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Epidemiology of Cervical Muscle Strains in Collegiate and High School Football Athletes, 2011–2012 Through 2013–2014 Academic Years

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Context: Cervical muscle strains are an often-overlooked injury, with neck- and spine-related research typically focusing on spinal cord and vertebral injuries.

Objective: To examine the rates and distributions of cervical muscle strains in collegiate and high school football athletes.

Design: Descriptive epidemiology study.

Setting: Collegiate and high school football teams.

Patients or Other Participants: The National Collegiate Athletic Association Injury Surveillance Program (NCAA-ISP) collected data from collegiate football athletes. The High School National Athletic Treatment, Injury and Outcomes Network (HS NATION) and High School Reporting Information Online (HS RIO) collected data from high school football athletes. Data from the 2011–2012 through 2013–2014 academic years were used.

Main Outcome Measure(s): Athletic trainers collected injury and exposure data for football players. Injury counts, injury rates per 10 000 athlete-exposures (AEs), and injury rate ratios with 95% confidence intervals (CIs) were calculated.

Results: The NCAA-ISP reported 49 cervical muscle strains (rate = 0.96/10 000 AEs), of which 28 (57.1%) were TL (time loss; rate = 0.55/10 000 AEs). High School NATION reported 184 cervical muscle strains (rate = 1.66/10 000 AEs), of which 33 (17.9%) were TL injuries (rate = 0.30/10 000 AEs). The HS RIO, which collects only TL injuries, reported 120 TL cervical muscle strains (rate = 0.51/10 000 AEs). The overall injury rate was lower in the NCAA-ISP than in HS NATION (injury rate ratio = 0.58; 95% CI = 0.42, 0.79); when restricted to TL injuries, the overall injury rate was higher in the NCAA-ISP (injury rate ratio = 1.83; 95% CI = 1.11, 3.03). No differences were found when comparing TL injuries in HS RIO and the NCAA-ISP. Cervical muscle-strain rates were higher during competitions than during practices across all 3 surveillance systems for all injuries. Most cervical muscle strains were due to player contact (NCAA-ISP = 85.7%, HS NATION = 78.8%, HS RIO = 85.8%).

Conclusions: The incidence of cervical muscle strains in football players was low compared with other injuries. Nonetheless, identifying and implementing interventions, particularly those aimed at reducing unsafe player contact, are essential to further decrease the risk of injury and associated adverse outcomes.

Key Words: injury rate, incidence, neck injuries

Key Points

- The incidence of cervical muscle strains in collegiate and high school football players was low compared with other football injuries.
- The rate of cervical muscle strains was higher during competitions than during practices.
- Many cervical muscle strains resulted in limited restricted participation, yet they should not be perceived as minor as they can still be associated with adverse outcomes.

Football players have one of the highest injury rates at both the collegiate and high school (HS) levels,[1–3] likely due to legal contact being allowed during gameplay. Although much of the focus on football injuries has been on concussion[4,5] and other potentially catastrophic conditions, such as cervical spine injuries,[6–8] less severe injuries such as cervical muscle strains are not often discussed.

The cervical spine provides proprioceptive information to the brain, helping to define the reference system for postural control and movement of the entire body.[9,10] Injury or fatigue of the cervical muscles can negatively affect postural control and balance in otherwise healthy people.[11] When the cervical spine is injured, patients may experience deficits in motor performance due to decreased proprioceptive information, as well as dizziness or unsteadiness often referred to as *cervicogenic dizziness*.[12,13] It is particularly important to consider such injuries in the context of concussion because postconcussion symptoms may be confused with cervicogenic pain. Each condition requires specific treatment, and the inability to differentiate between the conditions may lead to suboptimal treatment for patients.

Epidemiologic data on cervical muscle injuries among collegiate and HS football players are limited. Data from the National Collegiate Athletic Association Injury Surveillance Program (NCAA-ISP) during the 1988–1989 through 2003–2004 academic years provided injury rate estimates.[14] The authors of previous surveillance studies considered only time-loss (TL) injuries (ie, those injuries resulting in participation-restriction time $\geq$24 hours). More recent surveillance data from the NCAA-ISP and the HS National Athletic Treatment, Injury and Outcomes Network (HS NATION) have included non–TL (NTL) injuries (ie, those injuries resulting in participation-restriction time $<$24 hours). Furthermore, although cervical muscle strains may not be perceived as severe, they can negatively affect quality of life and may result in high treatment costs.[15–17] Such injuries, despite having a short participation-restriction time, may affect athletes' ability to compete in their sport at the highest level. They may also place these individuals at risk for subsequent injuries if the athletes are unable to properly protect themselves or create compensations during movement. In addition, injury to a muscle or associated pain can affect the muscle's ability to function at rest and during both static and dynamic contractions.[18]

By examining recent data that include both TL and NTL cervical muscle strains, one can better determine the breadth of cervical muscle strains among collegiate and HS football players. A better understanding of the incidence and etiology of these injuries may also help to inform both clinical practice and future research related to their prevention and management. The purpose of our study was to describe the epidemiology of cervical muscle strains during the 2011–2012 through 2013–2014 academic years using data from 3 injury-surveillance programs: the NCAA-ISP, HS NATION, and HS Reporting Information Online (HS RIO).

METHODS

Design

Data for collegiate football players originated from the NCAA-ISP[19]; data for HS football originated from HS NATION[20] and HS RIO.[1,21] The study period examined was the 2011–2012 through 2013–2014 academic years. Although data from the NCAA-ISP and HS RIO were available for previous years, HS NATION did not begin data collection until 2011. The methods of the NCAA-ISP, HS NATION, and HS RIO have been previously described.[1,19–21] The study was approved by the Institutional Review Board at the University of North Carolina.

The NCAA-ISP and HS NATION

The NCAA-ISP and HS NATION used a convenience sample of NCAA member institutions and HSs, respectively. During the 2011–2012 through 2013–2014 academic years, the NCAA-ISP annually acquired data from an average of 23 collegiate football programs. During the 2011–2012 through 2013–2014 academic years, HS NATION annually acquired data from an average of 54 HS football programs.

The NCAA-ISP and HS NATION data are managed by the Datalys Center for Sports Injury Research and Prevention, Inc (Indianapolis, IN). Both systems used the same methods, technology, and variables in data collection.[19,20] Athletic trainers (ATs) at participating programs collected injury and exposure data and reported them via their electronic medical record applications during the academic year. For each injury event (including both TL and NTL injuries), the AT completed a detailed event report on the injury and the circumstances (eg, activity, mechanism, event type [ie, competition or practice]). The ATs were able to view and update previously submitted information as needed during the season. In addition, ATs provided the number of athletes participating in each practice and competition.

Exported data passed through an automated verification process that conducted a series of range and consistency checks. Data were reviewed and flagged for invalid values. The automated verification process notified the AT and data quality-assurance staff, who assisted the AT in resolving questionable values. Data that passed the verification process were then placed into sport-specific aggregate datasets for use by researchers. Before analysis, the data were stripped of any personally identifiable information (eg, name, date of birth, insurance information), retaining only relevant variables and values. Elements of common data were deidentified, recoded, and imported into a separate database.

High School RIO

High School RIO is based on an earlier iteration of the NCAA-ISP, which provides comparability with the other 2 surveillance systems. High School RIO consists of a volunteer sample of HSs with 1 or more National Athletic Trainers' Association–affiliated ATs who have valid e-mail addresses.[12,13] Although HS RIO has a national randomized sample to acquire national estimates of injury incidence, the larger convenience sample was used for this study (annual average of 152 HS football programs during the 2011–2012 through 2013–2014 academic years).

The ATs at participating HSs reported injuries and athlete-exposure information weekly throughout the academic year using a secure Web site. High School RIO typically collects data on TL injuries only. For each injury, the AT completed a detailed injury report on the injured athlete (eg, age, height, weight), the injury (eg, site, diagnosis, severity), and the injury event (eg, activity, mechanism). Throughout each academic year, participating ATs were able to view and update previously submitted reports as needed with new information (eg, time loss).

Definitions

Athlete-exposure. An *athlete-exposure* (*AE*) was defined as 1 athlete participating in 1 school-sanctioned practice or competition.

Injury. An *injury* was defined as (1) occurring during a sanctioned collegiate or HS practice or competition during the preseason, in-season, or postseason and (2) requiring medical attention from an AT or physician. For *cervical muscle strains*, operational definitions varied. In discussions with the research team, we decided that data pulled from each surveillance program would adhere to the following: for the NCAA-ISP and HS NATION, all injuries noted with an injury code of *cervical strain* were included; for HS RIO, all injuries noted with a body part injury code

Table 1. Injury Counts and Athlete-Exposures in Collegiate Men's and High School Boys' Football for Cervical Muscle Strains, 2011–2012 Through 2013–2014 Academic Years

	All Injuries		Time-Loss Injuries Only[a]	
Surveillance System and Event Type	Count (%)	Rate/10 000 AEs (95% CI)	Count (%)	Rate/10 000 AEs (95% CI)
NCAA-ISP				
Competitions	20 (40.8)	3.95 (2.22, 5.68)	12 (42.9)	2.37 (1.03, 3.71)
Practices	29 (59.2)	0.63 (0.40, 0.86)	16 (57.1)	0.35 (0.18, 0.52)
Total	49 (100.0)	0.96 (0.69, 1.22)	28 (100.0)	0.55 (0.34, 0.75)
HS NATION				
Competitions	47 (25.5)	2.28 (1.63, 2.94)	17 (51.5)	0.83 (0.43, 1.22)
Practices	137 (74.5)	1.52 (1.26, 1.77)	16 (48.5)	0.18 (0.09, 0.26)
Total	184 (100.0)	1.66 (1.42, 1.90)	33 (100.0)	0.30 (0.20, 0.40)
HS RIO				
Competitions			51 (42.5)	1.26 (0.92, 1.61)
Practices			69 (57.5)	0.35 (0.27, 0.44)
Total			120 (100.0)	0.51 (0.42, 0.60)

Abbreviations: AE, athlete-exposure (1 athlete participating in 1 practice or competition); CI, confidence interval; HS NATION, High School National Athletic Treatment, Injury and Outcomes Network; HS RIO, High School Reporting Information Online; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.

[a] Injuries resulting in participation-restriction time of at least 24 hours; HS RIO only included TL neck-strain injuries.

of *neck* and a diagnosis code of *muscle strain* were included. Using these definitions helped to ensure that the injuries included were differentiated from conditions such as cervical sprain or mechanical neck pain.

Statistical Analysis

Data were analyzed using SPSS (version 24; IBM Corp, Armonk, NY). Because the data collected from the 3 surveillance systems are similar, they were recoded when necessary (eg, injury mechanism, injury activity) to increase the comparability between collegiate and HS football athletes. Participation-restriction time was categorized as NTL (<24 hours) and TL (≥24 hours). The TL injuries were further categorized as *minor* (1–6 days), *moderate* (7–21 days), or *severe* (>21 days and injuries resulting in a premature end to the season [eg, medical disqualification, athlete withdrawal]). The injury-mechanism categories were player contact, surface contact, equipment contact, noncontact/overuse, and unknown/missing. Player contact was further categorized as tackling, blocking, being tackled, being blocked, or other player contact. The injury mechanism was available only for TL injuries in HS NATION.

Injury counts and rates per 10 000 AEs were calculated for cervical muscle strains in collegiate and HS football players. Injury rate ratios (IRRs) were used to compare injury rates within football by event type (competitions versus practices) and by level of competition (collegiate versus HS). The following is an example of an IRR comparing competition and practice injury rates:

$$\mathrm{IRR} = \frac{\left(\frac{\sum \text{Competition injuries}}{\sum \text{Competition AEs}}\right)}{\left(\frac{\sum \text{Practice injuries}}{\sum \text{Practice AEs}}\right)}$$

Injury proportion ratios (IPRs) compared distributions of participation-restriction time and injury mechanism by level of competition. The following is an example of an IPR comparing the proportion of injuries that were NTL in the NCAA-ISP versus HS NATION:

$$\mathrm{IPR} = \frac{\left(\frac{\sum \text{NTL injuries in the NCAA-ISP}}{\sum \text{All injuries in NCAA-ISP}}\right)}{\left(\frac{\sum \text{NTL injuries in HS NATION}}{\sum \text{All injuries in HS NATION}}\right)}$$

All IRRs and IPRs with 95% confidence intervals (CIs) excluding 1.00 were deemed statistically significant.

RESULTS

Injury Counts and Rates

During the 2011–2012 through 2013–2014 academic years, the NCAA-ISP recorded a total of 49 cervical muscle strains in collegiate football players, for an overall injury rate of 0.96/10 000 AEs (95% CI = 0.69, 1.22; Table 1). Overall, 57.1% (n = 28) of these were TL injuries, for a TL injury rate of 0.55/10 000 AEs (95% CI = 0.34, 0.75). The majority (59.2%) of these injuries occurred during practices. The injury rate was higher during competitions than during practices for all injuries (IRR = 6.29; 95% CI = 3.56, 11.11) and for TL injuries only (IRR = 6.84; 95% CI = 3.23, 14.45).

The HS NATION recorded a total of 184 cervical muscle strains in HS football players, for an overall injury rate of 1.66/10 000 AEs (95% CI = 1.42, 1.90; Table 1). Overall, 17.9% (n = 33) were TL injuries, for a TL injury rate of 0.30/10 000 AEs (95% CI = 0.20, 0.40). The majority (74.5%) of these injuries occurred during practices. The injury rate was higher during competitions than during practices for all injuries (IRR = 1.50; 95% CI = 1.08, 2.09) and for TL injuries only (IRR = 4.65; 95% CI = 2.35, 9.20).

The HS RIO recorded a total of 120 TL cervical muscle strains in HS football players, for a TL injury rate of 0.51/10 000 AEs (95% CI = 0.42, 0.60; Table 1). The majority (57.5%) of these injuries occurred during practices. The TL injury rate was higher during competitions than during practices (IRR = 3.57; 95% CI = 2.49, 5.13).

Table 2. Cervical Muscle Strain Frequencies in Collegiate Men's and High School Boys' Football by Participation-Restriction Time, 2011–2012 Through 2013–2014 Academic Years

	Count (%)				
	NCAA-ISP		HS NATION		HS RIO
Participation-Restriction Time	All Injuries	TL Injuries[a]	All Injuries	TL Injuries	TL Injuries
Non–TL injuries	21 (42.9)	NA	151 (82.1)	NA	NA
Time-loss injuries	28 (57.1)	28 (100.0)	33 (17.9)	33 (100.0)	120 (100.0)
Minor (1–6 d)	19 (38.8)	19 (67.9)	19 (10.3)	19 (57.6)	80 (66.7)
Moderate (7–21 d)	5 (10.2)	5 (17.9)	9 (4.9)	9 (27.3)	27 (22.5)
Severe (>21 d)[b]	4 (8.2)	4 (14.3)	5 (2.7)	5 (15.2)	5 (4.2)
Other/unknown	0	0	0	0	8 (6.7)
Total	49 (100.0)	28 (100.0)	184 (100.0)	33 (100.0)	120 (100.0)

Abbreviations: HS NATION, High School National Athletic Treatment, Injury and Outcomes Network; HS RIO, High School Reporting Information Online; NA, not available; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program; TL, time loss.

[a] Time-loss injuries (injuries resulting in participation-restriction time of ≥24 hours); HS RIO included only TL injuries.

[b] Includes injuries that caused athletes to prematurely end their season (ie, season-ending injury).

Injury Rate Comparisons by Level of Play

The rate of cervical muscle strains in football players was lower in the NCAA-ISP than in HS NATION (0.96/10 000 AEs versus 1.66/10 000 AEs, respectively; IRR = 0.58; 95% CI = 0.42, 0.79). However, when restricted to TL injuries, the rate of cervical muscle strains in football players was higher in the NCAA-ISP than in HS NATION (0.55/10 000 AEs versus 0.30/10 000 AEs, respectively; IRR = 1.83; 95% CI = 1.11, 3.03). In addition, the TL cervical muscle-strain rate in football players did not differ between the NCAA-ISP and HS RIO (0.55/10 000 AEs versus 0.51/10 000 AEs, respectively; IRR = 1.07; 95% CI = 0.71, 1.62).

Participation-Restriction Time

Less than half of all cervical muscle strains sustained by collegiate football players were NTL (42.9%; Table 2); in contrast, more than three-quarters of cervical muscle strains were NTL in HS NATION (82.1%). Although HS RIO did not collect data on NTL injuries, the largest proportion of cervical muscle strains were minor (1–6 days of participation-restriction time; 66.7%). The proportion of injuries that were NTL was higher in HS NATION than in the NCAA-ISP (IPR = 1.91; 95% CI = 1.38, 2.66).

Injury Mechanism

Most cervical muscle strains in football were due to player contact in the NCAA-ISP (85.7%), HS NATION (78.8%), and HS RIO (85.8%; Table 3). In the NCAA-ISP, tackling and blocking were common, specific injury mechanisms among all player-contact injuries (26.5% and 28.6%, respectively, of all injuries). Tackling was also a frequent injury mechanism among TL player-contact injuries in HS NATION and HS RIO (24.2% and 29.2%, respectively, of all injuries); however, being tackled also constituted large proportions of injuries (27.3% and 25.0%, respectively, of all injuries).

DISCUSSION

The goal of our study was to advance the knowledge base surrounding cervical muscle strains to help coaches, parents, athletes, and medical providers better understand the associated risks and mechanisms and subsequently develop injury-prevention strategies for reducing the

Table 3. Cervical Muscle Strain Frequencies in Collegiate Men's and High School Boys' Football by Injury Mechanism, 2011–2012 Through 2013–2014 Academic Years

	Count (%)			
	NCAA-ISP		HS NATION	HS RIO
Injury Mechanism	All Injuries	TL Injuries[a]	TL Injuries	TL Injuries
Player contact	42 (85.7)	23 (82.1)	26 (78.8)	103 (85.8)
Tackling	13 (26.5)	8 (28.6)	8 (24.2)	35 (29.2)
Blocking	14 (28.6)	10 (35.7)	5 (15.2)	21 (17.5)
Being tackled	6 (12.2)	3 (10.7)	9 (27.3)	30 (25.0)
Being blocked	5 (10.2)	1 (3.6)	1 (3.0)	13 (10.8)
Other player contact	4 (8.2)	1 (3.6)	3 (9.1)	4 (3.3)
Surface contact	2 (4.1)	2 (7.1)	2 (6.1)	9 (7.5)
Equipment contact	1 (2.0)	1 (3.6)	1 (3.0)	2 (1.7)
Noncontact/overuse	1 (2.0)	0	1 (3.0)	6 (5.0)
Other/missing	3 (6.1)	2 (7.1)	3 (9.1)	0
Total	49 (100.0)	28 (100.0)	33 (100.0)	120 (100.0)

Abbreviations: HS NATION, High School National Athletic Treatment, Injury and Outcomes Network; HS RIO, High School Reporting Information Online; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program; TL, time loss.

[a] Time-loss injuries (injuries resulting in participation-restriction time of ≥24 hours); HS NATION had injury mechanism data for TL injuries only; HS RIO included only TL injuries.

incidence and severity of such injuries. Using data collected from the NCAA-ISP, HS NATION, and HS RIO surveillance systems, we examined the epidemiology of cervical muscle strains in collegiate and HS football players. Overall, the incidence of cervical muscle strains was low, and many injuries were either NTL or minor, resulting in <7 days of participation restriction. Despite the low incidence, our findings, coupled with previous research[15–17] examining the adverse effects of neck injuries and pain, nonetheless highlight the need to consider prevention strategies for reducing the incidence and severity of such injuries.

Because ATs provide on-site medical services, they can help to identify the incidence of these injuries, while examining strategies that may be most effective to manage them and return athletes to full participation in the least but safest amount of time. Unfortunately, certain factors may make identifying the incidence of cervical muscle strains difficult. First, when examining the range of cervical and shoulder injuries sustained by athletes, cervical muscle strains are often considered one of the more insignificant due to the relatively low participation-restriction time. This may lead to underreporting of these injuries, especially when they occur concurrently with more severe injuries such as fractures, dislocations, and neurapraxia. Second, head trauma may result in injuries to both the head and cervical regions. Head trauma can often be associated with low-grade sprain-strain injuries of the cervical spine, making diagnosis and symptom management difficult.[22] After head injury, patients may experience *posttraumatic headache*—a headache that occurs within 1 week after head trauma.[23] Continued symptoms can be related to cervical muscle tension and postural impairment.[23] Last, many musculoskeletal cervical conditions may present with similar symptoms. The differential diagnosis can include cervical strain or sprain, mechanical neck pain, nonspecific neck pain, and whiplash, among others. This may make diagnosis of the patient's particular condition difficult. Future researchers should examine how cervical muscle strains occur in isolation versus in combination with other cervical or shoulder injuries and how they may be associated with head trauma and other cervical injuries.

It is also important to note that our metric of severity (ie, participation-restriction time) was based on when the athlete returned to participation and not when his or her pain resolved. Returning to sport despite pain may vary by the level of competition. This may be reflected in the higher percentage of severe injuries in HS RIO compared with TL injuries in the NCAA-ISP, meaning that HS athletes were less likely to play through pain. Concerns related to playing through pain are not exclusive to cervical muscle strains. Previous investigators[24,25] noted athletes' beliefs that pain or injury should not get in the way of the game, that athletes should push their bodies and accept injury risks, and, that if needed, they should play while injured to further the success of the team. Therefore, it is important to increase our understanding of the effect that cervical muscle strains have on athletes' ability and willingness to participate in sport. Moreover, we must consider the effects of return to play while an athlete is still experiencing pain. For example, athletes who return to play despite experiencing pain may still be affected by their injury, which may limit their ability to compete in their sport at the highest level. This inability to fulfill the demands of their sport may also put these athletes at increased risk for future injury by rendering them unable to properly protect themselves or by developing compensations during movement. Although premature return to play due to other injuries (such as concussion) has been a focus, future researchers should examine potential risks related to cervical muscle strains.

Previous authors[15–18] found that neck injuries and associated pain were linked with a lower quality of life and psychosocial wellbeing, higher costs for treatment, and changes in the muscles' ability to function at rest and during static and dynamic contractions. Muscle-strain injuries can be associated with varying degrees of pain, swelling, and hematoma and impair strength and range of motion (perhaps including a complete loss of muscle function).[26] However, due to the rarity of cervical muscle strains, programs specifically focused on preventing these injuries may be limited. Programs focused on the treatment of other cervical conditions may be applicable to patients with cervical muscle strains. For example, Highland et al[27] examined an 8-week rehabilitation protocol for a variety of cervical injuries; after completion of the protocol, patients reported increased cervical flexion and extension strength, as well as significantly decreased pain. Saal et al[28] followed patients with herniated cervical discs for 1 year as they completed an assigned rehabilitation program; all but 2 of the patients were able to resolve their symptoms and avoid surgery. By strengthening the musculature surrounding and supporting the cervical spine, such as the shoulder and trunk, some of the stress may be taken off the cervical muscles and the risk of injury may decrease. In addition, many individuals suffer from a forward-head and rounded-shoulder posture that can increase stress throughout the spine and shoulder. For 23 adults with this posture, Harman et al[29] implemented a 10-week rehabilitation program focused on shoulder and cervical range of motion and strengthening. At the end of the program, preintervention and postintervention measurements showed differences in range of motion and posture. Instituting similar interventions may help to decrease the stress placed on the cervical spine during contact, with the goal of decreasing injury risk among these athletes. Athletic trainers can advocate for the use of such interventions within their sports programs.

The rate of cervical muscle strains was lower in collegiate than in HS football players when all injuries in NCAA-ISP versus HS NATION and TL injuries in NCAA-ISP versus HS RIO were compared. Researchers studying injury rates between collegiate and HS athletes have found mixed results. Football data from the NCAA-ISP and HS RIO during the 2005–2006 academic year showed a higher all-injury rate in collegiate than in HS players.[30] However, only TL injuries were included. More recent authors[31] found that the rate of NTL injuries was higher in HS than in collegiate athletes. This greater proportion of NTL injuries at the HS level may explain our findings. Yet the findings were similar when we examined TL injuries only in comparison with HS RIO data. Given that collegiate football athletes typically have more years of experience, HS football players may be less skilled and less physically fit for the demands of their sport (eg, protecting themselves when tackling or being tackled). Collegiate athletes may have also been exposed to intense strength and conditioning programs focused specifically on their sport and supervised

by highly trained staff. This increased focus on strengthening can increase muscle preparation during tackling, as well as protection of the cervical structures during a tackle due to increased muscle activation and strength. Although we were unable to determine the mechanisms for these differences, the results nonetheless highlight the need to ensure that proper gameplay techniques are taught to all athletes. Continued communication among ATs and strength and conditioning staff within and across levels of competition may help personnel identify and integrate strategies that can reduce the injury risk. Focusing on athletes at the HS level, which is a larger population, also aids those athletes who will move to the collegiate level.

As seen in previous findings on a larger range of injuries,[14,32–34] cervical muscle-strain rates were higher during competitions than during practices in both collegiate and HS football players. Competitions are often faster paced than practices and may pose an increased likelihood of injury for participants. During practices, athletes are competing against their teammates, which may lead to self-restraint during drills requiring player contact, thereby lessening the risk of injury.[35] It is also important to acknowledge that across a season, the number of sessions and therefore exposures is greater for practices than competitions. Thus, the injury count from practices may be higher than from competitions, but the overall injury rate may be lower. Ensuring proper medical coverage for both practices and competitions is important so that athletes can receive proper care when an injury is sustained.

Most cervical muscle-strain injuries were due to player contact. This concurs with previous investigations[3,14,33] of the epidemiology of injuries in general and in football. Because player contact continues to be the leading cause of injury in football and numerous other sports, it may be important to take a closer look at these sports and their rules to determine whether changes can be made to further protect participants. Stakeholders (eg, coaches, athletes, officials, sport administrators) must be involved in developing recommendations to ensure that they are appropriate for the sport level, thereby improving the likelihood of "buy in" and subsequent compliance.

Limitations

Data from all 3 surveillance systems were obtained from convenience samples, which may hinder generalizability of the results to the entire at-risk population of collegiate and HS football athletes. Data were also not available for out-of-season injuries. However, these data provide the largest dataset on cervical muscle strains among collegiate and HS football players.

Our study's comparisons may also be limited because HS RIO collects data on TL injuries only and HS NATION did not have injury-mechanism data for NTL injuries. Nevertheless, these data provide a starting point on which future researchers can build. These surveillance systems offer ongoing data collection, allowing for continued understanding of injuries. This ongoing collection allows researchers to monitor the effects of any prevention or management strategies that may be implemented. Because of possible variations in the documentation of exposures and injuries at the collegiate and high school levels, data comparability may be affected. Still, relying on ATs, who are specifically trained to properly detect, diagnose, and manage injuries, helps to ensure data validity.

Finally, given the variations in surveillance systems, we had different operational definitions for *cervical muscle strains* in the NCAA-ISP and HS NATION data versus HS RIO data. Although we believe these definitions nevertheless differentiated such injuries from other injuries, our findings must be interpreted cautiously. Furthermore, cervical muscle strains may have been misclassified due to their potential association with shoulder injuries, head trauma, or general neck pain. Previous authors[36] noted the variations in reporting of other injury types, highlighting the need for continued progress to better understand the source of injury and the appropriate treatment.

CONCLUSIONS

The incidence of cervical muscle strains among collegiate and HS football players was low compared with other football injuries. Despite low injury counts, cervical muscle strains can nonetheless affect the performance of athletes[15–17] at both levels. Although many of the cervical muscle strains resulted in little participation-restriction time and may thus be perceived as minor, sports stakeholders, including ATs, the coaching staff, and organizers, should nonetheless advocate injury-prevention strategies to prevent such injuries and their associated adverse outcomes. Prevention should also include focusing on proper technique, appropriate strength and conditioning programs, and rule changes to minimize illegal contact.

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REFERENCES

1. Centers for Disease Control and Prevention (CDC). Sports-related injuries among high school athletes—United States, 2005–06 school year. *MMWR Morb Mortal Wkly Rep*. 2006;55(38):1037–1040.
2. Kerr ZY, Marshall SW, Dompier TP, Corlette J, Klossner DA, Gilchrist J. College sports-related injuries—United States, 2009–10

through 2013–14 academic years. *MMWR Morb Mortal Wkly Rep*. 2015;64(48):1330–1336.
3. Hootman JM, Dick R, Agel J. Epidemiology of collegiate injuries for 15 sports: summary and recommendations for injury prevention initiatives. *J Athl Train*. 2007;42(2):311–319.
4. Kerr ZY, Thomas LC, Simon JE, McCrea M, Guskiewicz KM. Association between history of multiple concussions and health outcomes among former college football players: 15-year follow-up from the NCAA Concussion Study (1999–2001). *Am J Sports Med*. 2018;46(7):1733–1741.
5. Clark MD, Asken BM, Marshall SW, Guskiewicz KM. Descriptive characteristics of concussions in National Football League games, 2010–2011 to 2013–2014. *Am J Sports Med*. 2017;45(4):929–936.
6. Puvanesarajah V, Qureshi R, Cancienne JM, Hassanzadeh H. Traumatic sports-related cervical spine injuries. *Clin Spine Surg*. 2017;30(2):50–56.
7. Schroeder GD, Vaccaro AR. Cervical spine injuries in the athlete. *Instr Course Lect*. 2017;66:391–402.
8. Chan CW, Eng JJ, Tator CH, Krsasioukov A; Spinal Cord Injury Research Evidence Team. Epidemiology of sport-related spinal cord injuries: a systematic review. *J Spinal Cord Med*. 2016;39(3):255–264.
9. Taylor JL, McCloskey DI. Proprioception in the neck. *Exp Brain Res*. 1988;70(2):351–360.
10. Bove M, Brichetto G, Abbruzzese G, Marchese R, Schieppati M. Neck proprioception and spatial orientation in cervical dystonia. *Brain*. 2004;127(pt 12):2764–2778.
11. Gosselin G, Rassoulian H, Brown I. Effects of neck extensor muscles fatigue on balance. *Clin Biomech (Bristol, Avon)*. 2004;19(5):473–479.
12. Gandevia S, Burke D. Afferent feedback, central programming and motor commands. *Behav Brain Sci*. 1992;15(4):815–819.
13. Brandt T, Bronstein AM. Cervical vertigo. *J Neurol Neurosurg Psychiatry*. 2001;71(1):8–12.
14. Dick R, Ferrara MS, Agel J, et al. Descriptive epidemiology of collegiate men's football injuries: National Collegiate Athletic Association Injury Surveillance System, 1988–1989 through 2003–2004. *J Athl Train*. 2007;42(2):221–233.
15. Côté P, Cassidy JD, Carroll L. The factors associated with neck pain and its related disability in the Saskatchewan population. *Spine (Phila Pa)*. 2000;25(9):1109–1117.
16. Borghouts JA, Koes BW, Vondeling H, Bouter LM. Cost-of-illness of neck pain in the Netherlands in 1996. *Pain*. 1999;80(3):629–636.
17. Demyttenaere K, Bruffaerts R, Lee S, et al. Mental disorders among persons with chronic back or neck pain: results from the World Mental Health Surveys. *Pain*. 2007;129(3):332–342.
18. Arendt-Nielsen L, Graven-Nielsen T. Muscle pain: sensory implications and interaction with motor control. *Clin J Pain*. 2008;24(4):291–298.
19. Kerr ZY, Dompier TP, Snook EM, et al. National Collegiate Athletic Association Injury Surveillance System: review of methods for 2004–2005 through 2013–2014 data collection. *J Athl Train*. 2014;49(4):552–560.
20. Dompier TP, Marshall SW, Kerr ZY, Hayden R. The National Athletic Treatment, Injury and Outcomes Network (NATION): methods of the surveillance program, 2011–2012 through 2013–2014. *J Athl Train*. 2015;50(8):862–869.
21. Gessel LM, Fields SK, Collins CL, Dick RW, Comstock RD. Concussions among United States high school and collegiate athletes. *J Athl Train*. 2007;42(4):495–503.
22. Marshall CM, Vernon H, Leddy JJ, Baldwin BA. The role of the cervical spine in post-concussion syndrome. *Phys Sportsmed*. 2015;43(3):274–284.
23. Weightman MM, Bolgla R, McCulloch KL, Peterson MD. Physical therapy recommendations for service members with mild traumatic brain injury. *J Head Trauma Rehabil*. 2010;25(3):206–218.
24. Connaughton D, Wadey R, Hanton S, Jones G. The development and maintenance of mental toughness: perceptions of elite performers. *J Sports Sci*. 2008;26(1):83–95.
25. Nixon H. Accepting the risks of pain and injury in sport: Mediated cultural influences on playing hurt. *Sociol Sport J*. 1993;10(2):183–196.
26. Järvinen TAH, Kääriäinen M, Järvinen M, Kalimo H. Muscle strain injuries. *Curr Opin Rheumatol*. 2000;12(2):155–161.
27. Highland TR, Dreisinger TE, Vie LL, Russell GS. Changes in isometric strength and range of motion of the isolated cervical spine after eight weeks of clinical rehabilitation. *Spine (Phila Pa 1976)*. 1992;17(suppl 6):S77–S82.
28. Saal JS, Saal JA, Yurth EF. Nonoperative management of herniated cervical intervertebral disc with radiculopathy. *Spine (Phila Pa 1976)*. 1996;21(16):1877–1883.
29. Harman K, Hubley-Kozey CL, Butler H. Effectiveness of an exercise program to improve forward head posture in normal adults: a randomized, controlled 10-week trial. *J Man Manip Ther*. 2005;13(3):163–176.
30. Shankar PR, Fields SK, Collins CL, Dick RW, Comstock RD. Epidemiology of high school and collegiate football injuries in the United States, 2005–2006. *Am J Sports Med*. 2007;35(8):1295–1303.
31. Kerr ZY, Lynall RC, Roos KG, Dalton SL, Djoko A, Dompier TP. Descriptive epidemiology of non–time-loss injuries in collegiate and high school student-athletes. *J Athl Train*. 2017;52(5):446–456.
32. Rechel JA, Yard EE, Comstock RD. An epidemiologic comparison of high school sports injuries sustained in practice and competition. *J Athl Train*. 2008;43(2):197–204.
33. Kerr ZY, Simon JE, Grooms DR, Roos KG, Cohen RP, Dompier TP. Epidemiology of football injuries in the National Collegiate Athletic Association, 2004–2005 to 2008–2009. *Orthop J Sports Med*. 2016;4(9):2325967116664500.
34. McGuine T. Sports injuries in high school athletes: a review of injury-risk and injury-prevention research. *Clin J Sport Med*. 2006;16(6):488–499.
35. Agel J, Olson DE, Dick R, et al. Descriptive epidemiology of collegiate women's basketball injuries: National Collegiate Athletic Association Injury Surveillance System, 1988–1989 through 2003–2004. *J Athl Train*. 2007;42(2):202–210.
36. Roos KG, Marshall SW, Kerr ZY, Dompier TP. Perception of athletic trainers regarding the clinical burden of, and reporting practices for, overuse injuries. *Athl Train Sports Health Care*. 2016;8(3):122–126.

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