Time to Authorized Clearance from Sport-Related Concussion: The Influence of Healthcare Provider and Medical Facility

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ABSTRACT

Context: Return-to-play following sport-related concussion (SRC) requires authorized clearance from a healthcare provider (HCP). Variability in HCPs and facilities where athletes seek care may influence return time.

Objective: Determine the initial examiner, HCPs that authorize clearance, and medical facilities authorizing clearance among high school student-athletes following SRC, and compare authorized clearance time by HCPs and medical facilities.

Design: Prospective Cohort Study.

Setting: High school.

Patients or Other Participants: Student-athletes (n=16,001) with SRC participating in STATE-XXX High School Athletic Association (XHSAA)-sponsored athletics.

Main Outcome Measure(s): Frequencies of initial examiner and authorized clearance for each HCP (Doctor of Osteopathic Medicine (DO), Doctor of Medicine (MD), Nurse Practitioner (NP), Physician Assistant (PA)) and medical facility (Neurologist’s Office, Team Physician, Primary Care Physician or Pediatrician’s Office (PCP), Hospital, Urgent/Ready Care) for each SRC case. Kaplan–Meier curves and Peto tests evaluated differences in median time to authorized clearance between HCPs and facilities. Only cases with a follow-up authorized clearance date (80.3%, n=12,856) were included in authorized clearance and time to return analyses.
Results: An athletic trainer was at least one of the initial examiners for 71.3% (n=11,404) of cases; 80.2% (n=12,990) had only one initial examiner. There was an association between initial examiner and medical facility providing clearance for athletic director ($\chi^2=52.6$, $p<.001$, $V=.06$), athletic trainer ($\chi^2=172.0$, $p<.001$, $V=.12$), coach ($\chi^2=161.5$, $p<.001$, $V=.11$), DO ($\chi^2=59.4$, $p<.001$, $V=0.07$), and NP ($\chi^2=10.0$, $p<.03$, $V=.12$). The majority (n=8,218, 63.9%) received clearance by an MD; 70.8% (n=9,099) were cleared at a PCP. Median time to authorized clearance varied by facility (Urgent/Ready Care: 7 days [4,11], Hospital: 9 days [6,14], PCP: 10 days [6,14], Team Physician: 12 days [8,16], Neurologist Office: 13 days [9,20]; $p \leq .001$).

Conclusions: Clearance was frequently provided by an MD and at a PCP. Median time to return to unrestricted participation following SRC varied by HCP and medical facility. Future research should elucidate why differences exist and determine why athletes seek care at different medical facilities.

Key Words: concussion, recovery, sports, health disparity

Key Points:

- An athletic trainer was the initial examiner for a majority (71.3%) of high school SRC cases, followed by a coach (35.5%). Approximately 20% of cases had more than one initial examiner.
- The median time to authorized clearance following SRC differs by each medical facility: Urgent/Ready Care: 7 days [4,11], Hospital: 9 days [6,14], PCP: 10 days [6,14], Team Physician: 12 days [8,16], Neurologist Office: 13 days [9,20]
- Boys (74.1%) had an AT as an initial examiner more often than girls (65.8%); differences in medical facility cleared existed between boys (69.3% PCP, 11.3%
Team Physician, 8.4% Neurologist Office) and girls (73.6% PCP, 8.5% Team Physician, 8.3% Neurologist Office).
Sport-related concussion (SRC) is a growing health concern, particularly in younger, at-risk athletic populations. Research estimates between 1.1 and 1.9 million sports- and recreation-related concussions occur annually in youth under the age of 19 years.\(^1\) Currently, all states and the District of Columbia have passed youth concussion laws. However, these laws vary in the credential requirements of health care providers (HCP) authorized to clear a concussed athlete and do not specify which medical facilities may provide clearance. Moreover, with the advancement in SRC literature on diagnosis and return to play guidelines, and continuous updates to consensus and positions statements on concussion, return-to-play decisions may be a daunting responsibility for many HCPs.

Health care providers that are responsible for concussed athletes and return-to-play clearance should ensure decisions are guided with best practices. Current consensus and position statements suggest that concussed athletes should progress through a stepwise progression prior to returning to participation.\(^2,3\) Additionally, it is recommended that athletes first have an initial period (24-48 hours) of relative physical and cognitive rest, and progress through stages of symptom-limited activity, light aerobic exercise, sport-specific exercise, and non-contact training with at least 24 hours between each step. Then, after an athlete is asymptomatic and cleared by a HCP, they can continue full practice and competition.\(^2\) However, discrepancies still exist as to which HCP is making the return-to-play decision. Valovich and colleagues\(^4\) reported that the athletic trainer served as the primary decision maker for the athlete in 69.2% of concussed cases, followed by other physician (17.3%), and team physician (8.9%); however, this study included data prior to mandated concussion laws. Now, in some
states, athletic trainers may not be included as a HCP responsible for medical clearance. For example, in the State of XXX, only a Medical Doctor (MD), Doctor of Osteopathic Medicine (DO), Physician Assistant (PA), and Nurse Practitioner (NP) are allowed to clear a concussed athlete participating in a sanctioned STATE-XXX High School Athletic Association (XHSAA) sport or activity. Thus, it is important to determine which HCP is making return to play decisions in the State of XXX as athletic trainers are no longer an option.

Although a physician can clear an athlete who has sustained a concussion, parents or guardians are usually responsible for bringing their child to the physician. However, research has indicated that parents have inconsistent views on which physician or medical facility to take their concussed child. For example, in a study by Zamparripa and colleagues, 44% would call or go to the child’s normal care provider (i.e., pediatrician, primary care physician) and 42% of parents would seek immediate care at a hospital Emergency Department (ED). Approximately two-thirds of parents who took their concussed child to an ED expected to be told whether their child had or did not have a concussion, 68% definitely expected to be told how long to stay out of school or activities, and half the parents expected the ED physician to sign a return-to-activity form for gym or sports.

Despite parents expectations for care provided to their concussed child by an ED physician, HCPs in these settings may not have the training or resources to manage the injury according to best practices, yielding variability in concussion clinical care practice. In a study by Stern and colleagues, approximately one-third of ED physicians did not use any formal clinical guidelines for concussion assessment, while 57% of
physicians used neuroimaging to guide their clinical decision, despite numerous consensus and position statements indicating the absence of structural damage during concussion diagnosis.\textsuperscript{2,3} Furthermore, only 32\% of ED physicians recommended a gradual or stepwise return to participation.\textsuperscript{6} This lack of gradual or stepwise return to participation may influence recovery time or place athletes at further risk for injury. Additionally, a study of pediatric primary care and emergency medicine providers revealed that, although they regularly care for concussed patients, they may not have adequate training or infrastructure to properly manage the injury. Lastly, when athletic trainers and school nurses were asked about SRC management, they cited inconsistent care practices including discordance between physician practice and regulation protocols, physicians precleared students prospectively with a note and other healthcare providers cleared students without documentation of physician oversight, and premature medical clearance by physicians,\textsuperscript{6} which may be due differences in where a concussed athlete seeks care.

In the past decade, emerging evidence has provided insight into recovery timelines following SRC and improved education has aided with recognition and management. Studies have demonstrated that a typical recovery for pediatric athletes is within 1-4 weeks,\textsuperscript{9,10} however for some recovery persists beyond 4 weeks.\textsuperscript{11} Previous reports recommended physical and cognitive rest,\textsuperscript{11} but recent evidence suggests negative consequences from strict rest and that early exercise may improve recovery time.\textsuperscript{12-16} Furthermore, since 2015, recovery from SRC has been shown to be influenced by immediate removal from sport\textsuperscript{6,17-19} and academic accommodations,\textsuperscript{20} both of which are management practices that may vary by HCP and medical facility.
Therefore, it is critical to identify who is involved in acute care and which HCPs are authorizing clearance and where clearance is authorized in order to determine if any differences in concussion management exist. As such, the purpose of this study was to determine the initial examiner for high school athletes with a SRC, the credentials of HCPs that authorize clearance, and the medical facility where athletes obtained the medical clearance. The second aim of this study was to determine if the time for authorized clearance was the same for concussed athletes cleared by different medical providers and medical facilities. The third aim was to compare an athletic trainer as an initial examiner and the medical facility for authorized clearance between sexes.

METHODS
Research Design, Schools, and Participants

This was a prospective cohort design using data obtained from the STATE-XXX High School Athletic Association (XHSAA) Head Injury Reporting System (HIRS). Data was collected during the 2015-16 through 2018-19 academic years, and included 9th grade through 12th grade. Current XHSAA concussion protocol requires all participating high schools in the State of XXX (2015-16: n = 755; 2016-17: n = 751; 2017-18: n = 750; 2018-19: n = 747) to enter data into the HIRS, however individual high schools set their own deadlines for reporting participant and concussion data. There are 28 sports sanctioned by the XHSAA which include baseball, boy’s and girl’s basketball, boy’s and girl’s bowling, girls competitive cheerleading, boy’s and girl’s cross country, 11 and 8-player football, boy’s and girl’s golf, girls gymnastics, boy’s ice hockey, boy’s and girl’s lacrosse, boy’s and girl’s skiing, boy’s and girl’s soccer, softball, boy’s and girl’s swimming and diving, boy’s and girl’s tennis, boy’s and girl’s track and field, girl’s...
volleyball and boy’s and girl’s wrestling. To date, there are 16,001 SRC cases retained in the HIRS (male: 65.5% n = 10,483; female: 35.5%, n = 5,518). Table 1 reports the frequencies of student-athletes in each grade.

Data Reporting and Definitions

Operational Definition of Sport-Related Concussion

SRCs reported into the HIRS had to meet the following three criteria: (1) occur during participation in a XHSAA-sanctioned sport that provided a post-season tournament, (2) occur during an in-season practice, scrimmage, or game and (3) required the student-athlete to be withheld from activity after exhibiting signs, symptoms or behaviors consistent with SRC (e.g., loss of consciousness, headache, dizziness, confusion, balance problems). An MD, DO, PA, or NP diagnosed all SRCs.

Initial Examiner

For each case, the HIRS includes an initial examiner(s) either that recognized the SRC, or that the suspected SRC was reported to, and provided an initial assessment. The initial examiner included an athletic trainer, sideline emergency personnel, DO, MD, PA, NP, other appropriate HCP, athletic director, coach, or a combination of multiple examiners if more than one initial examiner was reported.

Return-to-Play Clearance

According to the XHSAA, clearance must be unconditional and in writing. Return-to-play clearance is defined as unrestricted return to full participation. Thus, HCPs can only provide written authorized clearance if the concussed student-athlete is able to return to unrestricted activity.

Authorizing Healthcare Provider
The XHSAA defines an authorizing HCP as a MD, DO, NP or PA. These individuals are the only providers allowed to give written authorization to return to unrestricted activity.

**Medical Facility Providing Clearance**

The medical facility providing clearance identified where the concussed student-athletes obtained written authorized clearance to return to unrestricted activity. These facilities include hospital emergency departments, primary care physician or pediatrician’s office (PCP), team physician, Neurologist’s office, and Urgent/Ready Care.

**Procedures**

The Institutional Review Board approved this study as exempt due to de-identifiable data. Data collection procedures are described in previous studies. XHSAA concussion protocol requires school personnel to submit an online report for each SRC. In addition to SRCs, data recorders were also required to submit total student-athlete participation per sport, as well as demographic (i.e., sex, grade, level, sport) data. The SRC injury event included date of injury, whether the event occurred during a game or practice, the HCP or other professional providing the initial assessment, the authorizing HCP providing unrestricted written clearance, and medical facility used for final clearance. Each student-athlete had a seven-digit ID number to ensure the data remained anonymous. If a student-athlete incurred a second SRC either in the same sport or different sport, each SRC was recorded as a separate injury. Athletic trainers were the primary data recorder for the HIRS; however, if an athletic
trainer was not employed by a high school, coaches and school officials were required to record data into the HIRS.

XHSAA staff members monitored SRCs on a daily basis for errors. If an error or anomaly was identified, the XHSAA staff contacted participating schools to make edits. The XHSAA also required high schools to report if they did not have an SRC into the HIRS. The XHSAA deemed SRC data collection complete when no less than 99% of all injury reports were received. Only XHSAA staff members were authorized to edit SRC reports once submitted.

Statistical Analysis

Descriptive statistics described frequencies, mean values, medians, and ranges. Chi-square analyses determined if there was an association between initial examiner and medical facility providing clearance, and if there was an association between the authorizing HCP and the medical facility providing clearance. Chi-square analyses also determined if there was an association between sex and if an AT was involved as the initial examiner, and sex and the medical facility providing clearance. The effect size for the interpretation was calculated with Cramer’s V and interpreted as small=0.1, medium=0.3, and large=0.5 effect. Kaplan-Meier survival analyses, adjusting for previous concussion history and year of athletic season, assessed the median time in days between the date the SRC occurred and the date of authorized clearance to return to unrestricted activity. All survival times were truncated at 40 days and SRC cases were censored if the student-athlete obtained authorized clearance after their season ended. Peto tests assessed whether the median number of days for authorized clearance differed between authorizing HCP and medical facility cleared.
analysis was completed with Stata (StataCorp, version 16.0), and significance was set at \( p \leq .05 \).

RESULTS

The accrued SRC cases are presented in Figure 1. A total of 16,001 SRC cases occurred throughout the four athletic seasons. Table 1 represents demographics and characteristics of SRC cases. The initial examiner for SRC cases was most often an athletic trainer (71.3\%, \( n = 11,404/16,001 \)) or a coach (35.5\%, \( n = 5,673/16,001 \)). Each SRC could have had more than one initial examiner; however, for a majority of SRC cases only one initial examiner was involved (81.2\%, \( n = 12,990/16,001 \)). Of all SRC cases, 80.3\% (\( n = 12,856/16,001 \)) of cases obtained authorized clearance to return to unrestricted activity. Student-athletes with a SRC most often obtained authorized clearance from an MD (63.9\%, \( n = 8,218/12,856 \)) or DO (18.9\%, \( n = 2,423/12,856 \)), and sought medical clearance at a PCP office (70.8\%, \( n = 9,099/12,856 \)) followed by a team physician (10.4\%, \( n = 1,331/12,856 \)) (Figure 1).

There was an association between initial examiner and medical facility providing clearance for athletic director (\( \chi^2 = 52.6, p \leq .001, V = .06 \)), athletic trainer (\( \chi^2 = 172.0, p \leq .001, V = .12 \)), coach (\( \chi^2 = 161.5, p \leq .001, V = .11 \)), DO (\( \chi^2 = 59.4, p \leq .001, V = .07 \)), sideline emergency personnel (\( \chi^2 = 37.9, p \leq .001, V = .05 \)), other appropriate HCPs (\( \chi^2 = 35.6, p \leq .001, V = .05 \)), and NP (\( \chi^2 = 10.0, p = .03, V = .12 \)) (Table 2). When an athletic trainer was involved in the initial examination, a greater proportion of student-athletes received authorized clearance by a team physician and a lower proportion was cleared at a PCP than when an athletic trainer was not an initial examiner. The opposite occurred when a coach was involved in the initial examination; a greater proportion of
student-athletes received authorized clearance at a PCP and a lower proportion was

cleared by a team physician than when a coach was not an initial examiner. There was

a significant association between the authorized medical examiner and the medical
facility providing authorized clearance ($\chi^2 = 1,400, p \leq .001, V = .19$). A DO was most

often the examiner at the PCP (62.0%, n = 1,503/2,423) or the team physician (26.5%,
n = 642/2,423), an MD was most often the medical examiner at the PCP (71.2%, n =
5,893/8,218) or the Neurologist’s office (11.4%; n = 937/8,218), and NP and PA were

most often the examiner at the PCP (NP: 78.6%, n = 832/1,059; PA: 75.4%, n =
871/1,156) and Urgent/Ready Care (NP: 14.8%, n = 157/1,059; PA: 13.5%, n =
156/1,156) (Table 3).

Overall, the median [interquartile range] time between the date of injury and

authorized clearance to return to unrestricted activity was 11 [7-16] days. The median
time by each medical facility was 7 days [4,11] for Urgent/ready care, 9 days [6,14] for
hospital, 10 days [6,14] for PCP, 12 days [8,16] for team physician, and 13 days [9,20]
for a Neurologist’s office ($p \leq .001$ when adjusting for previous concussion history and
year of athletic season (Figure 2). The median time for authorized clearance by each
authorizing HCP was 9 days [5,13] for PA, 10 days [6,14] for NP, 10 days [6,14] for MD
and 10 days [6,14] for DO ($p \leq .001$) when adjusting for previous concussion history and
year of athletic season (Figure 3).

There were significant differences in initial examiner between boy’s and girl’s
SRC cases. Table 4 Displays the frequencies of each initial examiner stratified by sex
for all SRC cases (n = 16,001), a significantly greater proportion of boys (74.1%, n =
7,772/10,483) had an AT as their initial examiner compared to girls (65.8%, n =
(χ² = 122.2, p ≤ .001, V = .08). In addition, for cases that obtained
authorized clearance, there was a significant association between sex and medical
facility where the student-athlete was cleared (Table 5). A significantly greater
proportion of boys (11.3%, n=957/8,459) compared to girls (8.5%, n=374/4,397)
received authorized clearance through a Team physician, while a significantly greater
proportion of girls (73.6%, n=3,235/4,397) compared to boys (69.3%, n=5,864/8,459)
received clearance at a PCP office.

DISCUSSION

This study sought to 1) identify personnel involved in the initial SRC examination
and 2) compare the time to authorized clearance to return to unrestricted activity
between the HCP (MD, DO, PA, NP) authorizing clearance and medical facilities using
the largest sample, to date, of SRC injury surveillance in the high school athletic setting.
The XHSAA mandates written authorized clearance prior to return to full participation,
however athletes with SRC seek care from a variety of medical providers and medical
facilities. An athletic trainer was at least one of the initial examiners in 71% percent of
SRC cases. We found that 19.7% cases did not obtain authorized clearance to return,
which may be due to many different factors (e.g., end of the season, return occurred
after the season, not given authorization to return, did not seek authorization, or quit
sport) and warrants further exploration. Athletes most often obtained authorized
clearance to return to unrestricted activity from a PCP office. When comparing time to
authorized clearance, athletes obtained clearance a median of 5-6 days sooner from an
Urgent/Ready care facility compared to a team physician or Neurologist's office,
respectively. While this difference may be perceived as small, for a student-athlete this
could be the difference between playing in a game vs. sitting out. Furthermore, there is
a potential for serious consequences (i.e. subsequent concussion, prolonged recovery)
if student-athletes are returned too soon. In addition, these results may be clinically
useful in conversations between athletic trainers and key stakeholders (i.e., athletes,
coaches, parents) to explain anticipated return outcomes, which vary between medical
settings. The findings in the current study may exemplify more conservative
management practices based on medical facilities, and therefore can be used to direct
future research questions based on medical facility and provider RTP management
practices.

Athletic trainers play a major role as initial examiners in identifying and managing
athletes with SRC. A recent study of Wisconsin high schools found that athletic trainer
availability was positively associated with the reported incidence of SRC and proper
management practices, including use of a return-to-play protocol. That being said,
34% of public and private high schools across the United States with athletic programs
do not have access to athletic training services; in the State of XXX, 48% have no
access. Our findings indicate that 29% of SRC cases did not have an athletic trainer
involved in the initial examination. Post and colleagues reported that coaches (66.8%)
are most often responsible for immediate medical care during practices, while athletic
trainers (57.9%) are most often responsible for immediate medical care during
competitions, as athletic trainers’ presence at practice and competitions is variable.
Appropriate medical coverage is often prioritized based on the risk of the sport, and
some high school sports (e.g., football, basketball, soccer, track) require more athletic
training services than others. This creates disparities in medical coverage for athletes
that participate in other sports in an athletics program without access to athletic training services. In our sample, a greater proportion of boys (74.1%) had an athletic trainer listed as an initial examiner compared to girls (65.8%). These findings suggest a potential disparity in athletic training coverage for high school female athletes for acute SRC management that may influence referral and where female athletes seek further care, warranting further research in this area. In addition, the clinical implications of these findings provide rationale to increase athletic trainer access to all athletes, including females, and also to ensure coaches are trained to properly identify and acutely manage SRC in the absence of an athletic trainer due to the involvement found for the initial evaluation in males (31.4%) and females (43.2%), respectively. Early access to appropriate medical care is demonstrated to influence length of recovery from SRC; therefore, future work should address disparities in athletic trainer coverage that may facilitate seeking proper care and management of SRC.

Identifying personnel involved in the SRC initial examination is also important because these professionals may influence where a student-athlete goes to receive further medical care and obtain authorized clearance. A study of return-to-play compliance found that high school students followed guidelines more consistently when managed by an interdisciplinary team (i.e., athletic trainer and physician). A second study found that athletes were more likely to present to a sports medicine clinic than an ED if they were initially examined by an athletic trainer. These are similar to the findings in our study supporting the benefit of an athletic trainer in the acute phase of SRC management, as there was an association between the initial examiner of SRC and where the student-athlete ultimately sought authorized clearance to return to
unrestricted activity, however these findings yielded small effect sizes. Specifically, a

greater percentage of student-athletes with an athletic trainer as an initial examiner
obtained clearance from a team physician and Neurologist’s office and less from a PCP
compared to student-athletes without an athletic trainer involved in their initial
examination. In contrast, a lower percentage of student-athletes obtained clearance
from a team physician if a coach or athletic director was an initial examiner compared to
those without a coach or athletic director. This potentially could be due to a number of
reasons. As a HCP, an athletic trainer is more qualified to ascertain the severity and
specificity of concussion symptoms than a coach or athletic director and, therefore, may
be able to refer a student-athlete to a more specialized care facility, such as a
Neurologist’s office. Furthermore, if a coach or athletic director is the initial examiner,
this may indicate a lack of sports medicine resources and access to athletic training
services for that particular team, and may suggest less collaboration with sports
medicine or a team physician in SRC management. While we did not have specific
information regarding healthcare access in this study, these findings warrant further
investigation into this issue in high schools in the State of XXX.

This study also found a significant difference in median time to clearance for
medical facility. Student-athletes with a SRC returned to unrestricted activity 5-6 days
sooner if they obtained authorized clearance in an Urgent/Ready care facility compared
to a team physician or Neurologist’s office, respectively. The median days for clearance
authorized at an Urgent/Ready care was 7 days while adjusting for previous concussion
history and year of academic season, while time for authorized clearance increased with
specialized care. It is likely that adherence to return-to-play progression influences
these differences in time for authorized clearance. In addition, this may be due to the nature of Urgent/Ready care available for immediate access, verses appointments likely needed for more specialized care. However, if an athlete is progressing through a return to play progression as expected, it is probable appointments for clearance are made in a timely fashion. A study by Wallace and colleagues\textsuperscript{32} found that 84% of athletic trainers report following a gradual stepwise progression during SRC management, and the most commonly used return-to-play guidelines are the National Athletic Trainers’ Association 2014 position statement and the International Conference on Concussion in Sport consensus statement.\textsuperscript{2,33} Wallace and colleagues\textsuperscript{32} also reported an interdisciplinary approach (e.g., athletic trainers and team physician, or athletic trainers and PCP) for final return-to-play decisions is utilized 28% of the time, and 22% of the time a PCP making final return-to-play decisions alone. Whereas, a recent report identified team physicians (41.3%), athletic trainers (37.1%), and PCP (14.5%) as the final decision makers, with athletic trainers collaboratively involved in a majority (93.8%) of the decisions.\textsuperscript{33} Importantly, these aforementioned studies are reports of athletic trainers practicing in a variety of states and work settings, where XHSAA requires authorized clearance to be made by an MD, DO, NP, or PA.

Our results suggest that in cases where student-athletes obtained clearance from an Urgent/Ready care facility, the gradual stepwise progression may have been accelerated, not monitored properly or not incorporated, resulting in the earlier clearance time. SRC management practices among other HCPs in these settings are discouraging as parents often seek immediate care from an emergency setting where the HCP admits to not having adequate training or resources.\textsuperscript{5} For example, in EDs,
94% of HCPs routinely provide formal written discharge recommendations; however, 35% do not use formal clinical guidelines and only 13-19% recommend a gradual or stepwise progression, respectively.\textsuperscript{6} When asked about referral practices, ED providers indicated referral to a PCP (57%) most often, followed by a neurologist (46%), sports medicine specialist (20%), neuropsychologist (7%), or a concussion clinic (6%); 25% indicated no referrals.\textsuperscript{6} Similarly, 20-21% of pediatric emergency medicine providers indicate inadequate training and time are barriers for educating families about SRC, respectively.\textsuperscript{7} Additionally, in two previous studies, PCPs reported they were uncomfortable with SRC management or had uncertainty about best SRC management practices, and lacked adequate training to prescribe a RTP protocol to return to sports.\textsuperscript{7,34} These results in the previous studies may partially explain why 87% of PCP report that they refer SRC cases to another provider; most often a concussion clinic (57%) or a child neurologist (31%).\textsuperscript{7,34} However, undoubtedly other factors should also be considered (e.g., stat practice acts). In addition, school professionals that are commonly involved in management of student-athletes with SRC (e.g., athletic trainers and school nurses) state that physicians often lacked adequate training in concussion diagnosis and treatment and are inconsistent in their practices. This creates confusion in parents and athletes due to discordance between practice and regulation.\textsuperscript{8} However, educational interventions and in-depth training in SRC management demonstrate favorable SRC management practices and changes in behavior among pediatric providers, including increased knowledge and comfort, implementation of return-to-play and -learn guidelines, and development of individualized treatment and return plans during SRC management.\textsuperscript{34-36} Importantly, athletic trainers can use the findings of this
study in clinical practice to describe anticipated return outcomes based on the medical facility an athletic receives clearance to athletes, coaches, and parents, and also refer to the potential for more conservative concussion management strategies.

Results from this study also revealed no meaningful difference in time to clearance by authorized hcp, in that student-athletes who sought care with a np received authorized clearance in a median of 9 days, compared to those who sought care with a md or do and received authorized clearance in 10 days. Note that while the test for equivalence of these times to clearance was statistically significant, that we attribute that to the large sample size in this study. Overall, our study finds that the type of medical facility appears to be more important than the authorizing hcp when it comes to time to clearance.

There are limitations to this study. First, some high schools that contributed data to the HIRS did not have licensed healthcare providers available at sponsored athletic events, therefore coaches or athletic administrators reported SRCs. Importantly, limitations of the database include inability to address who entered and reported SRC into the HIRS. Non-medical personnel may lack the training necessary to appropriately identify SRCs and refer the student-athlete to the proper resource. However, all student-athletes were required to seek care from a HCP to receive an official diagnosis of a SRC. Second, it is unknown what return-to-play protocol was utilized for each student-athlete at each facility and if an athletic trainer was involved in the RTP progression beyond the initial evaluation, which may have influenced the time to authorized clearance. Although it is also important to mention that the athletic association mandates that all authorized clearance requires an unconditional return, and therefore
this timing is inclusive of a return-to-play progression. Within the HIRS database, we were only able to determine the presence of an athletic trainer during the initial evaluation, but not other stages of SRC management process. Therefore, analyses to determine if athletic trainer presence throughout SRC recovery influences return outcomes were not appropriate. Within the HIRS database, specifics regarding the return to play progression or criteria used for return to play at each facility or by providers was not recorded for each SRC case. Future research should focus on elucidating why differences exist across medical facilities. Similarly, this study did not account for the number of patient encounters with a HCP for each case, or referral between HCP and medical facilities. The number of times a patient sees a HCP during recovery from a SRC may influence timing of return to activity and therefore should be included in the interpretation of findings and incorporated into future studies. Also, reasons why an athlete did not obtain clearance to return were not recorded for each cases, which may include but are not limited to end of the season, return occurred after the season, not given authorization to return, did not seek authorization, and/or quit sport. Lastly, although the sample size was one of the biggest strengths of the study, the sample consisted only of high school student-athletes in the state of XXX and the complexity of the cases was unknown. Therefore, these factors may have an unknown effect on the generalizability of the results, particularly in areas of the United States that lack a concussion reporting system.

CONCLUSIONS
This is the largest study, to date, examining differences in time to authorized clearance following SRC by HCPs and medical facilities in a high school student-athlete
population. Results from this study revealed that, most often, athletic trainers followed by coaches are the first point of contact after SRC, where student-athletes sought authorized clearance, and when they obtained authorized clearance to return to unrestricted activity. There were significant differences in initial examiner between boy’s and girl’s SRC cases, as a greater proportion of boys (74.1%) had an AT involved in their initial exam compared to girls (65.8%, n = 3,632). Also, for cases that obtained authorized clearance, there was a significant association between sex and medical facility where the student-athlete was cleared. Ultimately we found an association between personnel involved in initial SRC examinations and where a student-athlete obtained authorized clearance to return to unrestricted activity; with student-athletes most frequently cleared to return to full unrestricted activity by a PCP or from a team physician. Student-athletes were authorized to return to full, unrestricted activity 5-6 days sooner if they sought care at an Urgent/Ready care facility compared to more specialized medical facilities (e.g., team physician, Neurologist’s office). These findings provide meaningful data for athletic trainers to be used when directing clearance for return to full participation and describing anticipated recovery outcomes based on clearance between medical facilities. Future research should investigate why these differences in authorized clearance time exists, and why athletes seek care at different medical facilities.

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Table 1. Demographics and Injury Characteristics of Student-Athletes Reported in the Head Injury Reporting System (HIRS)

| Characteristic                        | N   | %   |
|---------------------------------------|-----|-----|
| **Sex**                               |     |     |
| Male                                  | 10,483 | 65.5 |
| Female                                | 5,518  | 34.5 |
| **Grade Level**                       |     |     |
| 6-8th<sup>a</sup>                     | 166  | 1.0 |
| Freshman                              | 4,689 | 29.3 |
| Sophomore                             | 4,477 | 28.0 |
| Junior                                | 3,488 | 21.8 |
| Senior                                | 3,381 | 19.9 |
| **Previous concussion history**       |     |     |
| Yes                                   | 2,470 | 15.4 |
| **Initial examiner**                  |     |     |
| Athletic director                     | 480  | 3.0 |
| Athletic trainer                      | 11,404 | 71.3 |
| Coach                                 | 5,673 | 35.5 |
| DO                                    | 178  | 1.1 |
| MD                                    | 749  | 4.7 |
| NP                                    | 56   | 0.4 |
| PA                                    | 80   | 0.5 |
| Sideline emergency personnel          | 279  | 1.7 |
| Other appropriate HCP                 | 460  | 2.9 |
| **Number of initial examiners**       |     |     |
| 1                                     | 12,990 | 81.2 |
| 2                                     | 2,716  | 17.0 |
| ≥3                                    | 295   | 1.8 |

<sup>a</sup> MSHAA middle schools are not included in the HIRS, however middle-school aged student-athletes participating in high school sports were included in the analyses.  
<sup>b</sup> SRC cases may have had more than one initial examiner, so frequencies do not total to 100%.  
<sup>c</sup> MD, Medical Doctor; DO, Doctor of Osteopathic Medicine; PA, Physician Assistant; NP, Nurse Practitioner; HCP, Healthcare professional.
Table 2. The Association between Initial Examiner and Medical Facility Providing Authorized Cleared (n = 12,856)\(^a\)

| Initial Examiner                  | Hospital | Neurologist’s Office | Medical Facility Cleared, n (%) | \(\chi^2\) | V   | p   |
|-----------------------------------|----------|----------------------|-------------------------------|----------|-----|-----|
| Athletic Director                 |          |                      |                               |          |     |     |
| Yes                              | 38 (10.2)| 16 (4.3)             | 283 (76.1)                    |          |     |     |
| No                               | 558 (4.6)| 1,062 (8.5)          | 8,816 (70.6)                  |          |     |     |
|                                  |          |                      | 1,319 (10.6)                  |          |     |     |
|                                  |          |                      | 719 (5.8)                     | 52.6     | .06 | \(\leq.001\) |
|                                  |          |                      |                               |          |     |     |
| Athletic Trainer                 |          |                      |                               | 172.0    | .12 | \(\leq.001\) |
| Yes                              | 386 (4.2)| 837 (9.1)            | 6,341 (68.7)                  |          |     |     |
| No                               | 220 (6.1)| 241 (6.7)            | 2,758 (76.1)                  |          |     |     |
|                                  |          |                      | 207 (5.7)                     |          |     |     |
|                                  |          |                      |                               |          |     |     |
| Coach                            |          |                      |                               | 161.5    | .11 | \(\leq.001\) |
| Yes                              | 247 (5.5)| 288 (6.4)            | 3,439 (75.9)                  |          |     |     |
| No                               | 359 (4.3)| 790 (9.5)            | 5,660 (68.0)                  |          |     |     |
|                                  |          |                      | 1,030 (12.4)                  |          |     |     |
|                                  |          |                      | 257 (5.7)                     |          |     |     |
|                                  |          |                      |                               |          |     |     |
| DO                               |          |                      |                               | 59.4     | .07 | \(\leq.001\) |
| Yes                              | 14 (9.3) | 6 (4.0)              | 85 (56.7)                     |          |     |     |
| No                               | 592 (4.6)| 1,072 (8.4)          | 9,014 (70.9)                  |          |     |     |
|                                  |          |                      | 1,290 (10.2)                  |          |     |     |
|                                  |          |                      | 738 (5.8)                     |          |     |     |
|                                  |          |                      |                               |          |     |     |
| MD                               |          |                      |                               | 6.1      | .02 | .19 |
| Yes                              | 32 (5.4) | 47 (7.9)             | 414 (69.7)                    |          |     |     |
| No                               | 574 (4.7)| 1,031 (8.4)          | 8,685 (70.8)                  |          |     |     |
|                                  |          |                      | 1,256 (10.2)                  |          |     |     |
|                                  |          |                      | 716 (5.8)                     |          |     |     |
|                                  |          |                      |                               |          |     |     |
| NP                               |          |                      |                               | 10.0     | .03 | .04 |
| Yes                              | 3 (6.8)  | 1 (2.3)              | 33 (75.0)                     |          |     |     |
| No                               | 603 (4.7)| 1,077 (8.4)          | 9,066 (70.8)                  |          |     |     |
|                                  |          |                      | 1,330 (10.4)                  |          |     |     |
|                                  |          |                      | 736 (5.8)                     |          |     |     |
|                                  |          |                      |                               |          |     |     |
| PA                               |          |                      |                               | 3.3      | .02 | .51 |
| Yes                              | 6 (9.0)  | 6 (9.0)              | 44 (65.6)                     |          |     |     |
| No                               | 600 (4.7)| 1,072 (8.4)          | 9,055 (70.8)                  |          |     |     |
|                                  |          |                      | 1,325 (10.4)                  |          |     |     |
|                                  |          |                      | 737 (5.8)                     |          |     |     |
|                                  |          |                      |                               |          |     |     |
| Sideline Emergency Personnel     |          |                      |                               | 37.9     | .05 | \(\leq.001\) |
| Yes                              | 24 (11.8)| 9 (4.4)              | 154 (75.9)                    |          |     |     |
| No                               | 582 (4.6)| 1,069 (8.5)          | 8,945 (70.7)                  |          |     |     |
|                                  |          |                      | 1,325 (10.5)                  |          |     |     |
|                                  |          |                      | 732 (5.8)                     |          |     |     |
|                                  |          |                      |                               |          |     |     |
| Other \(^b\)                     |          |                      |                               | 35.6     | .05 | \(\leq.001\) |
| Yes                              | 35 (10.7)| 33 (10.1)            | 224 (68.5)                    |          |     |     |
| No                               | 571 (4.6)| 1,045 (8.3)          | 8,875 (70.8)                  |          |     |     |
|                                  |          |                      | 1,314 (10.5)                  |          |     |     |
|                                  |          |                      | 724 (5.8)                     |          |     |     |

\(^a\) These data are inclusive on SRC cases that obtained authorization to return to unrestricted participation.

\(^b\) PCP, Primary Care Physician or Pediatrician’s Office; Other: Other Appropriate Health Care Professional
| Authorized Medical Examiner | Medical Facility Cleared, n (%) | \( \chi^2 \) | V | p |
|-----------------------------|---------------------------------|-----|-----|---|
| DO                          | 100 (4.1) | 85 (3.5) | 1,503 (62.0) | 642 (26.5) | 93 (3.8) | 1,400 | .19 | \leq .001 |
| MD                          | 417 (5.1) | 937 (11.4) | 5,893 (71.2) | 635 (7.7) | 336 (4.1) |       |       |       |
| NP                          | 42 (4.0) | 26 (2.5) | 832 (78.6) | 2 (0.2) | 157 (14.8) |       |       |       |
| PA                          | 47 (4.1) | 30 (2.6) | 871 (75.4) | 52 (4.5) | 156 (13.5) |       |       |       |

These data are inclusive on SRC cases that obtained authorization to return to unrestricted participation.

MD, Medical Doctor; DO, Doctor of Osteopathic Medicine; NP, Nurse Practitioner; PA, Physician Assistant

PCP, Primary Care Physician or Pediatrician’s Office
Table 4. The Initial Examiner for SRC Stratified by Sex (n = 16,001)\(^a\)

| Initial examiner\(^b\)                  | Boys          | Girls        |
|----------------------------------------|---------------|--------------|
|                                        | Boys (n = 10,483) | Girls (n = 5,518) |
| Athletic director                      | 317           | 163          |
| Athletic trainer                       | 7,772         | 3,632        |
| Coach                                  | 3,287         | 2,386        |
| DO                                     | 150           | 28           |
| MD                                     | 572           | 117          |
| NP                                     | 41            | 15           |
| PA                                     | 61            | 19           |
| Sideline emergency personnel           | 232           | 47           |
| Other appropriate HCP\(^c\)            | 333           | 127          |

\(^a\) These data are inclusive of all SRC cases included in the Head Injury Reporting System.

\(^b\) SRC cases may have had more than one initial examiner, so frequencies do not total to 100%.

\(^c\) HCP, Health Care Provider.
Table 4. The Association between Sex and Medical Facility Providing Authorized Clearance (n = 12,856)\(^a\)

| Sex   | Hospital | Neurologist’s Office | PCP \(^b\) | Team Physician | Urgent/Ready Care | \(\chi^2\) | V  | \(p\) |
|-------|----------|----------------------|-----------|----------------|-------------------|----------|----|------|
| Boys  | 417 (4.9)| 712 (8.4)            | 5,864 (69.3) | 957 (11.3) | 509 (6.0) | 34.4 | .05 | \leq 0.001 |
| Girls | 189 (4.3)| 366 (8.3)            | 3,235 (73.6) | 374 (8.5)  | 233 (5.3)  |        |     |      |

\(^a\) These data are inclusive of SRC cases that obtained authorization to return to unrestricted participation.

\(^b\) PCP, Primary Care Physician or Pediatrician’s Office.
Figure 1. Sport-Related Concussion (SRC) cases retained in the Head Injury Reporting System (HIRS) from the 2015-16 through 2018-19 athletic seasons. *Six cases did not provide date of injury or contained incorrect dates. HCP, Health care provider; MD, Medical Doctor; DO, Doctor of Osteopathic Medicine; PA, Physician Assistant; NP, Nurse Practitioner; PCP, Primary Care Physician or Pediatrician’s Office.
Figure 2. Time to authorized clearance by medical facility adjusted for previous concussion history and year of academic season. Median [interquartile range] Urgent/Ready Care: 7 days [4, 11], Hospital: 9 days [6, 14], Primary Care Physician’s Office (PCP): 10 days [6, 14], Team Doctor: 12 days [8, 16], Neurologist Office: 13 days [9, 20].
Figure 3. Time to authorized clearance by authorizing healthcare provider (HCP) adjusted for concussion history and year of season. Median [interquartile range] Medical Doctor (MD): 10 days [6, 14], Doctor of Osteopathic Medicine (DO): 10 days [6, 14], Physician Assistant (PA): 9 days [5, 13], Nurse Practitioner (NP): 10 days [6, 14].