked the link to complete the survey. This was explained in the introductory email they received from

their head AT. Collegiate student-athletes received 4 reminder emails in regards to completing the survey. This study contained self-report responses from student-athletes ranging from 11-23 years-old (X = 15.17 SD = 2.20 years) and across a wide range of athletic abilities (middle school to Division I collegiate athletics) to improve the generalizability of our study.

Research Design

A retrospective, cross-sectional survey was designed to collect information about middle school, high school, and collegiate student-athletes' demographics, and school and club-related SRC history, reporting behaviors, education, and AT access. A pilot study of 8 high school and middle school student-athletes was conducted to improve question validity and understanding for the younger age groups. Grammatical adjustments were made to 5 survey questions to improve clarity. Following our pilot study, all materials and procedures were approved by the Texas State University Institutional Review Board.

Researchers have successfully utilized online and paper surveys to investigate similar concussion-related questions.[12,30,32] Student-athletes at the middle schools and high schools completed the hard-copy surveys using pen and paper due to lack of computer availability and upon requests from administration. Conversely, the collegiate participants were sent the same survey using an Internet-based system (Qualtrics.com) to increase access to student-athletes outside of Texas State University and improve generalizability across the NCAA levels (Division I to III).

Data Collection

The surveys were kept in an organized storage bin that separated completed and

blank surveys for easy access during distribution by the coaches at all middle school and high school locations. These storage bins were kept inside a locked coaches' office. Prior to and at the completion of data collection, a member of research team transported all materials to and from each of the middle school and high school locations in unmarked, identical storage containers. This technique was utilized to blind the researchers to the athletes, teams, and schools. This was important because members of the research team worked as an AT at one or more of the schools and we did not want our presence to bias our participants' survey answers. The athletic coordinators and coaches for all middle school and high school locations were given a script detailing the study protocol to read to the participants prior to distributing the surveys. These same individuals distributed surveys to our enrolled participants for completion. Participants placed their completed surveys in an envelope that was sealed by the site coordinator and placed back into our storage bin.

Data Collection Instrument

The de-identified survey included dichotomous (yes/no), ordinal, and categorical variables. A total of 45 questions were used to obtain information about topics including participant demographics, SRC history, education, reporting behaviors, participation while still symptomatic, AT access for school and club-related SRCs (**Appendix C**). The independent variables in this study include: sex (M/F), sport affiliation (school, club), academic level (middle school, high school, college), concussion education (Y/N), and presence of an AT (Y/N). The main outcome measures in this study include: participation in sports while symptomatic after a concussion (Y/N) and future SRC reporting behavior (More Likely/Neutral/Less Likely). The survey asked student-athletes to estimate how

many SRC they had sustained in school athletics and how many SRC they had sustained in club athletics, however the follow-up questions did not require participants to respond individually for each previous concussion at both settings. Rather, if participants had more than one SRC in school or club, their responses were generalized for that particular setting.

Data Analysis

To improve generalizability and statistical power during data analyses, it was necessary to adjust the categorization of answers to 4 of our survey questions. Participants who noted any symptoms when they returned to sport were categorized as "symptomatic". Participants who responded "no" or "unsure" when asked if they currently have an AT present at their school/club sport were categorized as "no AT". The research team determined that if an athlete was "unsure" if they had an AT, then even if they did have access to an AT, they had not taken advantage of their medical services for their injuries and thus were more similar to the group without AT access compared to the group with AT access. Participants were categorized as "yes" for concussion education if they noted that they had received concussion information at least once at any level (middle school through college). Lastly, due to the data distribution for the likelihood of student-athletes withholding themselves from sport while symptomatic, it was determined that collapsing the 5 Likert-scale categories into 3 would be more informative. The far extreme categories "almost always" (n = 250) and "never" (n = 176) had fewer participants in each group which made it difficult to calculate and analyze the data due to lack of numbers. Therefore, "almost always" and "sometimes" were collapsed into a new category called "more likely", "every once in a while" was renamed "neutral", and

"rarely" and "never" were merged into the category called "less likely". If a participant left a survey question blank, they were not included in any analyses related to that question.

In regards to the SRC participants that sustained a concussion in both school and club athletics, their school SRC experiences and their club experiences were analyzed separately due to 39% of these student-athletes responding differently regarding their school and club concussions, such as having an AT available at school sports but not available at club sports. Thus, their SRC management could have been different and skewed the data if we had analyzed them together.

Statistical Analysis

Analyses were conducted using statistical software SPSS v.24 (IBM Corporation, Armonk, NY) using an a priori alpha level of 0.05. The full dataset was analyzed to determine overall participant demographics (**Tables 1 and 2**) and then separated into a second dataset that only included participants that reported sustaining a concussion during school and/or club participation. This group is further known as the 'concussion participants'. Each independent variable (sex, AT presence, sport affiliation, concussion education, and SRC history) and dependent variable (symptomatic at RTP and likelihood to sit out) analyzed in this study can be found in **Tables 3 and 4**. Chi-square and post-hoc binomial tests were used to analyze our data.

Results

A total of 4,729 student-athletes were recruited from 4 middle schools (n = 1,442), 2 high schools (n = 2,145), and 3 universities (n = 1,142) in the central and south Texas region. Researchers obtained assent/consent for 826 (57%) middle, 651 (30%) high

school, and 91 (8%) collegiate student-athletes, and received completed surveys from 612 (74%), 528 (86%), and 85 (93%) from each group respectively. A total of 1,225 surveys (83% of total consented) were completed by male (n = 671) and female (n = 553) participants ranging in age from 11-23 years old (14.47±2.17 years). The full dataset was reduced to include only participants with a history of SRC for particular analyses (research questions 1-3). In total, 282 participants (23%) reported sustaining a concussion during school and/or club sport participation. Within these SRC participants, 77 (27%) indicated they had sustained at least one SRC during both school and club activities; whereas the remaining 205 (73%) participants sustained a concussion in school or club sports. Therefore, a total of 359 different concussion experience responses from 23 participants that only play school sports and 259 participants that play school and club sports were reported and analyzed. Participants reported sustaining an average of 3.2 SRCs overall. The average number of SRCs reported during school (2.5) and club participation (2.4) was similar. The range seen within the average number of SRC reported by participants is likely to be most impacted by the large age gap (11-23) in participants, specifically collegiate athletes have years of athletic exposure compared to the middle school athletes. SRC by academic level is reported in **Table 5**. Research also suggests that once an athlete sustains a concussion, they are at greater risk of sustaining additional concussions[17,18], therefore it is not surprising that several of our participants reported more than 1 SRC.

Frequencies, means, and standard deviations for our independent and dependent variables can be found in **Tables 2-4**. **Tables 6 and 7** present the concussion group data for sport exposure and symptoms present at the time of RTP. Results found that football,

basketball, and cross country/track were the three most common sports among male and female student-athletes with a history of SRC. More males (33%) reported SRCs compared to females (24%), but the difference was not statistically significant. Additionally, headache, dizziness, difficulty concentrating, and light sensitivity were the most frequently reported symptoms that the participants were still experiencing when they returned-to-play. Again, males reported a higher overall total number of symptoms (n = 867) experienced at the time of RTP compared to females overall total number of symptoms (n = 623) experienced at the time of RTP.

For all study participants, there was a significant relationship between sport affiliation (school only [n = 204] vs. both school and club teams [n = 1,021]) and SRC history (yes [n = 282] vs. no [n = 943]) (χ^2 [1, N = 1,225] = 17.767, $p < 0.001$). A binomial test indicated that the proportion of student-athletes that only played school sports of 0.17 was lower than the expected 0.50, $p < 0.001$ (2-tailed); the proportion of student-athletes that had no history of SRC of 0.77 was higher than the expected 0.50, $p < 0.001$ (2-tailed). Thus most individuals participated on both a school and club team and had not sustained a concussion. Furthermore, among participants with a history of SRC, there was a significant relationship between student-athletes that play only school sports (n = 23) compared to student-athletes that play school and club sports (n = 259) (t[211] = 88.35, $p < 0.001$) There were no other significant relationships found among these variables ($p > 0.05$).

Relationship between Sex and Playing While Symptomatic

Due to some participants not indicating their sex or symptoms experienced at RTP, 31 surveys were removed from our sex-related analyses, leaving 328 (F = 124; M =

204) participants with a history of SRC. Sex did not have a significant effect on returning to play while symptomatic after a SRC (χ^2 [1, N = 328] = 1.301, p = 0.254). Returning to play while symptomatic did not differ between sex when compared among academic levels ($p > 0.05$).

Relationships between Presence of an AT, Sport Affiliation, and Playing While Symptomatic

The presence of an AT did not significantly effect the decision to RTP while symptomatic overall (χ^2 [1, N = 329] = 0.038, p = 0.845), or by academic level ($p > 0.05$). RTP while symptomatic in the concussion group was not significantly different between participants who sustained a SRC while participating in a school sport with an AT compared to participants who sustained a SRC while participating in a club sport with no AT (χ^2 [1, N = 270] = 0.001, p = 0.972). However, the presence of an AT significantly differed between student-athletes at each sport affiliations (χ^2 [1, N = 359] = 146.721, $p <$ 0.001). A binomial test indicated that the proportion of student-athletes involved in school athletics of 0.59 was higher than the expected 0.50, p = 0.001 (2-tailed); the proportion of student-athletes that have an AT of 0.74 was higher than the expected 0.50, $p < 0.001$ (2-tailed). There were no other significant relationships found between these variables ($p > 0.05$).

Relationship between Concussion Education and Playing Symptomatic

Concussion education did not have a significant effect on RTP while symptomatic after a SRC (χ^2 [1, N = 315] = 0.009, p = 1.00). The presence of an AT did not have a significant effect on student-athletes receiving concussion education (χ^2 [1, N = 344] = 0.011, p = 0.916). Furthermore, receiving concussion education and playing symptomatic

was not significantly related to sport affiliation or academic level ($p > 0.05$).

Relationship between SRC History and Likelihood of Restraining from Activity While Symptomatic

SRC history was not significantly associated with likelihood to voluntarily withhold themselves from activity while symptomatic after a future SRC (χ^2 [2, N = 1,167] = 0.282, $p = 0.868$). Sport affiliation also was not significantly associated with likelihood to voluntarily withhold themselves from activity while symptomatic after a future SRC (χ^2 [6, N = 1,167] = 2.630, $p = 0.854$). There were no other significant relationships found between the variables ($p > 0.05$).

Discussion

Our results did not find many statistical significant differences among participants; however we will discuss why these findings may indicate that our inclusion of middle school student-athletes may have influenced our results in differing with previous studies. Previous evidence has proposed that athletic exposure increases risk of concussion.[6,33,34] Our results showed that more student-athletes play both school and club sports during their athletic careers (83%) ($p < 0.001$) and more student-athletes had not sustained a concussion (75%) ($p < 0.001$). Individuals who participate in school and club sports would experience increased sport exposure and thus should be at an increased SRC risk and incidence compared to those who only participate in school sports. Our study found that among student-athletes with a history of SRC (n = 359), significantly more were involved in school and club sports (n = 259) compared to those involved in only school sports (n = 23) ($p < 0.001$). Therefore, 8.2% of the concussions were reported by athletes that only played on school teams, whereas 91.8% of the concussions were

reported by athletes that played on school and club teams. In agreement with previous studies, athletic exposure may be a greater risk factor for SRC. Our results do not indicate which sport student-athletes sustained their concussion in, but rather the sports they have played at some point in their athletic career. Therefore, the contact sports may be more common among student-athletes that play both school and club athletics, whereas the non-contact sports may be seen as school only sports among student-athletes. These differences may reflect why more concussions were sustained among student-athletes that participate in both school and club sports. Additionally, our study lacked responses from collegiate student-athletes which may have skewed the data and changed results if more had participated. Future research should determine the relationship between SRC risk and number of sports with exposure time (seasons, etc), mechanism of injury, and protective equipment.

This study found little evidence to suggest sex is associated with RTP while symptomatic among various academic levels or sport affiliation. Previous concussion researchers have investigated the differences seen between male and female athletes and their behaviors towards concussion injuries, which suggest male student athletes are less likely to report concussions compared to females.[10-13,15,16] Our non-significant findings between sex and RTP while symptomatic do not support our first hypothesis or the results of previous studies ($p = 0.254$). These findings could be related to the inclusion of middle school student-athletes along with including club-related SRC experience decisions. It was determined that out of the 328 student-athletes included in this specific analysis, 168 (82.3%) male and 108 (87.1%) female student-athletes RTP while symptomatic. Unfortunately, despite their gender, a high 84% of student-athletes returned to play while

symptomatic, which supports previous research suggesting athletes are likely to RTP while still symptomatic.[6,10,15] Although not significant, these findings differ from the majority of previous research that reported males are more likely to RTP earlier than females.[10-13,15,16] However, our findings did agree with a study conducted by Llewellyn et al., who concluded no differences were found between sex and reporting concussion-related symptoms among collegiate athletes.[35] We believe the differences in the current study may be due to the inclusion of middle school and club sport student-athletes; these individuals may approach concussions differently than high school and collegiate student-athletes. The middle school student-athletes may be young enough that sex-related social norms for concussion and symptom reporting have not developed yet. For example, middle school student-athletes may not be exposed to sex-related expectations about toughness or playing through pain to the same degree as their older counterparts. Many of the earlier SRC studies primarily focused on collision and contact sports.[15,17-19,23,28,36-39] Conversely, our study includes all sports offered at all three academic levels. The inclusion of non-contact male and female sports may have also affected our results. Additional non-significant results demonstrated that despite sex, high school student-athletes are more likely to return to sport while symptomatic (57%) compared to middle school (32%) and collegiate (11%) student-athletes. These results are difficult to directly compare to other studies due to the inclusion of middle school student-athletes. However, in comparison to the high school and collegiate student-athletes these findings still differ from previous research that suggests collegiate student-athletes are more likely to RTP sooner than high school student-athletes.[19,20] The differences found between high school and collegiate student-athletes are likely due to a lack of responses from our college

recruitment, the data may be skewed compared to the other academic levels included.

Our data indicated that the presence of an AT was not associated with student-athletes returning to play while symptomatic ($p = 0.85$), academic level ($p > 0.05$), or sport affiliation ($p > 0.05$). Therefore, the authors have determined that having an AT available does not influence student-athletes' decision to RTP while symptomatic regardless of academic level or sport affiliation. The authors hypothesized that student-athletes participating in club sports without an AT would be more likely to participate while symptomatic compared to student-athletes participating in school sports with an AT. However, our results indicated there were no significant differences between the groups ($p = 0.97$). Furthermore, these results did not differ between academic levels ($p > 0.05$). The percent of student-athletes at a school with an AT (n = 189) who returned to play while symptomatic (82.5%) was very similar to the number of student-athletes at a club sport with no AT (n = 81) who returned to play while symptomatic (82.7%). Among all the student-athletes who reported returning to play while symptomatic (n = 223), 156 (70%) of them were at a school with an AT and only 67 (30%) were at a club with no AT. Unexpectedly, more high school SRC student-athletes (77%) claimed to have an AT available to them compared to middle school (67%) and college (75%) participants. The authors were aware that each participating school had at least one employed AT, however these findings may be due to the lack of AT presence reported among club-related sports, therefore decreasing their overall access to an AT in athletics. Although our results were not significant, they suggest that student-athletes are more likely to RTP while symptomatic when an AT is present compared to when an AT is not present. Student-athletes are discouraged from hiding their concussion symptoms, they may feel a sense of

safety knowing that a medical professional is available to them, thus the increased number of athletes returning to sport who have AT access compared to those that do not have AT access. Data comparing AT presence with concussion RTP is lacking. However since the majority of student-athletes that returned to play while symptomatic were at schools with an AT, it could be suggested that the athletic environment in this setting may be affected by other factors including greater pressures from coaches or teammates to RTP as soon as possible compared to club teams. Pressure to RTP as soon as possible may be seen in high school and collegiate student-athletes that happen to have an AT and are trying to receive or uphold a scholarship to play a sport in college. Likewise, if athletes are returning to play while symptomatic then it could be suggested that they do not fully understand the severity of a SRC and the long-term effects that could linger due to premature RTP. Athletes have suggested they do not report concussion-related symptoms because they do not think it is serious enough.[14,21-24] These false assumptions should be addressed in future research to determine a way to decrease the amount of student-athletes that still down play the severity of SRCs. These findings could also be the result of the RTP protocol heavily relying on self-reported symptoms. Because symptoms are not visible, student-athletes may lie to their AT, coach, and parent about how they are feeling and deny symptoms when they are actually present. Additionally, middle school could be the first time some athletes are introduced to an AT, therefore they may feel safer playing while symptomatic or if the AT is part-time, middle school student-athletes may not feel comfortable or familiar enough to disclose their symptoms after a SRC. Furthermore, middle school student-athletes may not understand the importance of self-reporting symptoms and think the AT has to find their signs and

symptoms of the injury instead. The lack of experience middle school student-athletes may have with injuries might cause them to not understand that concussions differ from other injuries in that signs and symptoms are not as obvious. Research should investigate student-athlete and AT relationship to determine if trust plays a role in concussion reporting and RTP.

Although AT presence did not impact RTP, our results did suggest AT presence was significantly different between school and club sport affiliations ($p < 0.001$). All (100%) of our participants were involved in school sports and 74% of participants had an AT available at their school and/or club sports. This was anticipated by the research team considering we recruited our participants who were involved in school sports and all schools recruited for this study employed an AT. Fortunately, it is beneficial to see that the majority of student-athletes have access to an AT, whether at school or club athletics. If we had also recruited athletes who only play club sports, we may have found differences related to sport affiliation and access to an AT. Thus, future research should also recruit athletes that are only involved in club affiliated athletics.

Our findings support previous concussion research that has reported concussion education does not directly influence student-athlete's likelihood of reporting concussion-related symptoms.[10-13,30] All of our collegiate participants (100%) and the majority of middle school (92%) and high school (93%) student-athletes had received concussion education at some point in their athletic careers. Importantly, we found that concussion education did not have a significant effect on returning to play while symptomatic ($p > 0.05$). We found that 93% of middle school student-athletes received concussion education and although we did not ask the amount of concussion education athletes have

received, it can be assumed that the amount of exposure to these lessons are far less in middle school athletes compared to what high school and collegiate athletes have received over the years, yet their reporting remains the same. These results are similar to previous studies that have determined that concussion education does not positively impact one's behavior towards concussion reporting and/or compliance with RTP guidelines.[10-13,30] Specifically, Kroshus and Baugh concluded that coaches' attitude and the teams' environment towards concussions in conjunction with how the information is presented and who presents the concussion education information has an impact on how athletes respond to the information.[22,23,40] This is important to acknowledge because our data suggest that concussion education may not have the desired impact on student-athletes knowledge and behaviors. This indicates that exposure to concussion education does not significantly prevent student-athletes from returning to play while symptomatic.

Considering there were no differences found between the academic levels, it further implies that repeated exposure to concussion education is ineffective in altering concussion protocol compliance. It is possible that the presentation format may be important in its efficacy and may need to be investigated. The results gathered may suggest student-athletes are not aware that RTP evaluations heavily rely on self-reported symptoms and are not always sensitive enough to determine whether an athlete is not fully recovered unless they disclose the symptoms they are experiencing. Conversely, athletes may be aware that evaluations are an opportunity to lie to their AT, coach, and/or parent and hide symptoms they are experiencing in order to RTP sooner. Thus, future research should investigate the benefits of possible adjustments to SRC educational programs for feasibility, efficacy at modifying risky behaviors, and information retention.

Research should look specifically at who is presenting the information and in what format to gather the most beneficial information for future educational program adjustments.

Lastly, student-athletes with or without a history of SRC did not differ in their likelihood of withholding themselves from activity while symptomatic after a future SRC (n = 1,167) (p = 0.87). This is concerning and may imply that the seriousness of concussions is not well understood by student-athletes, especially by those with a concussion history. Contrarily, if athletes do understand the serious consequences that could result from playing while symptomatic after a SRC, then it should be determined why athletes are so willingly putting themselves at risk and whether this pressure comes from within or an outside source such as coaches, teammates, or parents. The authors found that previous exposure to a SRC did not have an impact on student-athletes' future likelihood of sitting out during athletic activity if they were to sustain another concussion. This finding does not support previous research that determined student-athletes with a history of SRC were less likely to report future concussions compared to athletes with no history of SRC.[10-13,16-18] Furthermore, sport affiliation did not significantly influence their likelihood to sit out of activity while symptomatic after a future SRC (p = 0.32). The differences found in our study continue to suggest that middle school and club student-athletes may approach concussions differently compared to previously studied high school and collegiate student-athletes.

Interestingly, the authors adjusted the categorization of the answers to this analysis due to lack of numbers in the 2 far extreme groups 'almost always' and 'never' likelihood to sit out on their own when experiencing concussion-related symptoms. The

majority of responses were within the middle groups, which suggests that student-athletes are not definitive on whether they would sit out or not when symptomatic. The authors believe this may be due to student-athletes making the decision to sit out based on the athletic situation they are currently in at the time of injury, for example a practice versus a game situation. Future research should investigate this relationship further by using situational questions and scenarios to determine the likelihood of sitting out of activity while symptomatic or even just reporting a SRC. Additional research could determine if these discrepancies extend outside of athletics by including non-sports related activities and situations to determine how athletes would behave in comparison.

Results suggest that despite SRC history status, athletes will not necessarily make the decision to sit out while symptomatic on their own; therefore ATs, coaches, and parents should take extra precaution if an injury is suspected and tell the appropriate medical personals to avoid further complications. Specifically, if an athlete had previously reported a concussion, it should not be assumed they will report future concussions. Our findings suggest best practice is to evaluate and determine the healthcare for athletes from AT experience and current knowledge about the athlete's testing results as well as information gathered from other individuals such as coaches and parents. Again, our findings may differ from past studies because of the inclusion of middle school student-athletes. At a younger age and a decreased amount of athletic environment exposure, they may not have developed the perception or pressures that influence older athletes to hide their symptoms. Future research should further investigate younger athletic populations' behaviors towards reporting concussions and determine if concussion reporting decisions are situational and not definitive in student-athletes.

This study, as do most research studies, had some limitations. We recruited student-athletes from local middle schools and high schools, eliminating the opportunity to collect data from club-only athletes. The addition of this group of athletes may have given us a slightly different perspective of the club sport athlete experience. However due to the clinical experience of the authors we feel that most middle and high school athletes are more likely to participate in school only or sports with both affiliations rather than just club. The research team members were not present during survey completion because of work affiliation with participating schools and to avoid response bias. The lack of researcher presence could have resulted in decreased understanding or adherence to instructions during survey distribution and completion. To account for this, the research team preemptively performed a pilot study to reduce participant error, wrote brief and clear directions for the site coordinators, and found only a few surveys that contained contradictory information. In the event that contradictory information was identified, all associated data were not included in our analyses. Lastly, the lack of responses from collegiate student-athletes compared to the other two academic levels may have skewed the data. Results may have differed if a more even response rate was gathered across all the academic levels. The research team found that our response rate was much higher in participants presented with the pen and paper format compared to those that received the survey via email. Therefore, in future studies it would be beneficial to use this approach for all participants.

Conclusion

Our study was able to enroll a large number of student-athletes from diverse age groups, athletic abilities, and various contact and non-contact sports which improved the

overall generalizability of the study. The amount of student-athletes with a history of SRC (23%) was similar to previous studies. Therefore, considering the differences found between the current study and previous studies, the authors have concluded these findings stem from the inclusion of middle school student-athletes who may approach concussions differently. In contrast to previous research, sex did not have a significant effect on returning to play while symptomatic. Our results continued to suggest that current education programs are not discouraging athletes from returning to sport while still experiencing concussion symptoms and that AT presence is not a mitigating factor in student-athletes' reporting behavior. Lastly, history of SRC was not found to be related to student-athletes' likelihood of withholding themselves from athletic activity after sustaining a future concussion. These results suggest that student-athletes may not fully understand the severity of a SRC even after receiving SRC education. Overall, it can be presumed that with factors such as ones' behavior towards concussions, receiving SRC education and having ATs available are not positively altering student-athletes' SRC reporting behaviors or decisions to RTP while symptomatic. Our findings indicate that even among middle school and club affiliated sports, athletes' behavior towards concussion still requires improvement and further research is necessary. The inclusion of middle school athletes in our study has created conflicting results regarding sex and SRC history from previous studies, thus reiterating the importance of including younger athletic populations to better understand SRC across all athletics. Younger athletes do not have as many years of athletic experience compared to high school collegiate student-athletes, therefore they may have a lower understanding of SRC, lower amounts of exposure to concussion education, and may not understand the self-reporting aspect of

concussion injuries. Middle school may be the first time these athletes are introduces to an AT which might make them feel safe, and/or believe that if the AT does not pull them from participation then they are not injured. Future research should investigate why student-athletes continue to RTP while symptomatic despite receiving concussion education and/or having an AT available to help them. Research should look at the relationship between student-athletes and ATs to determine if trust influences concussion reporting. Furthermore, future research can be used to determine a more influential concussion education presentation for student-athletes. Research should investigate whether concussion education would be more influential if they received it from a teammate or peer that has had negative concussion experiences. Future research should also determine if there is a more advanced RTP guideline that can better detect symptoms and may better encourage student-athletes to disclose their concussion symptoms and prevent early RTP.

KEYWORDS: *Athletic Trainer, Education, Sex, Sport Affiliation, Academic Level, TBI*

Table 1. Sex, Sport Affiliation, and Academic Level

Group	Independent Variables	Category	Frequency	Percent
Overall Participants (n = 1,225)	Sex	Male	671	54.8
		Female	553	45.1
	Sport Affiliation	School	1225	100.0
		Club	1021	83.3
	Academic Level	Middle School	612	50.0
		High School	528	43.1
		College	85	6.9
Concussion Participants (n = 359)	Sex	Male	224	62.4
		Female	134	37.3
	Sport Affiliation	School	211	58.8
		Club	148	41.2
	Academic Level	Middle School	117	32.6
		High School	202	56.3
		College	40	11.1

Table 2. Age and Years Playing Sports

Group	Variable	Mean (years)	Standard Deviation (years)
Overall Participants (n = 1,225)	Age	14.47	2.17
	Years Playing School Sports	3.72	2.62
Concussion Participants (n = 359)	Age	15.17	2.20
	Years Playing School Sports	5.15	2.84

Table 3. AT Presence, Concussion Education, and SRC History

Group	Independent Variable	Category	Frequency	Percent
Concussion Participants (n = 359)	AT Presence	Yes	264	73.5
		No	95	26.5
	Concussion Education	Yes	321	89.4
		No	23	6.4
Overall Participants (n = 1,225)	SRC History	Yes	282	23.0
		No	943	77.0

Table 4. Returned to Play While Symptomatic and Likelihood to Voluntarily Sit Out While Symptomatic

Group	Outcome Variable	Category	Frequency	Percent
Concussion Participants (n = 359)	Returned-to-Play Symptomatic	Yes	276	76.9
		No	52	14.5
	Likelihood to Sit Out While Symptomatic	Less Likely	128	35.7
		Neutral	45	12.5
		More Likely	171	47.6
Overall Participants (n = 1,225)	Likelihood to Sit Out While Symptomatic	Less Likely	427	34.9
		Neutral	179	14.6
		More Likely	561	45.8

Table 5. Sport-Related Concussions by Academic Level

Academic Level	SRC Location	SRC Participants	Number of SRC	Average
Middle School (n = 117)	School	58	128	2.2
	Club	59	142	2.4
High School (n = 202)	School	125	314	2.5
	Club	78	191	2.4
College (n = 40)	School	29	92	3.2
	Club	12	24	2.0
Total (n = 359)	School	211	534	2.5
	Club	148	357	2.4

Table 6. The Number of Concussion Participants with Sport Exposure by Sport, Sport Affiliation, and Sex (n = 282)

Sport	School		Club		Total
	Female	Male	Female	Male	
Baseball	0	33	4	53	90
Basketball	33	74	25	57	189
Cheer	23	2	15	2	42
CC/ Track	41	84	13	31	169
Football	2	129	2	70	203
Gymnastics	4	0	19	10	33
Soccer	34	34	33	41	142
Softball	17	0	26	0	43
Tennis	13	10	5	7	35
Volleyball	47	0	28	2	77
Other	13	33	17	42	105
Total	262	399	187	315	1,128

*Participants were able to circle all sports they had played for at least 1 season. The 'Other' category is a combination of sports that had less than 20 people. This group includes school and/or club sports such as: field hockey, golf, lacrosse, ice hockey, pole vault, power lifting, rugby, swimming, ultimate Frisbee, and other.

Table 7. Symptoms Present When Participant Returned to Sport after SRC

Symptoms	School (n = 211)		Club (n = 148)		Total
	Female (n = 72)	Male (n = 139)	Female (n = 62)	Male (n = 85)	
Headache	56	94	46	61	257
Dizziness	42	65	34	38	179
Difficulty Concentrating	19	38	10	23	90
Fatigue	17	31	11	18	77
Difficulty Sleeping	15	19	10	18	62
Blurred Vision	22	21	15	17	75
Confusion	20	27	12	20	79
Irritability	13	14	6	7	40
Ringing in the Ears	18	26	15	13	72
Light Sensitivity	19	38	15	18	90
Noise Sensitivity	23	22	16	16	77
Nausea	13	22	14	15	64
Balance Disturbances	12	21	9	12	54
Vomiting	4	10	7	8	29
Memory Loss	7	24	6	5	42
Sadness	14	9	5	5	33
Feeling in a 'Fog'	18	21	9	14	62
Anxiety	18	8	15	11	52
Other	2	0	1	2	5
None	7	25	8	11	51
Total	359	535	264	332	1490

* These numbers do not match the number of participants because they were instructed to select all symptoms experienced.

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APPENDIX SECTION

Appendix A: Graduated Return-to-Play Protocol

Stage	Rehabilitation	Functional Exercise	Objective of Stage
1	No activity	Symptom-limited physical and cognitive rest	recovery
2	Light aerobic exercise	Walking, swimming, or stationary cycling keeping intensity less than 70 percent maximum permitted heart rate. No resistance training	Increase heart rate
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	Normal play – Full recovery

*2013 International Conference on Concussion in Sport. Zurich, Switzerland.[4,53]

Appendix B: American Academy of Neurology and Prague Guidelines for Concussion Grading and Return-to-Play

Table I. American Academy of Neurology (AAN) and Prague guidelines for concussion grading and return-to-play (RTP).

Definition	Return-to-play
AAN [16]	
Grade I	
• Transient confusion	1st occurrence: Same day
• No LOC	2nd occurrence: After 1 asymptomatic week
• Symptoms <15 min	
Grade II	
• Transient confusion	1st occurrence: After 1 asymptomatic week
• No LOC	2nd occurrence: After 2 asymptomatic weeks
• Symptoms >15 min	
Grade III	
• Any LOC	1st occurrence: Brief LOC: After 1 asymptomatic week; Prolonged LOC: After 2 weeks, following 1 asymptomatic week
	2nd occurrence: After 1 asymptomatic month
Prague [19]	
Simple	
• Symptoms resolve within 7–10 days	No RTP same day Player should not be left alone, regular monitoring for deterioration Player should be medically evaluated Follow stepwise RTP protocol. Athlete should continue to proceed to the next level if asymptomatic at the current level. If symptomatic, the athlete should drop back to the previous asymptomatic level and attempt progression after 24 hours. (1) No activity, complete rest (2) Light aerobic exercise (walking, etc.), no resistance training (3) Sport-specific exercise, progressive resistance training (4) Non-contact training drills, progressive resistance training (5) Full contact training after medical clearance (6) Game play
Complex	
• Symptoms are persistent • LOC >1 min • Prolonged cognitive impairment • Athlete has suffered multiple concussions	Rehabilitation will be more prolonged Complex cases should be managed by experienced doctors

LOC, loss-of-consciousness; PTA, post-traumatic amnesia.

*2nd International Conference on Concussion in Sport, Prague 2004.[66]

Appendix C: Sport-Related Concussion Survey

1. How old are you?

   10 11 12 13 14 15 16 17 18 19 20 21 22 23

2. What gender are you?

   Female Male

3. What is your current school level?

   Middle school High school College

4. What size school do you attend?

   1A 2A 3A 4A 5A 6A Division 1 Division 2 Division 3

Please answer questions 5 – 20 in regards to school-sponsored sports team participation (UIL, TAPPS, or varsity college teams). This section does **NOT** include club sports.

5. How many <u>years</u> have you played school-sponsored sports?

   0-1 2-3 4-5 6-7 8-9 10-11 12-13 14-15

6. Circle all school-sponsored sports (UIL/TAPPS/college) you have participated in for at least 1 season from 6th grade until your current academic year:

- Baseball
- Basketball
- Cheerleading
- Cross country / Track (not including Pole Vault)
- Field Hockey
- Football
- Golf
- Gymnastics
- Ice Hockey
- Lacrosse
- Pole Vault
- Power Lifting
- Rugby
- Softball
- Soccer
- Swim/Diving
- Tennis
- Ultimate Frisbee
- Volleyball
- Wrestling
- Other _____

7. Have you ever experienced a concussion(s) during school-sponsored (UIL/TAPPS) sports? *Concussion: Contact to the head or body which results in signs & symptoms including but not limited to headache, dizziness, light/noise sensitivity, balance disturbances, or memory loss that last for several days to weeks.*

   Yes No Unsure

If you answered **NO** above for concussions in school-sponsored sports (UIL/TAPPS/college sports), please skip to **<u>question #14</u>**

8. How many concussions do you think you have experienced while playing school-sponsored sports?

   0 1-2 3-4 5-6 7-8 9-10 More than 10

9. Was an athletic trainer available at the time of your concussion(s)?

   Almost always Sometimes Every Once in a While Rarely Never

10. Who did you tell about your concussion(s) during school sponsored sports? (Circle all that apply)

    Athletic trainer Coach Nurse Parent Teacher

    Friend/Teammate Other_____ I did not tell anyone

11. Did you get cleared by a doctor before returning to play/activity?

    Almost Always Sometimes Everyone Once in a While Rarely Never

12. Who helped you complete your concussion(s) return-to-play guidelines/protocol/rehabilitation? *Return-to-play: a multiple day progression back into activity after clearance from a doctor.*

    Athletic trainer Coach Nurse Parent

    I did not participate in a return-to-play program; I just went back to playing when I wanted to

13. Circle all symptoms you have experienced when you **returned to play** after a concussion in a school sponsored sport (only symptoms you had when you restarted activity):

- Headache
- Dizziness
- Difficulty concentrating
- Fatigue
- Difficulty sleeping
- Blurred vision
- Confusion
- Irritability
- Ringing in the ears
- Light sensitivity
- Noise sensitivity
- Nausea
- Balance disturbances
- Vomiting
- Memory loss
- Sadness
- Feeling in a 'fog'
- Anxiety
- Other_____
- None, I felt fine

14. Do you currently have an athletic trainer at your school?

    Yes No Unsure

If you answered **NO** or **UNSURE** above to having an athletic trainer, please skip to **question #21**

15. How often is your school athletic trainer available during school-sponsored **competitions**?

a. Never
b. Less than 25% of competitions
c. 25-50% of competitions
d. 50-75% of competitions
e. 75-99% of competitions
f. Always

16. How often is your school athletic trainer available during school-sponsored **practices**?

a. Never
b. Less than 25% of practices
c. 25-50% of practices
d. 50-75% of practices
e. 75-99% of practices
f. Always

17. How well do you know your school athletic trainer?

Very Much Somewhat Undecided Not Really Not at All

18. Do you trust your school athletic trainer to help your injuries?

Very Much Somewhat Undecided Not Really Not at All

19. My school athletic trainer is usually considerate of my needs and puts them first:

Strongly Agree Agree Uncertain Disagree Strongly Disagree

20. I trust my athletic trainer so much that I always try to follow his/her advice:

Strongly Agree Agree Uncertain Disagree Strongly Disagree

Please answer the following questions 21-35 in regards to club sport participation. (No school affiliated teams or intramurals) If you have **NEVER** participated in club sports, please skip to **question #36**

21. Circle all club sports teams you have participated on for at least 1 season throughout your life:

- Baseball
- Basketball
- Cheerleading
- Cross country / Track (not including Pole Vault)
- Field Hockey
- Football
- Golf
- Gymnastics
- Ice Hockey
- Lacrosse
- Pole Vault
- Power Lifting
- Rugby
- Soccer
- Softball
- Swim/Diving
- Tennis
- Ultimate Frisbee
- Volleyball
- Wrestling
- Other _____

22. Have you ever experienced a concussion(s) during club sports?

Yes No Unsure

If you answered **NO** above to having a concussion during a club sport, please skip to **question #29**

23. How many concussions do you think you have experienced while playing club sports?

0 1-2 3-4 5-6 7-8 9-10 More than 10

24. Was an athletic trainer available at the time of your club sport concussion(s)?

Almost Always Sometimes Every Once in a While Rarely Never

25. Who did you tell about your concussion(s) during club sport? (Circle all that apply)

Athletic trainer Coach Parent Nurse Teacher

Friend/Teammate Other _____

I did not tell anyone about my concussion symptoms

26. Did you get cleared by a doctor before returning to play/activity?

Almost Always Sometimes Every Once in a While Rarely Never

27. Who helped you complete your club sport concussion(s) return-to-play guidelines/protocol/rehabilitation? *Return-to-play: a multiple day progression back into athletic activity after clearance from a doctor*

Athletic trainer Coach Nurse Parent

I did not participate in a return-to-play program; I just went back to playing when I wanted to

28. Circle all the symptoms you have experienced when you **returned to play** after a concussion(s) during club sports (only symptoms you had when you restarted activity):

- Headache
- Dizziness
- Difficulty concentrating
- Fatigue
- Difficulty sleeping
- Blurred vision
- Confusion
- Irritability
- Ringing in the ears
- Light sensitivity
- Noise sensitivity
- Nausea
- Vomiting
- Memory loss
- Sadness
- Feeling in a 'fog'
- Balance disturbances
- Anxiety
- Other _____
- None, I felt fine

29. Do you have an athletic trainer available to you during club sports?

Yes No Unsure

If you answered **NO** or **UNSURE** about having an athletic trainer during club sports, please skip to **question #36**

30. How often is the club athletic trainer available during **competitions**?

a. Never
b. Less than 25% of competitions
c. 25-50% of competitions
d. 50-75% of competitions
e. 75-99% of competitions
f. Alway

31. How often is the athletic trainer available during **practices**?

a. Never
b. Less than 25% of practices
c. 25-50% of practices
d. 50-75% of practices
e. 75-99% of practices
f. Always

32. How well do you know your club sport athletic trainer?

Very Much Somewhat Undecided Not Really Not at All

33. Do you trust your athletic trainer to help your injuries?

Very Much Somewhat Undecided Not Really Not at All

34. My club sport athletic trainer is usually considerate of my needs and puts them first:

Strongly Agree Agree Uncertain Disagree Strongly Disagree

35. I trust my club sport athletic trainer so much that I always follow his/her advice:

Strongly Agree Agree Uncertain Disagree Strongly Disagree

36. If you were experiencing concussion-like symptoms, how likely are you to sit out of athletic activities until you felt normal/symptom-free, without being told to sit out?

Almost Always Sometimes Every Once in a While Rarely Never

37. At what academic levels have you received information about concussion education? (Select all that apply)

Grade School Middle School High School None

38. Did you attend a concussion information meeting prior to starting sports this year?

Yes No Unsure

39. Who gave the information about concussions during that meeting?

Athletic Trainer School Nurse Coach Athletic Director Health Teacher

Unsure I don't know/I didn't go We didn't have a concussion meeting

40. How strongly does your athletic trainer/nurse stress the seriousness of concussions?

    Very Much Somewhat Undecided Not Really Not at All

41. If you were experiencing concussion symptoms who would you probably tell first? (Choose only 1)

    Athletic trainer Nurse Coach Parent Teacher

    Friend /Teammate Other _____ I wouldn't tell anyone

42. How likely are you to tell someone that a teammate/friend is experiencing concussion symptoms?

    Very Much Somewhat Undecided Not Really Not at All

43. How many **total** concussions do you think you have experienced **overall** (sports, car accidents, falls, etc.)?

    0 1-2 3-4 5-6 7-8 9-10 More than 10

44. How many concussions do you think you have experienced while **playing sports**?

    0 1-2 3-4 5-6 7-8 9-10 More than 10

45. Of your total concussions, how many did you **tell to an athletic trainer, coach, or non-friend adult**?

    0 1-2 3-4 5-6 7-8 9-10 More than 10

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