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Postinjury Outcomes After Non–Sport-Related Concussion: A CARE Consortium Study

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Context: Concussion research has primarily focused on sport-related mechanisms and excluded non–sport-related mechanisms. In adult populations, non–sport-related concussions (non-SRCs) demonstrated worse clinical outcomes compared with sport-related concussions (SRCs); however, investigations of non-SRCs in college-aged patients are limited.

Objectives: To examine clinical outcomes in collegiate athletes with non-SRCs compared with SRCs and explore sex differences in outcomes among collegiate athletes with non-SRCs.

Design: Prospective cohort study.

Setting: Clinical setting.

Patients or Other Participants: A total of 3500 athletes were included (n = 555 with non-SRCs, 42.5% female) from colleges or universities and service academies participating in the National Collegiate Athletic Association Department of Defense Concussion Assessment, Research and Education (CARE) Consortium.

Main Outcome Measure(s): Dichotomous outcomes (*yes* or *no*) consisted of immediate reporting, mental status alterations, loss of consciousness, posttraumatic amnesia, retrograde amnesia, motor impairments, delayed symptom presentation, and required hospital transport. Continuous outcomes were symptom severity, days with concussion symptoms, and days lost to injury. Data were collected within 24 to 48 hours of injury and at return to play. Adjusted relative risks (ARRs) compared the likelihood of dichotomous outcomes by mechanism and by sex within patients with non-SRCs. Multivariate negative binomial regressions were used to assess group differences in continuous variables.

Results: Athletes with non-SRCs were less likely to report immediately (ARR = 0.73, 95% CI = 0.65, 0.81) and more likely to report delayed symptom presentation (ARR = 1.17, 95% CI = 1.03, 1.32), loss of consciousness (ARR = 3.15, 95% CI = 2.32, 4.28), retrograde amnesia (ARR = 1.77, 95% CI = 1.22, 2.57), and motor impairment (ARR = 1.45, 95% CI = 1.14, 1.84). Athletes with non-SRCs described greater symptom severity, more symptomatic days, and more days lost to injury ($P < .001$) compared with those who had SRCs. Within the non-SRC group, female athletes indicated greater symptom severity, more symptomatic days, and more days lost to injury ($P < .03$) than male athletes.

Conclusions: Athletes with non-SRCs had worse postinjury outcomes compared with those who had SRCs, and female athletes with non-SRCs had worse recovery metrics than male athletes. Our findings suggest that further investigation of individuals

with non-SRCs is needed to improve concussion reporting and management.

Key Words: mild traumatic brain injuries, symptoms, injury reporting

Key Points

- Athletes with non–sport-related concussions reported later and with worse clinical signs, had a higher symptom burden, and lost more days to injury compared with athletes who had sport-related concussions.
- Among athletes with non–sport-related concussions, females described a greater symptom burden and more days lost to injury compared with males.
- Our findings suggest that athletic trainers should closely monitor athletes who incurred non-sport mechanisms to improve injury management and prognosis.

Traumatic brain injury (TBI) accounts for an estimated 16% of US hospitalizations each year,[1] and more than 200 000 US patients with nonfatal TBIs were hospitalized in 2018.[2] Although most TBIs are classified as mild (often referred to as *concussions*),[3] their consequences may lead to significant negative effects on an individual's function and quality of life.[4] Non–sport-related mechanisms, such as motor vehicle crashes, falls, and both intentional and unintentional impacts to the head, represent the majority of patients with concussions presenting to US emergency departments (EDs).[5] Despite the high incidence and prevalence of non–sport-related concussions (non-SRCs), research in which authors examined critical clinical questions regarding athletes with non-SRCs remains limited.

Delineating the nature of non-SRCs is important to quality medical care. This is particularly important for young adults, as non-SRCs may represent an often unrecognized cause of subtle neurologic deficits that may substantially affect everyday function and quality of life. Non–sport-related mechanisms of concussion occurred at a higher incidence compared with sport-related concussions (SRCs) in college-aged patients (81/10 000 versus 52/10 000, respectively),[6] and approximately 20% of concussions in collegiate athletes resulted from non–sport-related mechanisms,[7] yet few authors have described the clinical outcomes from these injuries. In the general adult population, those with non-SRCs reported a greater initial symptom burden and symptom duration than those with SRCs.[8] Additionally, fewer discharge instructions were given to patients with non-SRCs than to those with SRCs,[5] suggesting discrepancies in adult concussion management. Investigators have primarily analyzed patients presenting to EDs and specialty care settings, who may reflect a sampling bias of more severe injuries or prolonged recoveries. Whether similar mechanism-based discrepancies in clinical outcomes exist in college-aged patients is currently unclear because much of collegiate concussion research has focused on sport-related mechanisms. Moreover, though non-SRCs are reported more frequently by women than men,[5] most investigations into sex differences after concussion have concentrated on sport-related injuries. By definition, non-SRCs occur outside of organized sport, and collegiate athletes who sustain injuries away from the sports environment may experience differences in the care of non-SRCs versus SRCs, including the lack of immediate access to health care providers, such as athletic trainers (ATs), which may impede injury reporting.[9] Additionally, the various potential mechanisms of non-SRCs introduce greater variability in injury biomechanics as well as potential subsequent clinical, psychological, and physiological sequelae.

Therefore, the primary purpose of our study was to examine concussion reporting characteristics and clinical outcomes in collegiate athletes who sustained non-SRCs compared with athletes who sustained SRCs. Our secondary purpose was to specifically assess sex differences in concussion reporting characteristics and clinical outcomes in collegiate athletes with non-SRCs.

METHODS

Study Design and Setting

This study was a secondary analysis of data obtained from the National Collegiate Athletic Association Department of Defense (NCAA-DOD) Concussion Assessment, Research and Education (CARE) Consortium, which includes varsity athletes from 26 civilian universities and 4 US service academies. A comprehensive description of the CARE Consortium methods has been previously published.[10] Participants were included in the analysis if they were NCAA athletes and were diagnosed with a concussion per current consensus guidelines during the 2014–2015 through 2019–2020 academic years.[11] They were grouped by mechanism of injury (eg, sport related versus non-sport related) based on the postinjury question, "Injury occurred during…" Injuries that occurred during competition, training, or practice were grouped as *sport related*, and injuries that occurred outside of sport were grouped as *non-sport related*. Specific injury scenarios were collected for SRCs (eg, collision with teammate; contact with ball, stick, or puck; tackling; blocking) and non-SRCs (eg, fall, slip, or trip; motor vehicle crash; being struck by an object). Only the first concussion sustained by a participant was analyzed. Demographic information and medical history were obtained during athletes' preseason preinjury assessments using a standard case report form across all sites. Each person self-reported age, sex, race, ethnicity, sport, and health history, including concussion, headaches or migraines, psychiatric disorders, attention-deficit/hyperactivity disorder (ADHD), and learning disabilities. Sport was categorized by the research team as contact, limited contact, or noncontact.[12] To address the second aim, only data from non-SRCs were included. The Children's Hospital of Philadelphia institutional review board and the local institutional review board at each performance site reviewed and approved all study procedures. Individuals provided written informed consent before participation.

Injury Characteristics and Outcomes

Injury characteristics and outcomes were obtained from all patients with diagnosed SRCs and non-SRCs and included information on who made the initial diagnosis (eg, team

physician, AT, primary care physician) and if the injury was reported immediately (yes or no). Acute outcomes were delayed symptom onset, altered mental status, loss of consciousness (LOC), posttraumatic amnesia, retrograde amnesia (RGA), motor impairment, and if hospital transport was required (all yes or no). Concussion symptoms were self-reported at the first visit within 48 hours of injury using the Graded Symptom Checklist (GSC) from the Sport Concussion Assessment Tool-Third Edition (SCAT-3). The GSC is a 22-item scale that prompts participants to self-report symptom severity using a Likert scale from 0 to 6, with higher scores indicating worse symptom severity (total range = 0–132). Recovery outcomes were collected at the time of unrestricted return to play and consisted of the provider type issuing final clearance (eg, team physician, AT, primary care physician), the number of days of reported concussion symptoms, the number of days lost to injury, and whether the athlete experienced a *slow recovery*, defined as $\geq$14 days to being asymptomatic or $\geq$24 days to unrestricted return to play.[13]

Statistical Analysis

Our primary analysis assessed group differences in postinjury outcomes between participants with SRCs and those with non-SRCs. Independent *t* tests were performed to determine group differences in continuous demographic variables (age, height, and weight), and χ^2 tests were performed for categorical variables (sex, race, ethnicity, sport type, and concussion history). Effect sizes for continuous variables (age, height, and weight) were characterized using the Cohen *d*, and effect sizes for categorial variables were characterized using the φ coefficient for 2-level variables (sex and concussion history [yes or no]) and the Cramer V for variables with 2+ levels (race, ethnicity, and sport type). Adjusted relative risks (ARRs) with 95% CIs were used to evaluate differences in categorical postinjury outcomes between those with SRCs versus non-SRCs. We calculated the ARR via log-binomial regression analysis to control for relevant factors. Separate analyses were conducted to determine the effect of possible confounding variables, including sex, age, height, weight, race, ethnicity, NCAA sport type, and concussion history. Based on this analysis, we included sex and concussion history in the final models as covariates. Due to overdispersion of our count response variables, multivariate negative binomial regressions, controlling for sex and concussion history, were computed to assess associations between injury mechanism and acute GSC symptom severity (SRC mean = 27.2, variance = 452.3; non-SRC mean = 34.1, variance = 545.44), the number of days participants reported concussion symptoms (SRC mean = 8.2, variance = 74.9; non-SRC mean = 12.5, variance = 146.4), and the number of days lost to injury (days from injury to unrestricted return to play; SRC mean = 16.4, variance = 337.2; non-SRC mean = 23.0, variance = 406.5). Dispersion parameters were reviewed to evaluate the fit for each model.

For our secondary analysis, we investigated sex differences in injury outcomes within the non-SRC group only. Independent *t* tests were performed to identify group differences in continuous demographic variables (age, height, and weight), and χ^2 tests were performed for categorical variables (sex; race; ethnicity; sport type' history of concussion, psychiatric disorder, ADHD, and learning disability). The ARR (controlling for concussion history) with 95% CI was used to compare differences in categorical postinjury outcomes between male and female athletes with non-SRCs. Due to overdispersion of our count response variable, multivariate negative binomial regressions, controlling for concussion history, were used to characterize associations between male and female athletes with non-SRCs and acute GSC symptom severity (male mean = 29.7, variance = 481.5; female mean = 36.9, variance = 567.8), the number of days participants reported concussion symptoms (male mean = 9.9, variance = 91.4; female mean = 13.8, variance = 167.5), and the number of days lost to injury (days from injury to unrestricted return to play; male mean = 20.2, variance = 256.0; female mean = 24.3, variance = 487.6). We reviewed dispersion parameters to assess the fit for each model. For all analyses, α was set to .05 a priori. Data were analyzed using SAS (version 9.4; SAS Institute Inc).

RESULTS

A total of 5460 concussions from the CARE Consortium were examined for inclusion. After exclusion of nonathlete military academy cadets (n = 1283) and recurrent concussions (n = 677), 3500 athletes with concussions were included in the primary analysis (n = 555 non-SRC; 42.5% female; age = 20.1 ± 1.3 years). Participant demographics are summarized in Table 1. A greater proportion of female athletes sustained non-SRCs (23.3%) compared with male athletes (10.3%). Among the total sample, non-SRCs were evenly distributed among contact- (33.2%), limited-contact– (34.6%), and noncontact- (32.3%) sport athletes, whereas most SRCs were sustained by contact-sport athletes (76.3%). Most athletes reported no concussion history (56.8% and 67.0% for SRCs and non-SRCs, respectively). The most common injury scenario for non-SRCs was a fall, slip, or trip (28.3%), followed by being struck by an object (25.8%), motor vehicle crash (19.8%), and unintentional contact with a person (8.6%). The most frequent injury scenario for SRCs was collision with a teammate or opponent (51.9%), followed by contact with a ball, stick, or puck (20.0%); tackling or being tackled (15.5%); blocking (6.4%); heading with or without physical contact (5.0%); and checking or being checked (1.3%).

Non–sport-related concussions were less likely to be reported immediately (ARR = 0.73, 95% CI = 0.65, 0.81), and those with non-SRCs were more likely to have delayed symptom onset (ARR = 1.17, 95% CI = 1.03, 1.32), LOC (ARR = 3.15, 95% CI = 2.32, 4.28), RGA (ARR = 1.77, 95% CI = 1.22, 2.57), and motor impairment (ARR = 1.45, 95% CI = 1.14, 1.84; Figure 1 and Supplemental Table 1, available at https://dx.doi.org/10.4085/1062-6050-0181.23.S1). In the non-SRC-cohort, male athletes were more likely to present with altered mental status (ARR = 1.19, 95% CI = 1.001, 1.41) and RGA (ARR = 1.87, 95% CI = 1.01, 3.45) than female athletes (Figure 2 and Supplemental Table 2). Compared to SRCs, non-SRCs were more likely to require hospital transport (ARR = 4.02, 95% CI = 3.12, 5.18; Figure 1).

Participants with non-SRCs reported greater symptom severity within 48 hours of injury (median = 28 versus 22; $P < .001$), had a longer duration of symptoms (median = 9 days versus 6; $P < .001$), and lost more days to injury (median = 17 versus 12; $P < .001$; Table 2) than those with SRCs. Patients with non-SRCs were also more likely to experience slow recovery (ARR = 1.50, 95% CI = 1.31,

Table 1. Demographic Information for Each Concussion Included in Analysis by Injury Mechanism

Variable	Concussions			*P* Value	Effect Size
	Total	Sport Related	Non-sport Related		
Sample size	3500	2945 (84.1)	555 (15.9)	NA	NA
		Mean ± SD			
Age, y	20.1 ± 1.3	20.2 ± 1.3	20.0 ± 1.3	.004	0.14
Height, cm	70.2 ± 4.5	70.5 ± 4.5	68.7 ± 4.1	<.001	0.41
Weight, kg	178.4 ± 46.3	182.0 ± 47.3	159.3 ± 34.6	<.001	0.55
		No. (%)			
Sex				<.001	0.18
Female	1488 (42.5)	1141 (76.7)	347 (23.3)		
Male	2012 (57.5)	1804 (89.7)	208 (10.3)		
Race				<.001	0.12
Asian	62 (1.8)	42 (1.4)	20 (3.6)		
Black	649 (18.5)	593 (20.1)	56 (10.1)		
Hawaiian Pacific Islander	32 (0.9)	26 (0.9)	6 (1.1)		
Indian Alaskan	10 (0.3)	8 (0.3)	2 (0.4)		
Multiple	293 (8.4)	236 (8.0)	57 (10.3)		
Unknown or skipped question	114 (3.3)	88 (3.0)	26 (4.7)		
Ethnicity				<.001	0.08
Hispanic	253 (7.2)	192 (6.5)	61 (11.0)		
Non-Hispanic	2764 (79.0)	2322 (78.8)	422 (79.6)		
Unknown or skipped question	483 (13.8)	431 (14.6)	52 (9.4)		
National Collegiate Athletic Association sport type				<.001	0.36
Contact sport	2430 (69.4)	2246 (92.4)	184 (7.6)		
Limited-contact sport	668 (19.1)	476 (71.3)	192 (28.7)		
Noncontact sport	402 (11.5)	223 (55.4)	179 (44.5)		
Concussion history				<.001	0.08
Yes	1368 (39.1)	1198 (87.6)	170 (12.4)		
No	2045 (58.4)	1673 (81.8)	372 (18.2)		
Missing or skipped question	87 (2.5)	74 (85.1)	13 (14.9)		

Abbreviation: NA, not available.

1.71; Figure 1). Within the non-SRC group, female athletes described greater symptom severity (median = 31 versus 24; $P = .003$), had a longer duration of symptoms (median = 10 versus 8; $P < .001$), and lost more days to injury (median = 18 versus 15; $P = .03$) compared with male athletes (Table 3). Additionally, among athletes with non-SRCs, male athletes were less likely to have a slow recovery (ARR = 0.61, 95% CI = 0.47, 0.79; Figure 2).

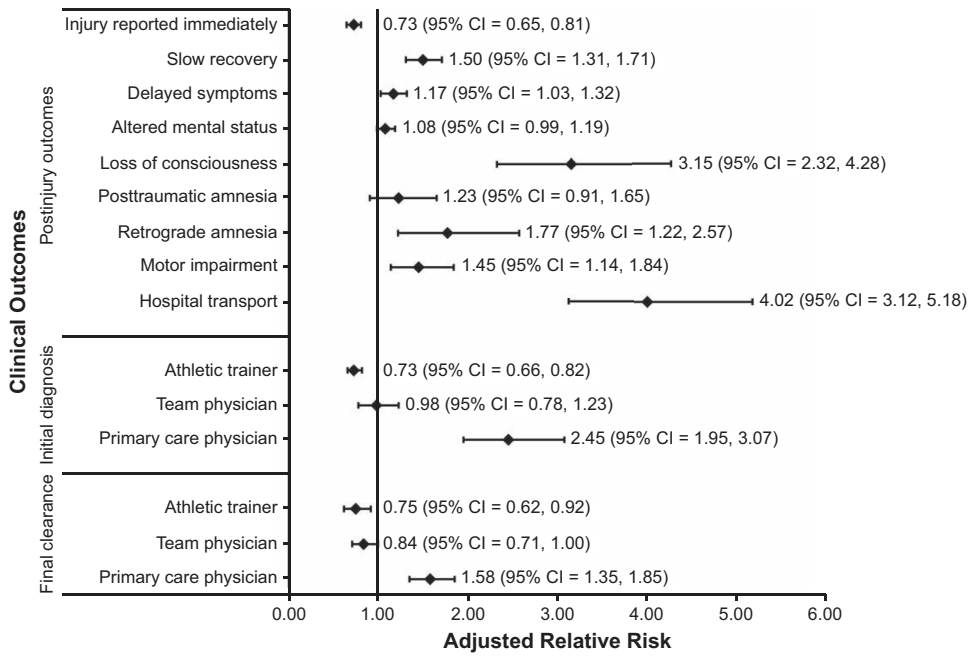

Figure 1. Adjusted relative risks (ARRs) and 95% CIs between non–sport-related concussions (n = 555) and sport-related concussions (n = 2945) for clinical outcomes after concussion, who gave the initial diagnosis, and who provided final clearance, controlling for sex and concussion history. The ARRs and 95% CIs not in contact with the vertical line at null value (1.00) were considered statistically significant.

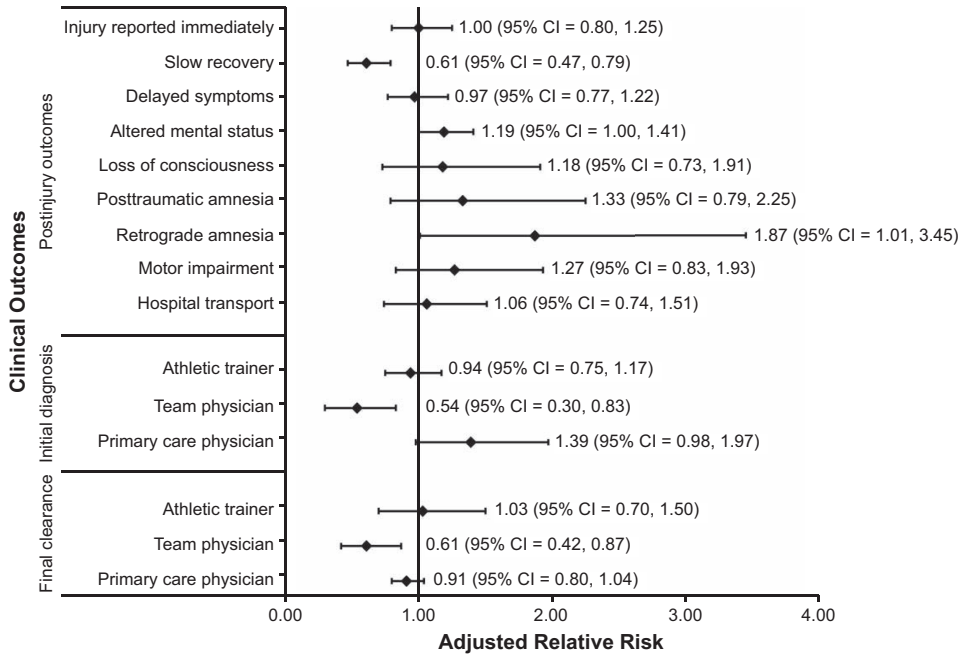

Figure 2. For the non–sport-related concussion cohort only, adjusted relative risks (ARRs) and 95% CIs between male (n = 208) and female (n = 347) athletes for clinical outcomes after concussion, who gave the initial diagnosis, and who provided final clearance, controlling for concussion history. The ARRs and 95% CIs not in contact with the vertical line at null value (1.00) were considered statistically significant.

Non–sport-related concussions were more likely to be diagnosed (ARR = 2.45, 95% CI = 1.95, 3.07) and cleared (ARR = 1.58, 95% CI = 1.35, 1.85) by primary care physicians and less likely to be diagnosed (ARR = 0.73, 95% CI = 0.66, 0.82) and cleared (ARR = 0.75, 95% CI = 0.62, 0.92) by ATs than SRCs (Figure 1). In the non-SRC cohort, male athletes were less likely to be diagnosed (ARR = 0.54, 95% CI = 0.30, 0.83) and cleared by team physicians (ARR = 0.61, 95% CI = 0.42, 0.87; Figure 2).

DISCUSSION

The primary purpose of our study was to investigate concussion reporting characteristics and postinjury clinical outcomes in collegiate athletes who sustained non-SRCs compared with those who sustained SRCs and, secondarily, to compare reporting characteristics and acute clinical outcomes between male and female collegiate athletes with non-SRCs. The non-SRCs were more likely to be reported later, present with worse acute clinical outcomes (presence of LOC, RGA, motor impairment, and higher symptom burden), and have a slower recovery compared with SRCs. Among those with non-SRCs, female athletes indicated a greater acute symptom burden, more days with concussion symptoms, and more days lost to injury. Additionally, non-SRCs were more likely to be diagnosed and cleared by primary care physicians and less likely to be diagnosed and cleared by ATs. Within the non-SRC group, male athletes were less likely to be diagnosed and cleared by team physicians.

When assessing injury reporting characteristics, participants with non-SRCs were less likely to report their concussions immediately than participants with SRCs. This may have been due to the logistical limitations of an athlete sustaining a concussion outside the context of sport and, therefore, away from onsite or sideline health care providers (eg, ATs, team physicians). Athletes may seek initial care outside the university or academy-affiliated providers (eg, personal primary care physicians, ED) for concussions occurring outside athletics, outside the competitive season, or outside the academic year. Other factors may include different interpretations of "immediate" reporting among clinicians completing the postinjury report, embarrassment about or hesitation in reporting due to "mild" mechanisms (eg, falling out of bed, bumping one's head on a cabinet), or athletes being less apt to report a non-SRC to athletics-affiliated providers if they believe the mechanism might result in

Table 2. Median (Interquartile Range) for the Graded Symptom Checklist Reported at the First Visit Within 48 Hours of Injury, Days With Concussion-Related Symptoms, and Days Lost to Injury for Full Sample by Mechanism

Variable	Sport-Related Concussion (n = 2945)	Non–Sport-Related Concussion (n = 555)	*P* Value[a]
Symptom severity[b]	22 (10, 40)	28 (15, 49)	<.001
Days symptomatic	6 (3, 10)	9 (6, 15)	<.001
Days lost to injury	12 (8, 18)	17 (12, 27)	<.001

[a] Adjusted for sex and concussion history.
[b] Symptom severity measured by the Graded Symptom Checklist.

Table 3. Median (Interquartile Range) for the Graded Symptom Checklist Reported at the First Visit Within 48 Hours of Injury, Days With Concussion-Related Symptoms, and Days Lost to Injury for Non–Sport-Related Concussions by Sex

Variable	Males (n = 208)	Females (n = 347)	*P* Value[a]
Symptom severity[b]	24 (12–42)	31 (18–53)	.003
Days symptomatic	8 (5–12)	10 (6–17)	<.001
Days lost to injury	15 (10.5–23)	18 (13–28)	.03

[a] Adjusted for sex and concussion history.
[b] Symptom severity measured by the Graded Symptom Checklist.

team or legal disciplinary action (eg, fighting, substance related). This aligns with previous results that children with non-SRCs took longer to seek care and were less typically diagnosed than children with SRCs.[14–17] In the pediatric ED, patients aged 5 to 18 years with non-SRCs were less likely to receive a concussion diagnosis[14,15] and to be immediately diagnosed.[16] Among adults, patients who sustained a concussion via motor vehicle crashes or other non–sport-related mechanisms were 8 and 5 times more likely, respectively, to not be diagnosed with a concussion in the ED compared with those who incurred sport-related mechanisms.[17] In a specialty concussion clinical setting, adolescent and young adult patients involved in motor vehicle crashes took an average of 21 days to report to the clinic compared with 14 to 16 days for those with sport-related mechanisms.[18] Our findings in collegiate athletes add to these data and indicate that delayed reporting or presentation for initial care of non-SRCs occurs across health care settings and providers. This may be true even in acute care settings such as EDs or urgent care clinics. The delay may, in part, also be due to the lack of recognition of concussion symptoms after a non-sport injury; efforts educating about and raising awareness of concussions from mechanisms outside sports may represent an important intervention that could reduce the time to concussion diagnosis and improve outcomes.

We found that athletes with non-SRCs were more likely to report with delayed symptom presentation, LOC, RGA, and motor impairment and that non-SRCs were associated with a greater initial symptom burden, more days with concussion symptoms, more days lost to injury, and a greater risk of slow recovery. Similarly, in the general adult population, previous research showed that non-SRCs were associated with greater symptom endorsement and severity,[8] sleep disturbance,[19] and persistent postconcussion symptoms[20] compared with SRCs. Poor clinical outcomes after non-SRCs may reflect several factors, including delayed reporting or variable injury mechanisms. As mentioned earlier, we identified that participants with non-SRCs less often reported their injuries immediately, in part, perhaps, because they were unrecognized. Mild non-SRC injury mechanisms (eg, falling out of bed, bumping one's head on a car door) that occur without medical supervision may not be recognized as possible injuries and, after delayed reporting, may result in a greater symptom burden at the clinical visit. In a recent meta-analysis of 12 studies (10 included SRCs only, 2 included all injury mechanisms), the authors established that delayed reporting was associated with greater initial symptom severity scores and a longer recovery relative to concussions reported immediately.[21] In pediatric patients seen in the ED, a delayed concussion diagnosis has been associated with more medical visits, a longer time to symptom recovery, and a higher likelihood of persistent symptoms.[16] Among collegiate athletes,[22] delayed reporting and delayed removal from play have been associated with more time missed due to injury and more days with concussion symptoms, though the researchers excluded those with non-SRCs.[22] Though prolonged recovery (concussion symptoms for >28 days)[23] is commonly used as a prognostic indicator, only 3% ($n = 106$) of the study sample experienced prolonged recovery, and therefore, slow recovery was determined to provide a more granular description of athlete recovery in this study. We suggest that delayed reporting may similarly influence postinjury clinical outcomes for patients who sustain concussions with non–sport-related mechanisms.

Within our non-SRC cohort, male athletes were more likely to present with altered mental status and RGA compared with female athletes and female athletes reported greater initial symptoms and had a longer duration of symptoms, more days lost to injury, and a greater risk of slow recovery. Prior studies that assessed sex differences in clinical outcomes after SRCs described mixed results, with some indicating that female athletes described greater symptom burden[24–26] and a longer recovery trajectory[24,26,27] than male athletes, whereas others demonstrated no sex-based differences in symptoms or recovery.[7,25] Specifically in collegiate athletes with SRCs, Master et al[7] observed that female athletes had higher symptom severity scores, which aligns with our results. Elevated self-reported symptoms in female athletes after SRCs is well known[7,24] and may indicate either biologically based or gender-based behavioral differences in symptom reporting. Similar to previous literature in which authors examined sex differences after SRCs in sex-comparable collegiate sports,[7] we found no sex differences in LOC after injury. Though we noted that female athletes with non-SRC had worse recovery outcomes (more days with concussion symptoms, more time lost due to injury, and a higher risk of slow recovery), previous research of collegiate SRCs only identified sex differences in recovery metrics between female and male contact-sport athletes.[7]

Approximately 1 in 5 non-SRCs required hospital transport compared with 1 in 20 SRCs. This may be due to several factors, including a lack of access to onsite or sideline medical care, differences in acute clinical presentation, or comorbid injuries. In athletic-related situations at the collegiate level (practice, training, or competition), initial injury assessment is usually provided by ATs or team physicians, and hospital transport is only required when a higher level of care is deemed necessary.[28] Athletes who sustain a concussion outside of sport often do not receive the initial assessment by an onsite health care provider and may be more likely to require emergency services. Additionally, the variable mechanisms of non-SRCs may indicate more severe injuries, leading to increased hospital transports. Although patients who had non-SRCs were more likely to require hospital transport compared with patients who had SRCs, they represented only 20% of the overall non-SRC population, suggesting that hospital transport was still infrequent for those with a non-SRC. Also, 19 (3.4%) non-SRCs were diagnosed by ED clinicians. This small proportion of ED diagnoses may indicate missed diagnoses of non-SRCs in EDs[17] or data-collection errors when reporting diagnosis information. Continued research regarding the diagnosis and management of non-SRCs as well as education or training (or both) is needed in emergency and urgent care settings.

When assessing health care provider diagnosis and clearance, we found that non-SRCs were more likely to be diagnosed and cleared by primary care physicians and less likely to be diagnosed and cleared by ATs. As non-SRCs, by definition, occur outside of sport, it is unsurprising that they are more often seen by health care providers outside of athletics-affiliated providers. Baugh et al[29] recently showed that greater trust in relevant stakeholders (ie, sports medicine clinicians, coaches, administrators) was associated with higher odds of intending to report a concussion in collegiate football athletes. If athletes with non-SRCs have a low level of trust in the sports medicine system, have poor rapport with clinicians, or are unwilling to disclose an injury that resulted from illegal or inappropriate activity (eg, assault, substance use), they may be less likely to report an

injury occurring outside of sport to athletics-affiliated clinicians. Further, male athletes were less likely to be diagnosed and cleared by team physicians compared with female athletes. Weber et al[30] have demonstrated sex differences in concussion reporting among collegiate athletes: female athletes had greater indirect intentions to report (ie, "I would stop playing and report symptoms. . ."). Our results build on this, suggesting that sex differences in whom the athletes are reporting to after a non-SRC may exist. Future researchers should continue investigating care-seeking behaviors after non-SRCs to better guide injury management across providers.

This study was not without limitations. As a secondary analysis of a larger dataset, our sample was limited to collegiate athletes, and therefore, our findings regarding non-SRCs may not be generalizable to a nonathlete population. Reporting of acute clinical signs (LOC, RGA, posttraumatic amnesia, motor impairment, and altered mental status) by athletes with concussions occurring without immediate or sideline access to care (non-SRCs and SRCs that may have been reported late) relied on athlete self-report and may have been subject to recall bias. Immediate injury reporting was not operationally defined before the study period, and thus, the meaning of *immediate* was left to the discretion of the clinician completing the postinjury report. Similarly, the selection of *team physician* as the diagnosing or clearing provider may have been viewed as describing different clinical specialties (eg, orthopaedics, sports medicine, primary care, neurology) depending on the interpretation of the clinician completing the report. Additionally, we did not collect information regarding whether the athlete was at home on break when the non-SRC occurred or when clearance took place, which may have influenced access to health care or concussion management (or both). Lastly, other social (eg, concussion reporting and management) and biological (eg, injury threshold or severity) factors may be associated with or interact with our primary outcomes but could not be distinguished with the current study design.

In summary, athletes who sustained non-SRCs reported later, had higher symptom severity scores at initial presentation, experienced slower recoveries, and more often reported to nonathletic medical team health care providers compared with athletes who sustained SRCs. Continued investigation of non-SRC management outside of athletic environments is critical, and medical teams need to improve clinical outcomes. Within the non-SRC group, female athletes reported higher symptom severity scores and had a greater risk of slow recovery compared with male athletes. This was likely due to a combination of intrinsic factors (ie, biological, reporting behaviors) and extrinsic factors (ie, access to medical teams) but warrants further evaluation into sex differences in non-SRC management.

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SUPPLEMENTAL MATERIAL

Supplemental Table 1. Adjusted Relative Risk (ARR) and 95% CI Shown in Figure 1 for All Postinjury Outcomes Between Sport-Related and Non–sport-Related Concussions

Supplemental Table 2. Adjusted Relative Risk (ARR) and 95% CI Shown in Figure 2 for All Postinjury Outcomes in Non–sport-Related Concussions Between Male and Female Athletes

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