Brain Injury

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ibij20

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To cite this article: Samuel R. Walton, Patricia M. Kelshaw, Thayne A. Munce, Erica Beidler, Thomas G. Bowman, Jessie R. Oldham, Kristin Wilmoth, Donna K. Broshek, Daniel J. Rosenblum, David X. Cifu & Jacob E. Resch (06 Feb 2024): Access to athletic trainers and sex as modifiers of time to reach clinical milestones after sport-related concussion in collegiate athletes, Brain Injury, DOI: 10.1080/02699052.2024.2310787

To link to this article: https://doi.org/10.1080/02699052.2024.2310787

Published online: 06 Feb 2024.

BRAIN INJURY
https://doi.org/10.1080/02699052.2024.2310787

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Access to athletic trainers and sex as modifiers of time to reach clinical milestones after sport-related concussion in collegiate athletes

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ABSTRACT

Objective: Investigate whether an athlete's biological sex and exposure to a dedicated athletic trainer (AT) were related to clinical milestones after a sports-related concussion (SRC).

Design: Retrospective chart review.

Methods: Medical charts of collegiate athletes ($n = 196$ [70.9% female]) diagnosed with SRC were reviewed to extract: biological sex, dedicated AT exposure for their sport (yes/no), and time (days) to reaching clinical milestones (diagnosis, symptom resolution, unrestricted return to sport [RTS]). Mann–Whitney U tests were used to determine whether time to clinical milestones differed by sex, AT exposure, or their interaction. Proportions of same-day diagnoses and times to diagnosis, symptom resolution, and unrestricted RTS were evaluated with chi-squared and spearman's rank correlations, respectively.

Results: There were no significant differences in times to reaching any clinical milestone by sex, AT exposure, or their interaction (ps > 0.05). Forty-three percent of participants were diagnosed on the day of their SRC. This did not differ by sex or AT exposure (ps > 0.29). Longer times to SRC diagnosis were associated with more days to symptom resolution ($\rho = 0.236$, $p = 0.001$) and unrestricted RTS ($\rho = 0.223$, $p < 0.001$).

Conclusions: Athlete sex and AT exposure were not associated with times to reach any clinical milestone; however, delayed diagnosis was associated with longer times to reach clinical recovery.

ARTICLE HISTORY
Received 2 March 2023
Revised 4 October 2023
Accepted 23 January 2024

KEYWORDS
Sex differences; gender differences; social determinants of health; healthcare disparities; health iniquities; mild traumatic brain injury (mTBI)

Introduction

Recovery from sport-related concussion (SRC) is highly variable and individualized. Several factors have been reported to modify recovery time such as higher initial symptom burden (1,2), race (3), genetics (4), prior concussion history (5), psychiatric history (6), delayed removal from play (7), and the presence of specific symptoms (8). Perhaps one of the most often discussed modifiers of recovery following a SRC is biological sex (9,10). Female athletes have been reported to take longer than males to reach symptom resolution following a diagnosed SRC (11), and this phenomenon may be associated with neck strength differences (12), hormonal considerations (13,14), and/or a higher symptom burden (15,16) during the acute phase of injury. Understanding sex (i.e., biologically male vs. female) as a modifier of SRC recovery among collegiate athletes is further complicated by notable differences between sexes regarding concussion reporting behaviors (17). Additionally, concussion knowledge, concussion history, external pressure to play, and sports type are associated with SRC non-disclosure even while accounting for sex differences (17). Despite these findings, mixed results have been reported when considering the influence of sex on SRC recovery. Specifically, only 38.6% (17/44) of articles included in a recent systemic review supported the finding that high school and collegiate female athletes take longer than male athletes to report symptom resolution following an SRC (9). A later study with a large sample of collegiate athletes reported that females take only 1 day (median) longer to return to sport (RTS) participation than males (18); thus, the evidence for sex differences remains inconclusive, and requires further investigation alongside consideration of additional factors that may influence the recognition of and recovery from SRC.

Early recognition of SRC-related signs and symptoms, and immediate removal from play have emerged as important contributors to better clinical outcomes after SRC (7,19–21). It is well understood that an athlete should be immediately removed from training or competition when a SRC is suspected (22,23). When removal from play is delayed, potentially due to nondisclosure of symptoms (17,24), collegiate athletes report higher initial symptom burdens and take longer to return to sport after SRC when compared to injured athletes that are removed immediately (6,7,19,20). Specifically,

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collegiate athletes with a delayed removal from play after SRC miss five more days of sport participation, on average, compared to those who are immediately removed (7,19). Further, other patient outcomes, such as the total number and total severity of symptoms are higher when compared to those promptly removed from play (7,19,20). These consistent findings highlight the importance of early recognition and management of SRC.

Although female and male collegiate athletes have shown similar RTS timelines after SRC (18), the relationship between access to healthcare resources, such as a certified athletic trainer (AT), and recovery length following SRC has been brought into question (25,26). ATs are health care professionals that specialize in the prevention, management, and rehabilitation of injuries in physically active individuals, and they are typically present before, during, and after sport training sessions and competitions. ATs undergo formal training in the recognition and management of SRC (22). Greater access to an AT, sometimes measured as an ideal ratio of ATs to athletes, may result in a more immediate recognition and removal from sport following an injury, inclusive of SRC (25,27–30). Moreover, varying levels of collegiate competition may have unequal access to ATs (31). As stated previously, early recognition and removal from participation after SRC is linked to reduced recovery times (7,20), yet athletes with regular access to an AT may be treated more effectively based on clinical guidelines and evidence-based care, including the use of progressive RTS protocols, and may take longer to RTS when compared to athletes with limited AT exposure (25). Taken together, access to an AT has been demonstrated to have important implications for the diagnosis of and recovery from SRC. However, there is still much to be understood about these relationships in collegiate sport settings, especially as they relate to other factors that reportedly influence SRC management and recovery.

The intersection between biological sex and access to an AT as modifiers of recovery from SRC has yet to be studied explicitly. Therefore, the overarching purposes of this multi-site study were to investigate whether athlete sex and exposure to a dedicated AT were independently related to clinical milestones after SRC (i.e., diagnosis, symptom resolution, unrestricted RTS), and to determine whether there were interactions between sex and AT exposure that might explain the differences in time to reach these clinical milestones observed in previous studies. Our *a priori* hypotheses were that: 1) no sex differences would be observed for each specific clinical milestone of interest; 2) collegiate athletes without access to a dedicated AT would take longer to reach each clinical milestone than those with a dedicated AT; and 3) when examining the interaction between sex and exposure to a dedicated AT, there would be no differences in time to reach any clinical milestone. As an exploratory aim, we also wanted to evaluate whether delayed diagnosis of SRC beyond the day of injury was associated with sex, AT exposure, and time to reach the other clinical milestones. Findings from this study may have implications for the variability in outcome after SRC in collegiate athletes due to inequities in access to healthcare resources (e.g., access to an AT) for the recognition and management of SRC.

Materials and methods

The Long-Term Impact of Military-Relevant Brain Injury Consortium (LIMBIC) Military and Tactical Athlete Research Study (MATARS) is a multi-site study dedicated to understanding total brain health, including the effect of concussions in collegiate and tactical athletes. The data in the current investigation were obtained via retrospective chart review between the 2015–16 and 2019–20 academic years at 11 National Collegiate Athletics Association (NCAA) LIMBIC MATARS member sites, as has been described elsewhere (32. Each member site had an NCAA approved concussion management protocol during the study period; however, these protocols were not uniform across institutions. Prior to data review and extraction, all member sites completed a confidentiality disclosure and data use agreements, and member sites gained institutional review board approval in alignment with the host-site under the direction of the co-principal investigators (JR and DC). Data were collected with a consensus-based list of common data elements related to premorbid and concussion-specific factors. The common data elements were retrieved from sport-specific and general medical records (32.

Participants

Concussion cases included in this study were drawn from collegiate athletes participating in varsity athletics programs during the five-year study period. Concussions were diagnosed by an AT or physician in alignment with the most current international consensus guidelines at the time of diagnosis (23,33). Exclusion criteria for this study were missing or incorrectly entered data as determined during the medical chart review for sex, dedicated AT status, date of injury, date of symptom resolution, and date of unrestricted RTS. Additionally, cases were excluded if the individual's primary sport did not have a comparable opposite sex sport (e.g., football, wrestling) or if no opposite sex cases were reported for that sport.

Study variables

Demographic information was reported within each medical chart, including biological sex, ethnoracial identity, age, height, and body mass. Self-reported lifetime concussion history and the premorbid diagnosis of depression and/or anxiety were also recorded. The presence of a dedicated AT was defined as 'an athletic trainer who was present at all practices and competitions' and responses were dichotomous (yes/no). Time to reaching three separate clinical milestones were calculated for the purpose this study: 1) the number of days from each SRC to the day of diagnosis, 2) the number of days from SRC until symptom resolution, and 3) the number of days from SRC until the athlete was cleared for unrestricted RTS.

Statistical analyses

Due to violations of the homogeneity of variance assumptions necessary for linear modeling (Levene's test p-values <0.05),

Mann-Whitney U tests were performed to test each of the study hypotheses. First, separate tests were performed to compare time to diagnosis, symptom resolution, and achieving unrestricted RTS between sexes. Next, separate tests were performed to compare times to each clinical milestone by dedicated AT exposure status (yes vs. no). To test whether there was an interaction between dedicated AT exposure status and sex, we tested the effect of dedicated AT exposure status within each sex separately. Nonparametric effect sizes were calculated using Z scores from each of the Mann-Whitney U tests (r = z/sqrt(n)) (34), and interpreted as small ($r = 0.10$), medium; ($r = 0.30$) or large ($r = 0.50$) (35).

The proportion of athletes who received their diagnosis on the day of their injury (days to diagnosis = 0) was compared between sexes and AT exposure groups, as was the proportion of athletes receiving their diagnoses within 1 day of their injury (days to diagnosis = 0 or 1) via Chi-squared tests with accompanying Cramer's V effect sizes, interpreted as small ($V = 0.06$–0.16), medium; ($V = 0.17$–0.28) or large ($V > 0.28$) (36). Finally, to explore whether delayed diagnosis was associated with clinical recovery times, we first calculated non-parametric Spearman's rank-order correlation coefficients and then performed Mann-Whitney U tests comparing those diagnosed on the same day as their SRC to those diagnosed one or more days later. All statistical analyses were performed with SPSS version 28.0.1 (Armonk, NY) with *a priori* alpha set to 0.05.

Results

Participants

Medical charts were reviewed and data were extracted for 1,311 concussion cases across participating NCAA institutions (32. After excluding for missing data and cases that did not meet our inclusion criteria (e.g., date of injury outside the inclusion time window), 421 (42.3% female) cases were eligible for inclusion in this study (Figure 1). A substantial portion of participants in this sample primarily participated in sports that were not comparable between sexes, or sports were not available for both sexes at the participating institutions ($n = 175$ football; $n = 23$ volleyball; $n = 11$ wrestling; $n = 8$ rowing; $n = 7$ field hockey; $n = 1$ equestrian; *total* $n = 225$), and this portion of the sample was predominantly male ($n = 186$ males; $n = 39$ females). To more closely investigate the effects of sex in this study, we selected only those participants that participated in comparable sports (*total* $n = 196$ [70.9% female]). Sport participation was as follows: basketball (men's $n = 19$; women's $n = 26$); baseball/softball (baseball $n = 8$; softball $n = 12$); cheer/dance (men's $n = 3$; women's $n = 16$); cross country/track & field (men's $n = 5$; women's $n = 15$); swimming & diving (men's $n = 1$; women's $n = 2$); gymnastics (men's $n = 0$; women's $n = 1$); lacrosse (men's $n = 6$; women's $n = 18$); soccer (men's $n = 11$; women's $n = 32$); squash (men's $n = 1$; women's $n = 9$); and tennis (men's $n = 3$; women's $n = 8$). There were similar proportions of female athletes ($n = 99$; 71.2%) and male athletes ($n = 44$; 77.2%) with access to a dedicated AT among these sex-comparable sports. Sample characteristics for the 196 included cases are described in Table 1.

A comparison of post-concussion clinical milestones by biological sex

There were no significant differences between sexes in the number of days from injury to diagnosis ($p = 0.53$), to symptom resolution ($p = 0.06$), or to unrestricted return to sport ($p = 0.18$; Table 2; Figure 2). The proportion of female athletes receiving their SRC diagnosis on the same day of injury was 57/139 (41.0%) and was not significantly different ($X^2 = 1.084$;

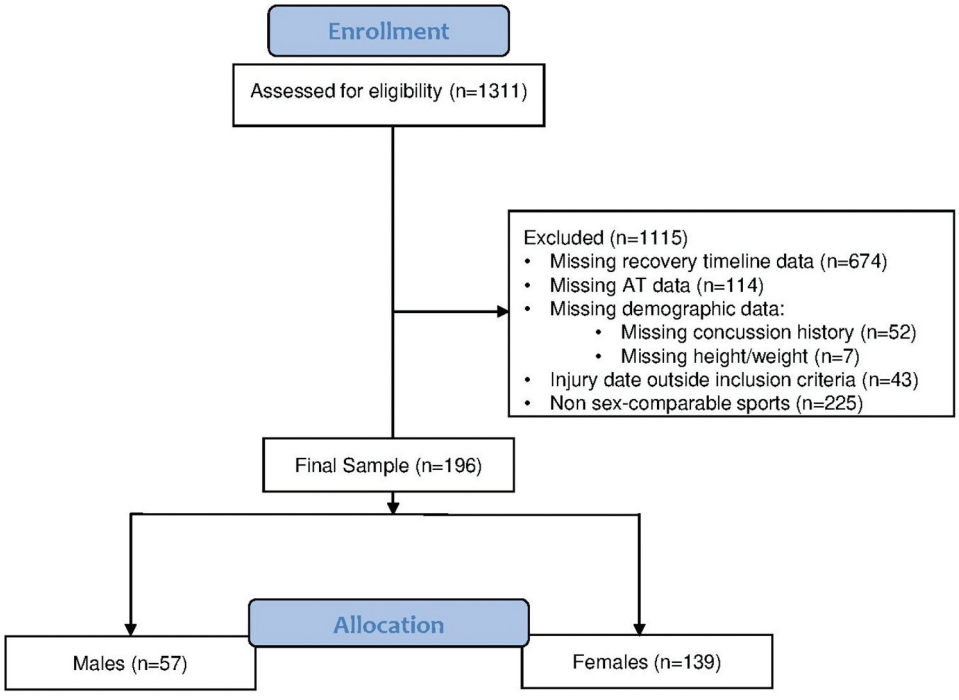

Figure 1. CONSORT diagram.

Table 1. Participant information.

	Full sample $n = 196$	Females $n = 139$	Males $n = 57$	Dedicated AT $n = 143$	No dedicated AT $n = 53$
Age (years), mean (SD)	19.6 (1.3)	19.5 (1.3)	20.0 (1.3)	19.5 (1.3)	19.8 (1.3)
Height (meters), mean (SD)	1.74 (0.12)	1.69 (0.09)	1.86 (0.10)	1.75 (0.13)	1.71 (0.09)
Weight (kilograms), mean (SD)	70.4 (12.4)	66.1 (11.4)	80.7 (8.1)	71.6 (12.9)	67.0 (10.5)
Race & ethnicity, *n* (%)					
American Indian or Alaska Native	1 (0.5)	0 (0)	1 (1.8)	1 (0.7	0 (0)
Asian	1 (0.5)	1 (0.7)	0 (0)	0 (0)	1 (1.9)
Black or African American	23 (11.7)	16 (11.5)	7 (12.3)	20 (14.0)	3 (5.7)
Hispanic or Latino	3 (1.5)	1 (0.7)	2 (1.5)	1 (0.7)	2 (3.8)
Native Hawaiian or other Pacific Islander	1 (0.5)	1 (0.7)	0 (0.0)	1 (0.7)	0 (0)
White	107 (54.6)	82 (59.0)	25 (43.9)	61 (42.7)	46 (86.8)
Unspecified or not reported	60 (30.6)	38 (27.3)	22 (38.6)	59 (41.3)	1 (1.9)
Biological sex: females, *n* (%)	139 (70.9)	N/A	N/A	99 (69.2)	44 (30.8)
Dedicated AT, *n* (%)	143 (73.0)	99 (71.2)	44 (77.2)	N/A	N/A
History of 1 or more concussions, *n* (%)	72 (36.7)	54 (38.8)	18 (31.6)	47 (32.9)	25 (47.2)
History of depression diagnosis[a], *n* (%)	21 (10.7)	16 (11.5)	5 (8.8)	16 (11.2)	5 (9.4)
History of anxiety diagnosis[a], *n* (%)	21 (10.7)	16 (11.5)	5 (8.8)	16 (11.2)	5 (9.4)
Days to diagnosis					
Median	1	1	1	1	1
Interquartile range	0, 3	0, 3	0, 2.5	0, 3	0, 2
Minimum-to-maximum values	0–27	0–16	0–27	0–27	0–14
Days to symptom resolution					
Median	7	8	6	7	7
Interquartile range	4, 14	5, 15	3, 11.5	4, 14	4, 14
Minimum-to-maximum values	0–234	0–234	0–43	0–234	0–114
Days to unrestricted return to sport					
Median	14	14	11	13	15
Interquartile range	9, 21	10, 21	8, 21	9, 21	10, 23.5
Minimum-to-maximum values	4–253	4–253	5–103	4–253	6–114

[a]Self-reported history of depression diagnosis and anxiety diagnosis were both missing for $n = 19$ (9.7%) of the full sample.

Table 2. Time to reach clinical milestones after sport-related concussion by sex and exposure to an athletic trainer. Values are median (interquartile range).

	Females	Males
Days to diagnosis		
Dedicated AT		
Yes	1 (0–3)	1 (0–3)
No	1 (0–2)	0 (0–2)
Days to symptom resolution		
Dedicated AT		
Yes	8 (4–15)	6 (3–10)
No	7 (5–14)	10 (2.5–15.5)
Days to unrestricted return to sport		
Dedicated AT		
Yes	14 (10–21)	11 (8–20.75)
No	14.5 (10–23)	16 (8–27)

$p = 0.30$; $V = 0.07$) than the proportion of male athletes receiving a same-day diagnosis (28/57 49.1%). Similarly, 84/139 (60.4%) female athletes received their SRC diagnosis within 1 day after injury and 36/57 (63.2%) of male athletes received their diagnosis within 1 day, which was also not a statistically significant difference between sexes ($X^2 = 0.127$; $p = 0.72$; $V = 0.03$).

Clinical milestones among athletes with and without a dedicated athletic trainer

Access to a dedicated AT was not associated with the number of days from injury to diagnosis ($p = 0.68$), to symptom resolution ($p = 0.94$), or to unrestricted RTS ($p = 0.41$; Table 2; Figure 2).

Overall, 61/143 (42.6%) athletes who had access to a dedicated AT received their SRC diagnosis on the same day as their injury, and 24/53 (45.3%) of those without a dedicated AT received their diagnosis on the same day. There was no statistically significant difference in the proportion receiving same-day diagnosis by AT exposure ($X^2 = 0.109$; $p = 0.74$; $V = 0.02$). Additionally, 86/143 (60.1%) athletes with access to a dedicated AT received their SRC diagnosis within 1 day of their injury, and 34/53 (64.2%) of those without a dedicated AT received their diagnosis within 1 day. Again, there was no statistically significant difference between AT exposure groups ($X^2 = 0.262$; $p = 0.61$; $V = 0.04$).

Comparison of sex by AT exposure interactions for each clinical milestone

Among female athletes, there were no significant effects of exposure to a dedicated AT for the number of days from injury to diagnosis ($p = 0.77$), to symptom resolution ($p = 0.80$), or to unrestricted return to sport ($p = 0.59$). Similarly, there were no significant effects of exposure to a dedicated AT among male

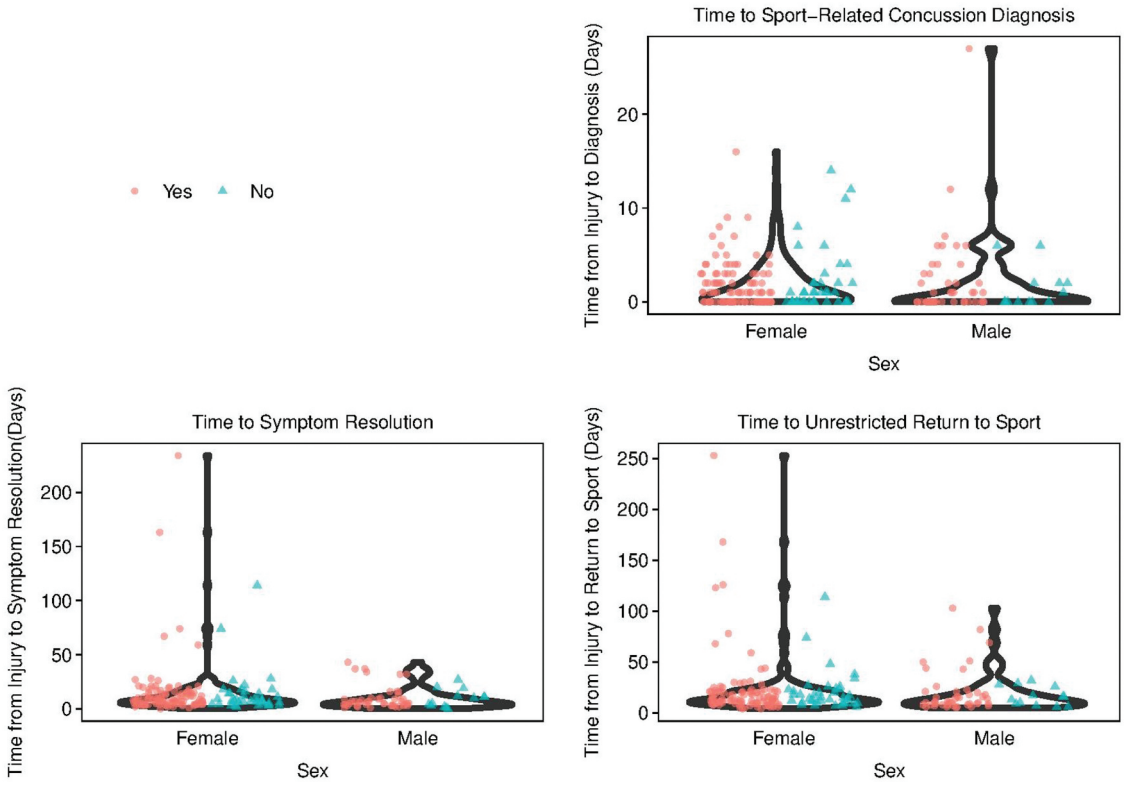

Figure 2. Days from injury to each clinical milestone after sport-related concussion. Individual data points are presented by sex and access to a dedicated athletic trainer. The violin plots represent the frequency distribution of values within each sex (female and male).

athletes for the number of days from injury to diagnosis ($p = 0.68$), to symptom resolution ($p = 0.86$), or to unrestricted return to sport ($p = 0.70$).

Exploratory analyses: associations between time to diagnosis and recovery milestones

Among the full sample, the number of days to diagnosis was significantly correlated with time to reporting symptom resolution ($\rho = 0.236$, $p = 0.001$) and time to unrestricted RTS ($\rho = 0.223$, $p < 0.001$). Athletes who were diagnosed on the same day of SRC had shorter times to reporting symptom resolution ($U = 3{,}568.5$, $p = 0.003$, $r = 0.21$; median[IQR] = 7 [3.5,11.5] vs. 9[5,16]) and times to unrestricted RTS ($U = 3{,}566.5$, $p = 0.003$, $r = 0.21$; 12[8,19] vs. 16[10,23]) compared to those diagnosed one or more days after their injury.

Discussion

Our study investigated the influence of biological sex on time to reaching clinical milestones after SRC, and in doing so, we also considered access to a ATs as a potential point of inequity between sexes. We hypothesized that access to a dedicated AT would influence the time to reach clinical milestones independent of sex, and may explain why previous research has reported post-injury sex differences for the same SRC recovery timepoints. Our hypothesis that sex would not be related to the number of days to achieve the clinical milestones of diagnosis, symptom resolution, and unrestricted RTS after SRC was supported by our results; however, our hypotheses related to the number of days to reach each milestone would be related to dedicated AT access were not supported. Regardless, there are potentially meaningful clinical inferences that can be drawn from our findings.

Time to diagnosis after SRC

Less than half of the athletes in this study, regardless of sex, received their SRC diagnosis on the same day of their injury. However, just over 60% of female and male athletes received their diagnosis within 1 day of injury. Although injury reporting was not explicitly measured, the median time to SRC diagnosis after injury was 1 day, regardless of sex or AT exposure status. Our findings align with a separate, large study of collegiate athletes with SRC that reported similar proportions of female and male athletes who were removed from play immediately when compared to female and male athletes who were not immediately removed from activity (19). A study with an overlapping sample also reported that female athletes initiated RTS protocols and experienced RTS a median 1 day later than male athletes (18). The samples included in those studies are representative of athletes within a clinical research protocol focused on concussion recognition and management, which may limit generalizability to institutions without similar protocols; however, they are among the largest representative samples available in the extant literature.

In our study, exploratory analyses revealed longer times to symptom resolution and unrestricted return to sport among those who did not receive their SRC diagnosis on the same day of injury when compared to those who did. This finding

corroborates previous reports on the effects of delayed versus immediate removal from play after SRC (6,7,19,20). Considering this, and despite observing no statistically significant differences between sexes, dedicated AT status, or the interaction of these factors on time to diagnosis, our observation that a majority of athletes were not diagnosed on the day of their injury is concerning. Notably, same-day diagnosis did not appear to be a function of dedicated AT access, as there was no statistically significant difference in this occurrence between athletes with and without a dedicated AT. This observation suggests that many athletes without a dedicated AT were still able to seek and receive care from an AT or other healthcare provider on the day of their injury, though we are unable to address the availability of other healthcare providers (e.g., in a shared athletic training clinic facility or AT event coverage shared across sports) in the current study. It is certainly possible that some athletes had access to a physician who made the diagnosis rather than an AT. Prior research has reported access to an AT as a function of the ratio of ATs to athlete patients in collegiate and secondary school settings (25,28,29), and has suggested that availability of ATs at competition and training activities may improve overall recognition of SRC injuries. Our study did not distinguish AT access for these activities as AT coverage was a dichotomous operation of a dedicated AT as present at all competitions and training sessions. Future work should consider access to ATs, as well as other healthcare providers, in multiple contexts, including considerations of access during competitions, training, other activities, and other reporting avenues.

Time to reporting symptom resolution after SRC

The distribution of days to reporting symptom resolution was not statistically different between sexes in our analyses; yet, there was a two-day difference in median values between female (8 days) and male (6 days) athletes. The 75th percentile for female athletes was 15 days, suggesting that most female athletes reported symptom resolution in just over 2 weeks, while male athletes were under two-weeks (75th percentile = 11.5 days). This finding is in keeping with extant literature that most adult athletes experience resolution of post-concussion symptoms within 3 weeks of their injury (18,23,37). There were no statistically significant differences between athletes with or without access to a dedicated AT; however, male athletes without a dedicated AT took a median of 4 days longer before reporting symptom resolution, with a wider interquartile range, as compared to male athletes with a dedicated AT. This observation may be a product of a small subset of male athletes without a dedicated AT ($n = 13$). By contrast, female athletes had nearly identical median days to reporting symptom resolution with (8 days) and without (7 days) a dedicated AT. Therefore, the independent and overlapping influences of sex and AT exposure remain somewhat convoluted regarding times to symptom resolution based on our findings.

Time to unrestricted return to sport after SRC

While there was not a statistically significant effect of sex on the time from injury to unrestricted RTS in the full sample, female athletes took a median of 3 days longer to return to their respective sports, and the 25th percentile value was also 2 days longer for female than male athletes. There was a small, but not statistically significant, difference in time to unrestricted RTS among the full group, which suggests that those without dedicated AT access took a median 2 days longer to RTS. There was no median difference specifically for female athletes (14 days versus 14.5 days), but male athletes with a dedicated AT returned to sport around 5 days more quickly than male athletes without a dedicated AT (11 days versus 16 days). While these comparisons were not statistically significant, even a one-day difference could mean valuable training and competition-time missed by collegiate athletes, regardless of athlete sex, illustrating the potential advantage of having a dedicated AT to provide appropriate clinical care and management after SRC from an athletic development and player availability standpoint.

Future considerations

Our observations support the need for further investigation into the overlapping relationships between inequitable access to ATs and clinical outcomes after SRC among female and male collegiate athletes. The National Athletic Trainers' Association has developed recommendations and guidelines for appropriate medical coverage of intercollegiate athletics that accounts for the rates and severity of injuries and treatment requirements, across a number of varsity sports (38). Despite these data and recommendations being introduced over a decade ago, this model is not always reflected in current intercollegiate athletics departments, and many sport programs may not have dedicated AT access – as observed in the present study. It should be noted that there was no statistical difference in the proportion of athletes with or without a dedicated AT who were diagnosed within 1 day of their SRC in the sex-comparable collegiate sports included in our study. This suggests that factors beyond sex and dedicated AT coverage alone, such as the availability of non-'dedicated' healthcare providers may influence SRC recognition, reporting, and diagnosis in collegiate athletics. Much is still to be gleaned regarding the availability of AT coverage and how it interacts with sex in the management of SRC, including the use of therapeutic interventions and RTS strategies across sports and settings. Additionally, access to other valuable health care professionals for the diagnosis and management of SRC (e.g., neuropsychologists and physicians) may have differed across institutions in this study. Future research should extend the present study to be inclusive of additional health care professionals beyond solely ATs to further characterize access to care for SRC.

Limitations

Our study involved a retrospective review of existing medical chart data. While data elements and definitions were standardized across sites, each concussion was managed individually. As such, each participant was subjected to institution-specific protocols for the management and unrestricted return to sport decision-making following SRC. Individual athletes' sport participation and access to ATs who were not dedicated to a given team (e.g., ATs who cover multiple sports, but are dedicated

during in-season events) were not accounted for in this study, and these constructs may have differed between study sites or even within individual institutions. Further, sex groups were not equally represented in our study, and neither were AT exposure groups, which further unbalanced the cross-comparisons between sex and AT exposure. Sex was operationalized by biological definitions and self-reported, as opposed to operationalizing the social construct of gender identity. Future research should be inclusive of non-binary markers of gender in culturally responsive care among diverse athletes. In addition, there are other sociocultural factors that may be associated with clinical outcomes following SRC that were not described in this study, including but not limited to: reporting behaviors, age, race, ethnicity, language, and other social determinants of health.

Conclusions

There were no statistically significant differences in the number of days from SRC to diagnosis, symptom resolution, or unrestricted RTS by sex, access to a dedicated AT, or the interaction between the two factors. However, there were potentially clinically meaningful differences in time to reach important recovery milestones by sex and access to a dedicated AT that warrant further investigation in prospective research studies. In alignment with previous work, longer time to injury diagnosis was associated with more days to symptom resolution and unrestricted return to sport. There are complicated interactions between sex, time to diagnosis, and clinical recovery milestones that need deeper investigation and warrant consideration when determining AT coverage for both female and male collegiate sports.

Acknowledgments

The authorship would like to acknowledge the contributing LIMBIC MATARS site investigators: Michelle Kirk, M.D. and David Gable, ATC, (Texas Christian University), Brett Mortensen, Ph.D., Michael J. Larson, Ph.D., (Brigham Young University), James Day, Ed.D. (Augustana University), Allison Peplowski (University of South Dakota), Nyaz Didehbani, Ph.D., and C. Munro Cullum, Ph.D., (The University of Texas Southwestern Medical Center), Meredith Decker, Ph.D., (The University of Texas at Arlington), Tom Campbell, M.S. (Old Dominion University), Monique Pappadis, Ph.D. (The University of Texas Medical Branch), Sean Ahonen, ATC (Virginia Union University), Verle Valentine, M.D. (Sanford Health), Kate Higgins, Psy. D. and Heather Bouchard, M.A. (University of Nebraska), Jessica Wallace, Ph.D. (University of Alabama), Jessica Gill, Ph.D. (Johns Hopkins University), Catherine Donahue, M.Ed., Rachel Smetana, Ph.D. (University of Virginia), Tenesha Helm (University of Lynchburg), as well as the NCAA collegiate athletes who contributed to this dataset.

Disclosure statement

In accordance with Taylor & Francis policy and our ethical obligations as researchers, the authorship team reports the following potential conflicts of interest: SRW reports receipt of honorarium and travel costs from the National Athletic Trainers' Association (NATA; 2022); DKB is Executive Director of the Sports Neuropsychology Society and receives an annual stipend for that work; JER has received funding by the Medical Technology Enterprise Consortium. The remaining authors (PMK; EB; JRO; TGB; TAM; KM; DJR; DXC) have nothing to declare.

Funding

Partial funding was provided by the University of Virginia School of Education and Human Development Foundation, with support from the U.S. Army Medical Research and Material Command and from the U.S. Department of Veterans Affairs Long-term Impact of Military-relevant Brain Injury Consortium under Award No. W81XWH-18/TBIRP-LIMBIC.

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