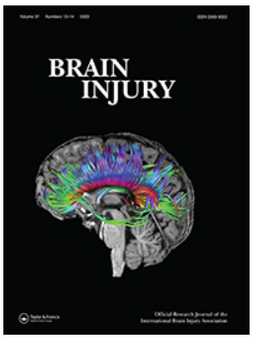

Brain Injury

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

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To cite this article: Thayne A. Munce, Allison D. Peplowski, Thomas G. Bowman, Patricia M. Kelshaw, Thomas R. Campbell, Sean B. Ahonen, Verle D. Valentine, David X. Cifu & Jacob E. Resch (09 Feb 2024): Concussion diagnosis and recovery in relation to collegiate athletic department classification: a LIMBIC MATARS consortium investigation, Brain Injury, DOI: 10.1080/02699052.2024.2310800

To link to this article: https://doi.org/10.1080/02699052.2024.2310800

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https://doi.org/10.1080/02699052.2024.2310800

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Concussion diagnosis and recovery in relation to collegiate athletic department classification: a LIMBIC MATARS consortium investigation

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ABSTRACT

Purpose: We investigated time to reach concussion diagnosis and recovery milestones in collegiate athletes relative to their schools' National Collegiate Athletic Association (NCAA) classification.

Methods: We retrospectively examined 849 (43.1% female) concussion cases from 11 NCAA institutions (Division I Power 5 [$n = 4$], Division I Non-Power 5 [$n = 4$], and Division II/III [$n = 3$]) from the 2015–16 to 2019–20 athletic seasons. Our primary outcome measures were days to reach specific clinical milestones following concussion.

Results: Median (IQR) time from injury to diagnosis was significantly longer at Division II/III institutions (1 [0–4] days) compared to Division I Power 5 (0 [0–1] days) and Division I Non-Power 5 (0 [0–1] days) institutions ($p < 0.001$). Likewise, Division II/III athletes (15 [11–22] days) took significantly longer to return to sport after concussion than Division I Power 5 (10 [7–16] days) and Division I Non-Power 5 (11 [7–18.5] days) athletes ($p < 0.001$).

Conclusion: Division II/III athletes had delayed concussion diagnoses and return to sport timelines compared to Division I athletes. Our results suggest that differences in sports medicine resources across NCAA divisions may influence injury recognition and recovery in collegiate athletes with concussion.

ARTICLE HISTORY
Received 2 March 2023
Revised 7 October 2023
Accepted 23 January 2024

KEYWORDS
Mild traumatic brain injury (mTBI); concussion management; athletic training; collegiate athlete; sports medicine

Introduction

Concussions are prevalent injuries in collegiate athletics, particularly among athletes who compete in contact or collision sports (1,2). In a review of National Collegiate Athletic Association (NCAA) injury data from the 2009–10 to 2013–14 seasons, football (36.1%), men's ice hockey (13.4%) and women's soccer (8.1%) had the highest incidence of concussion (2). Additionally, concussions represent 6.8% of all injuries in collegiate football games (3) and rank among the top five injuries in women's soccer (4), men's and women's ice hockey (5,6), men's and women's lacrosse (7), men's and women's basketball (8,9) and women's field hockey (10).

Emerging evidence has demonstrated that individuals who have earlier access to health care after a concussion have shorter recovery times (11,12). Eagle et al. (12) found that days to first clinical visit was the leading predictor of prolonged concussion recovery among children and adolescents diagnosed with a concussion, with an earlier time to clinic associated with earlier recovery. Using a systematic review and meta-analysis, Barnhart, Bay and Valovich McLeod (11) reported that patients who immediately reported their concussion recovered 5.4 days earlier than those who delayed their reporting. In addition to suffering acute neurological impairment that can affect cognition, mood, sleep, vestibular function, and/or behavior (13), athletes who experience a concussion are also at risk for social isolation, loss of identity, and neuropsychological consequences related to time lost from activity and disruption of social roles and networks (14,15. Thus, timely care and recovery from a concussion is imperative for collegiate athletes to be able to heal properly, return to school, return to play, and to minimize the disruption the injury has on their lives.

In collegiate athletics, the school's sports medicine staff is often the initial access point to diagnosis and care for concussions across all divisions of play. Discrepancies in sports medicine resources among schools of different sizes (16), NCAA classification (17,18) and/or administrative models have been identified and can impact injury care and management (19–21). Notably, athletic departments whose clinician-to-athlete ratio was more than one standard deviation above average had lower injury rates, including 6.7% fewer injuries diagnosed as concussions, suggesting that greater sports medicine resources may be associated with reduced injury rates (20).

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Regarding NCAA classification, athletic trainers at NCAA Division I schools reported caring for less athletes per person than athletic trainers at Division II or Division III schools (17). Therefore, NCAA athletes at Division II/III schools may have reduced or impeded access to health care, which may influence concussion diagnosis and management. In a survey of high-school athletes, those who attended schools with midlevel or high-level athletic training availability were more likely to report a sports-related concussion and interacted with an athletic trainer much sooner after injury compared to athletes from schools with low-level athletic training availability (22). In the collegiate setting, higher concussion rates were reported for ice hockey players at schools with higher ratios of athletic training staff to non-staff members (graduate assistants and interns), which was a surrogate measure of full-time athletic trainer availability, further supporting the importance of adequate athletic training staffing and coverage for proper concussion recognition and diagnosis (19). However, it is unknown if NCAA classification is associated with concussion diagnosis and recovery timelines of collegiate athletes. Moreover, downstream effects of institutional budgets and resources associated with NCAA classification, namely athletic training staffing and coverage, have not been explored in the context of concussion management and recovery.

Using a retrospective chart review of concussions diagnosed at 11 NCAA institutions (Division I – Division III), we explored interactions between athletic department classification, concussion diagnosis and recovery timelines, and athletic training coverage. We hypothesized that concussion diagnosis and recovery timelines would be related to NCAA classification and athletic training staffing, such that Division I athletes with a concussion would have more accessible athletic training care and would be diagnosed earlier and recover more rapidly from their injury.

Materials and methods

Research design

The current study used retrospective patient data compiled by the LIMBIC Military and Tactical Athlete Research Study (LIMBIC MATARS) consortium. Using a common data dictionary, data for every athlete who sustained a documented concussion from the 2015–16 to 2019–20 athletic seasons were extracted from the medical records of 11 LIMBIC MATARS institutions and aggregated into a de-identified dataset. Each school's medical professionals followed their own NCAA-approved procedures and systems (e.g., EMR) for concussion diagnosis, management,

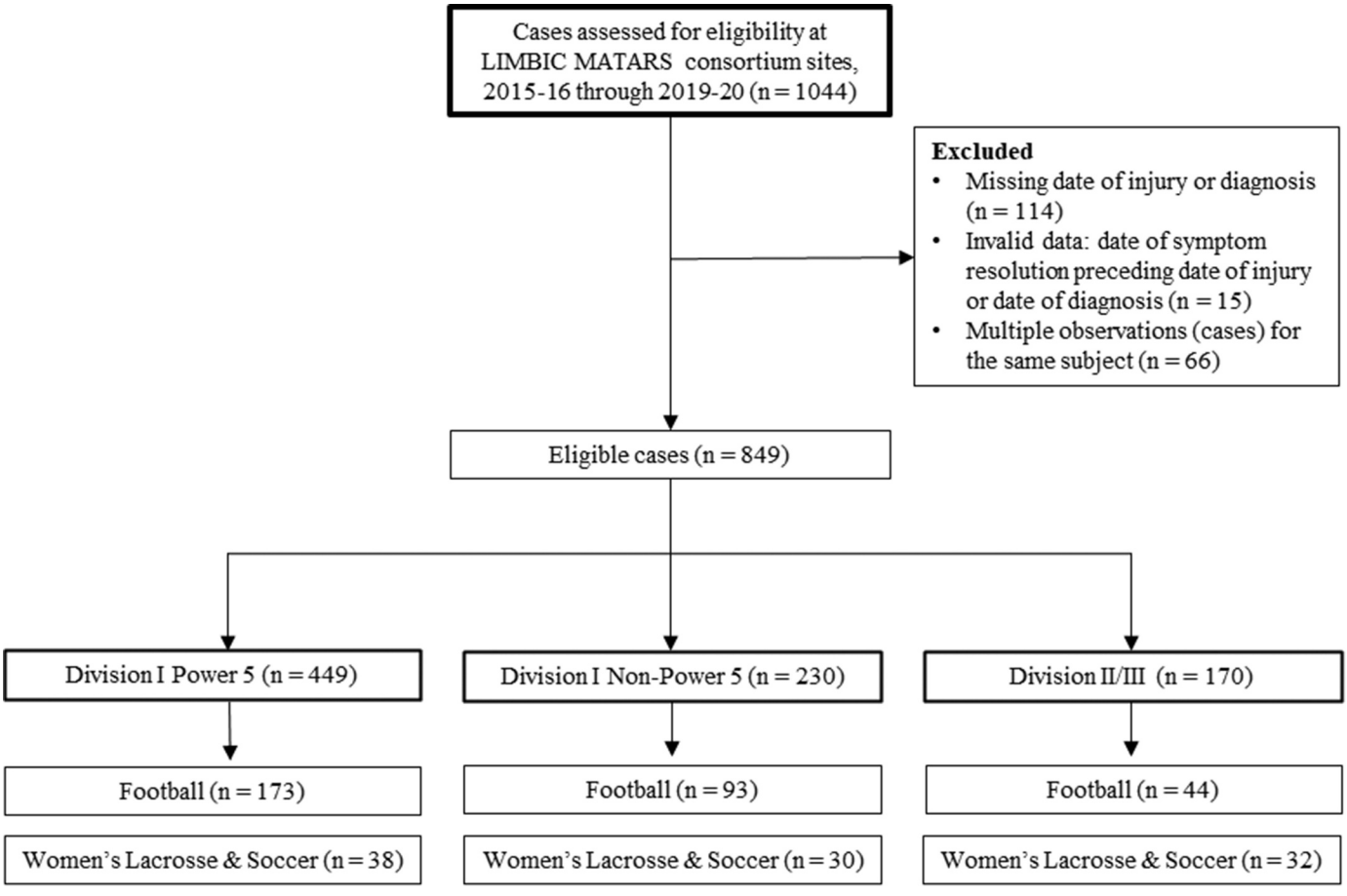

Figure 1. Determination of case eligibility and assignment to evaluate concussion diagnosis and recovery timelines by collegiate athletic department classification and sport subgroup.

and reporting during the 5-year period. This study was approved by the Institutional Review Board (IRB) at the University of Virginia and each participating institution followed its own IRB's procedures for participating in this multi-site collaboration.

Cases

Following data cleaning (see below and Figure 1 for more details), we retained 849 cases (age = 19.8 ± 1.4 yr; 43.1% female) from athletes participating in a variety of collision, contact and non-contact sports for analysis. We also performed subgroup analyses of the most representative contact and collision sports for male athlete cases (football) and female athlete cases (lacrosse and soccer). This approach controlled for sport and sex and provided context for the overall analysis. Athlete characteristics by athletic department classification and sport subgroups may be found in Table 1.

Athletic department classification

Participating institutions were grouped according to NCAA athletic department classifications (Division I, II, III), and Division I subgroups (Power 5, Non-Power 5). NCAA classifications are distinguished primarily by competition level, athletic department budgets (expenses and revenue), and scholarship offerings. The highest competition level, Division I, is further subdivided by conference affiliation, whereby member schools from the five major NCAA Division I conferences: Atlantic Coast Conference, Big Ten Conference, Big 12 Conference, Pac-12 Conference and Southeastern Conference are Power 5 schools, while other Division I schools are Non-Power 5. Overall, three groups were designated for this study: Division I Power 5 institutions ($n = 4$), Division I Non-Power 5 institutions ($n = 4$), and Division II/III institutions ($n = 3$). We grouped one Division I school with the Power 5 institutions even though it was not a member of a Power 5 conference during the study period. Our primary justification for this grouping is that the school was scheduled to join a Power 5 conference by summer 2023 and has a budget profile and competition status more on par with the other Power 5 schools than non-Power 5 schools. Summary athletic department budgets and school enrollment figures for the participating institutions in this study can be found in Table 2.

Data collection and cleaning procedures

Investigators at participating LIMBIC MATARS sites performed retrospective medical record reviews at their institutions. All documented concussion cases that occurred between the 2015–16 and 2019–20 athletic seasons were eligible for inclusion. Variables collected were standardized for all members of LIMBIC MATARS, including patient demographic information, dates of injury, diagnosis, symptom resolution and return to sport, as well as medical history (23. Cases with missing data were retained in the master dataset. Investigators at each site also reported the overall number of athletes who participated at their institution during the 2015–16 through 2019–20 athletic seasons, as well as athletic training staff sizes and coverage (e.g., full-time, part-time; designated to a particular team, etc.) during the study period.

Table 1. Case information.

	NCAA Classification			
Variable	Division I Power 5 $n = 449$	Division I Non-Power 5 $n = 230$	Division II/III $n = 170$	All $n = 849$
Overall Sample				
Age (yr), mean (SD)	19.8 (1.4)	19.7 (1.4)	19.8 (1.5)	19.8 (1.4)
Sex				
Female	180 (40.1%)	105 (45.7%)	81 (47.7%)	366 (43.1%)
Male	269 (59.9%)	125 (54.4%)	89 (52.4%)	483 (56.9%)
Race & ethnicity, *n* (%)				
Black or African American	86 (19.2%)	52 (22.6%)	21 (12.4%)	159 (18.7%)
White	281 (62.6%)	123 (53.5%)	74 (43.5%)	478 (56.3%)
Other	17 (3.8%)	4 (1.7%)	3 (1.8%)	24 (2.8%)
Unspecified or not reported	65 (14.5%)	51 (22.2%)	72 (42.4%)	188 (22.1%)
Football Subgroup				
n (%)	173 (38.5%)	93 (40.8%)	44 (25.9%)	310 (36.6%)
Age (yr), mean (SD)	20.0 (1.6)	20.0 (1.3)	20.9 (1.6)	20.1 (1.5)
Race & ethnicity, *n* (%)				
Black or African American	64 (37.0%)	39 (41.9%)	15 (34.1%)	118 (38.1%)
White	72 (41.6%)	39 (41.9%)	25 (56.8%)	136 (43.9%)
Other	7 (4.1%)	0 (0.0%)	2 (4.6%)	9 (2.9%)
Unspecified or not reported	30 (17.3%)	15 (16.1%)	2 (4.6%)	47 (22.1%)
Women's Lacrosse & Soccer Subgroup				
n (%)	38 (8.4%)	30 (13.0%)	32 (18.8%)	100 (11.8%)
Age (yr), mean (SD)	19.6 (1.2)	19.3 (1.2)	18.9 (1.0)	19.3 (1.1)
Race & ethnicity, *n* (%)				
Black or African American	0 (0.0%)	2 (6.7%)	1 (3.1%)	3 (3.0%)
White	30 (78.9%)	19 (63.3%)	9 (28.1%)	58 (58.0%)
Other	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Unspecified or not reported	8 (21.1%)	9 (3.0%)	22 (68.8%)	39 (39.0%)

Table 2. Institutional information.

	Median (minimum, maximum)	
Group	School Enrollment[a]	Annual Athletic Department Expenses[b,c]
Division I Power 5	24,726 (11,938 , 34,737)	109 (74, 115)
Division I Non-Power 5	17,129 (9,344, 45,949)	20 (16, 43)
Division II/III	2,080 (1,700, 2,800)	4 (4, 10)

[a]School enrollment data obtained on March 1, 2023 via Wikipedia (https://en.wikipedia.org) by searching for school name and using total enrollment value.
[b]Athletic department budget data obtained on March 1, 2023 via College Factual (https://www.collegefactual.com) by searching for school name and accessing athletic department data under 'Sports Programs,' 'Total Expenses.'
[c]Dollars (USD) in millions.

Researchers from each participating institution then sent coded data to the lead investigator (JR) who compiled an aggregated dataset for analysis. Upon receipt of the final dataset, we cleaned the data to remove cases with missing dates of injury ($n = 50$) or diagnosis ($n = 64$), and those with a symptom resolution date preceding the date of injury or diagnosis or both ($n = 15$). For subjects who had multiple observations (66), we retained the earliest case and removed the remaining case(s). We then analyzed the data for outliers using boxplots. Any datapoint flagged as an outlier was analyzed for clinical accuracy. No additional data points were removed beyond those meeting our *a priori* criteria. Details pertaining to data cleaning procedures can be found in Figure 1.

Statistical analysis

Athletic department classification, as defined above, served as the independent variable for our study. We chose four timelines as our dependent variables *a priori*, time (in days) from injury to diagnosis, time (in days) from diagnosis to symptom resolution, time (in days) from symptom resolution to return to sport and time (in days) from injury to return to sport. Separate analyses for each timeline were performed for A) overall cases, B) football cases and C) women's lacrosse and soccer cases. Due to violations of homogeneity of variance and normality in the dependent variables ($p < 0.05$ for all Levene's and Shapiro-Wilk's tests), we used Kruskal–Wallis tests (SPSS version 27, IBM Inc, Armonk, NY) to determine differences in dependent variables across the levels of athletic department classification. We set the alpha value to less than or equal to 0.05 *a priori* for all main effects and post hoc analyses. Bonferroni corrections for multiple comparisons were performed when appropriate. In particular, for the primary timeline analyses, 12 independent hypotheses tests were performed (4 timelines x 3 groups), reducing the main effect alpha value to 0.004.

Results

There were 849 concussion cases used in the full analysis, including 449 (52.9%) from Division I Power 5 institutions, 230 (27.1%) from Division I Non-Power 5 institutions, and 170 (20.0%) from Division II/III institutions. In the subgroup analysis for football, there were 310 (36.6%) cases, with 173 (55.8%) reported at Division I Power 5 schools, 93 (30.0%) at Division I Non-Power 5 schools and 44 (14.2%) at Division II/III schools. There were 100 (11.8%) cases in the subgroup analysis for women's lacrosse and soccer, with 38 (38.0%) from Division I Power 5 schools, 30 (30.0%) from Division I Non-Power 5 schools and 32 (32.0%) from Division II/III schools.

Time from injury to diagnosis was significantly different ($p < 0.001$) across all divisions, with Division II/III athletes (1 [0–4] days; median [IQR]) taking significantly longer to be diagnosed ($p < 0.001$) compared to athletes from Division I Power 5 schools (1 [0–1] days) and Division I Non-Power 5 schools (0 [0–1] days), respectively (Figure 2a). Time from injury to diagnosis was also significantly protracted at Division I Power 5 schools compared to Division 1 Non-Power 5 schools ($p < 0.001$), though the majority of all Division I athletes were diagnosed within 1 day of injury (Figure 2a). Among the football subgroup, time from injury to diagnosis was not significantly different across divisions when adjusting for multiple comparisons ($p = 0.02$) (Figure 2b). In the women's lacrosse and soccer subgroup, there was a significant main effect for all groups ($p = 0.003$), with Division II/III athletes having significantly longer times to diagnosis (2 [0–4] days) than Division I Non-Power 5 athletes (0 [0–1] days) (Figure 2c). Female soccer and lacrosse players from Division II/III schools also took 2 days longer on median to be diagnosed with a concussion than their counterparts at Division I Power 5 schools (0 [0–1] days), but this difference was not statistically significant ($p = 0.053$) (Figure 2c).

Time from diagnosis to symptom resolution was not significantly different across divisions in the overall sample ($p = 0.030$) (Figure 3a). Likewise, there were no significant differences by division in time from diagnosis to symptom resolution for football ($p = 0.363$) or women's lacrosse and soccer ($p = 0.093$) subgroups (Figure 3b,c).

Time from symptom resolution to return to sport was significantly different across divisions ($p < 0.001$), with Division II/III athletes (5 [4–7] days) having significantly longer return to sport times than Division I Power 5 (3 [3–5]; $p < 0.001$) and Division I Non-Power 5 (3 [1–6]; $p < 0.001$) athletes, respectively (Figure 4a). In the football subgroup, time from symptom resolution to return to sport was also significantly different across divisions ($p < 0.001$), with Division I Non-Power 5 athletes (5 [1–4]) having significantly shorter return to sport times following symptom resolution than Division I Power 5 (4 [3–5]; $p < 0.001$) and Division II/III athletes (5 [4–6]; $p < 0.001$) (Figure 4b). Time

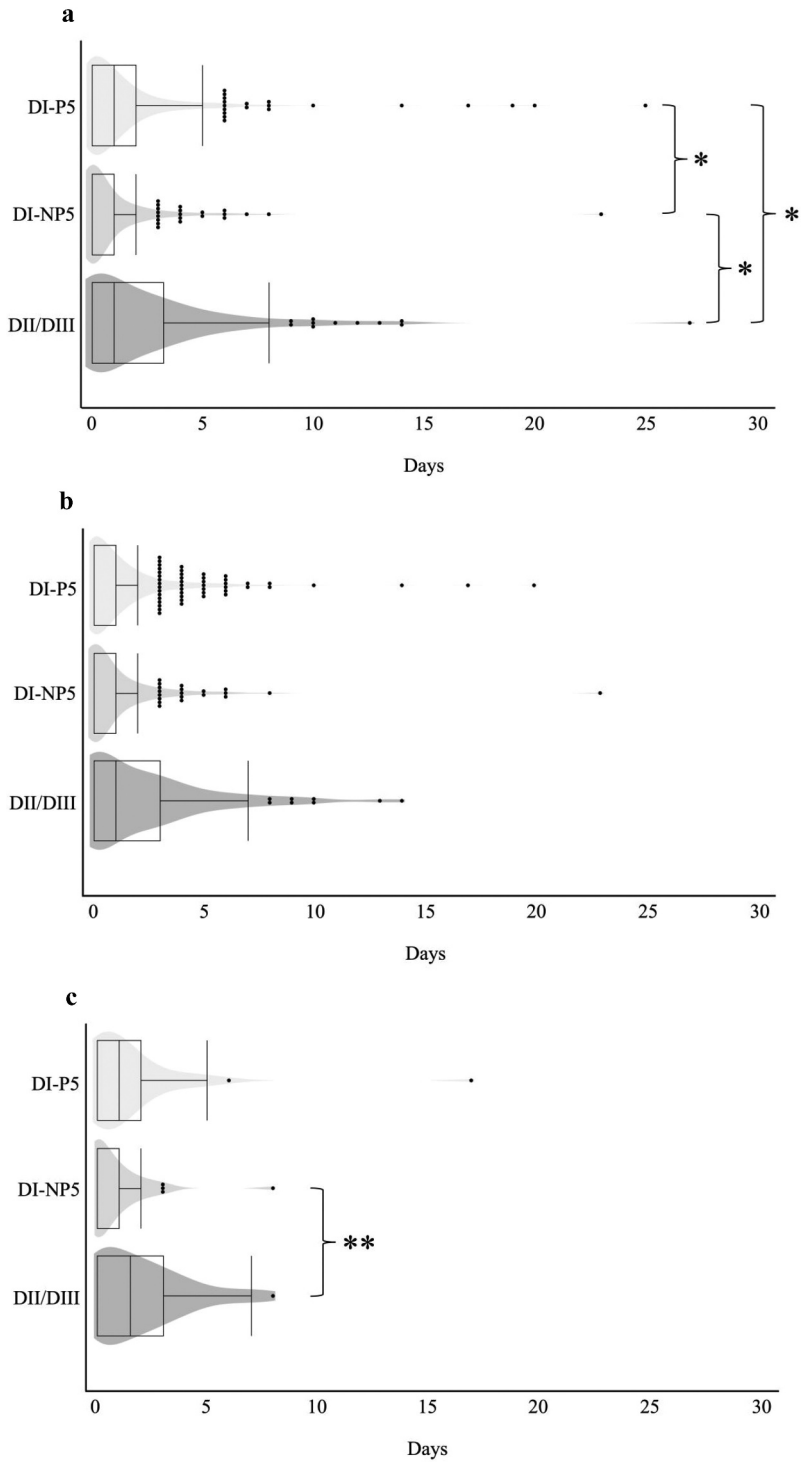

Figure 2. Time (days) from date of injury to date of diagnosis by collegiate athletic department classification for a) overall cases, b) football cases, and c) women's lacrosse and soccer cases. *$p < 0.001$, **$p < 0.01$.

from symptom resolution to return to sport was not significantly different across divisions for the women's lacrosse and soccer subgroup ($p = 0.008$) (Figure 4c)

Time from injury to return to sport was significantly different for all divisions ($p < 0.001$), with significant pairwise differences between athletes at Division II/III schools (15 [11–22] days) versus Division I Power 5 (11 [7–16]; $p < 0.001$) and Division I Non-Power 5 (11 [7–18.5] days; $p < 0.001$) schools, respectively (Figure 5a). In the football subgroup, time from injury to return to sport was not significantly different across divisions ($p = 0.085$); however, median time to return to sport was 3 to 4 days later for Division II/III football players (14 [9.5–19] days) as compared to Division I Power 5 (11 [8–18] days) and Division I Non-Power 5 (10 [6.75–15.75] days) players (Figure 5b). In the women's

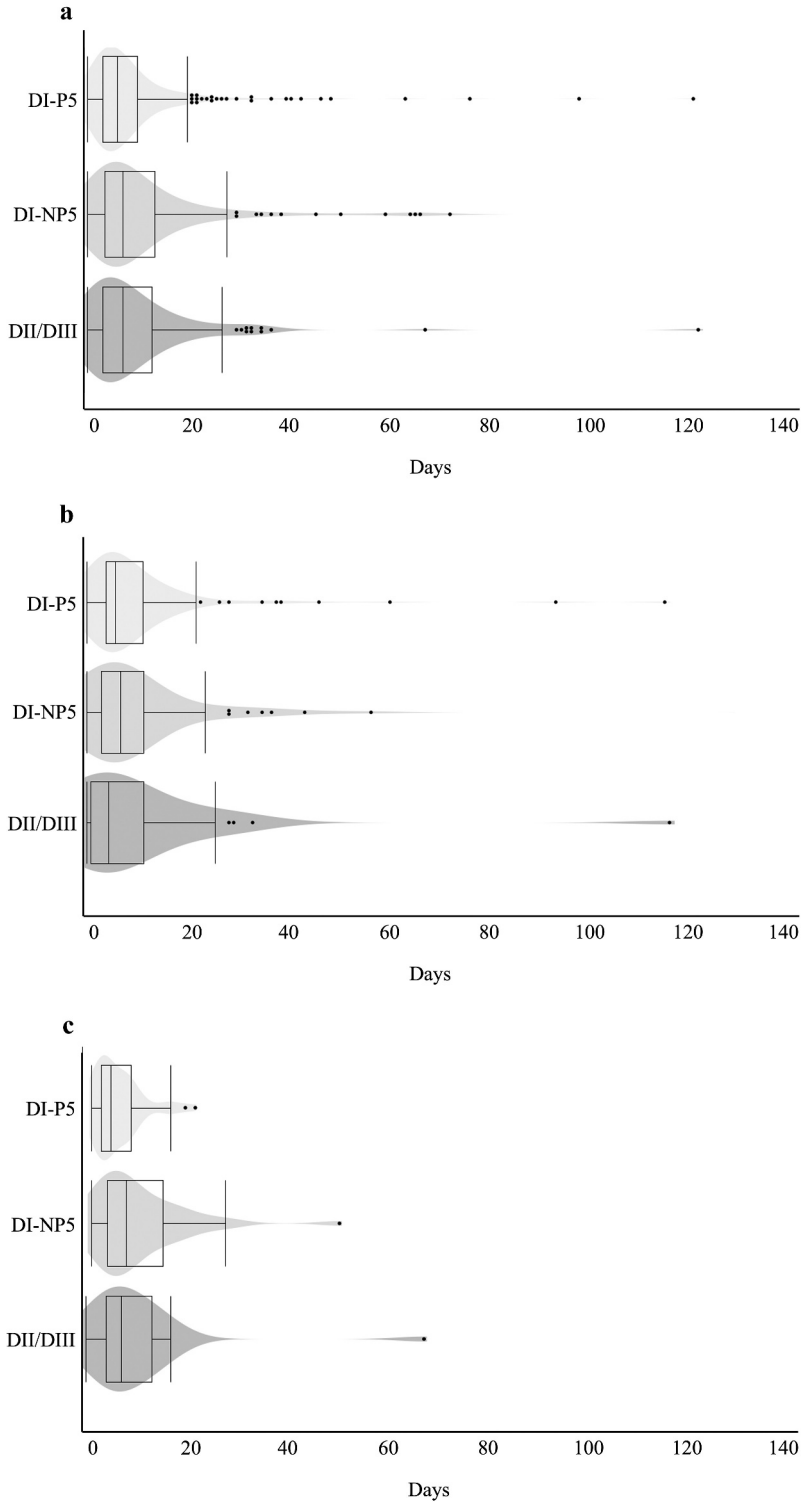

Figure 3. Time (days) from date of diagnosis to symptom resolution by collegiate athletic department classification for a) overall cases, b) football cases, and c) women's lacrosse and soccer cases.

lacrosse and soccer subgroup, time from injury to return to sport was significantly different across all groups ($p < 0.001$), with Division II/III female lacrosse and soccer players (17 [11–22.25] days) having significantly longer return to sport times than their counterparts from Division I Power 5 schools (9 [7–11]; $p < 0.001$) (Figure 5c).

There were distinct differences in the number of collegiate athletes and full-time athletic trainers by divisional classification, with each measure increasing progressively from Division II/III to Division I Power 5 (Table 3). However, athlete to full-time athletic trainer ratios were the opposite, with the highest ratios found at Division II/III schools.

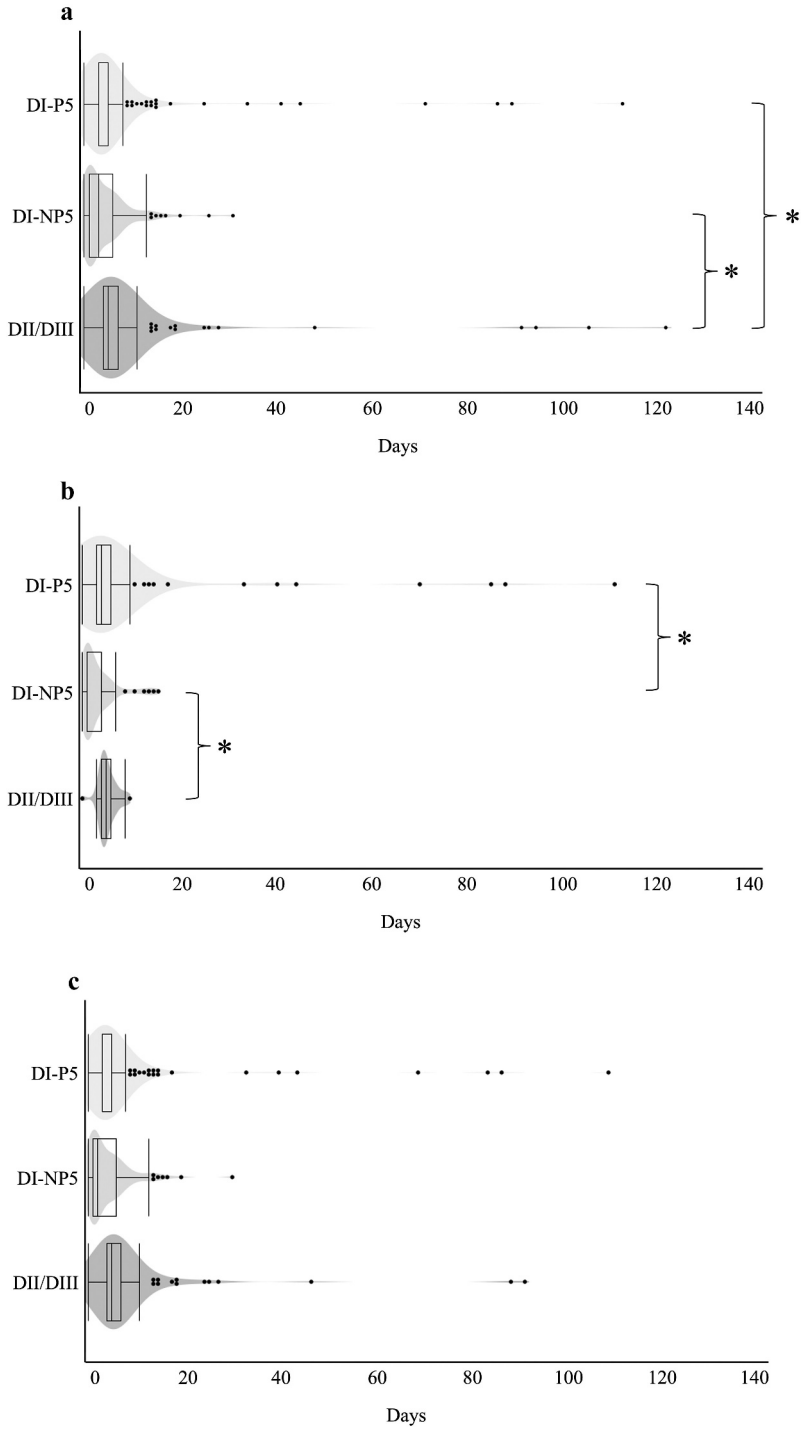

Figure 4. Time (days) from date of symptom resolution to return to sport by collegiate athletic department classification for a) overall cases, b) football cases, and c) women's lacrosse and soccer cases. *$p < 0.001$.

Discussion

Collegiate athletic departments vary in size and resources, which may impact the care that athletes receive for concussions. We observed several significant differences from the time of concussion until return to sport for collegiate athletes that supported our overarching hypothesis that concussion diagnosis and recovery timelines would be accelerated at schools with a higher NCAA classification. Notably, collegiate athletes from Division II/III schools who experienced a concussion had a significantly delayed time to diagnosis, time from symptom resolution to return to sport and time from injury to return to sport compared to their Division I peers. Moreover, athletic training coverage was progressively greater at each level of NCAA classification and was a plausible factor influencing the more rapid diagnosis and recovery timelines of Division I athletes.

Access to medical professionals trained in the care and management of concussions is thought to be a limiting factor in timely diagnosis of concussion (11,24). In collegiate sport settings, athletic trainers are often the first healthcare

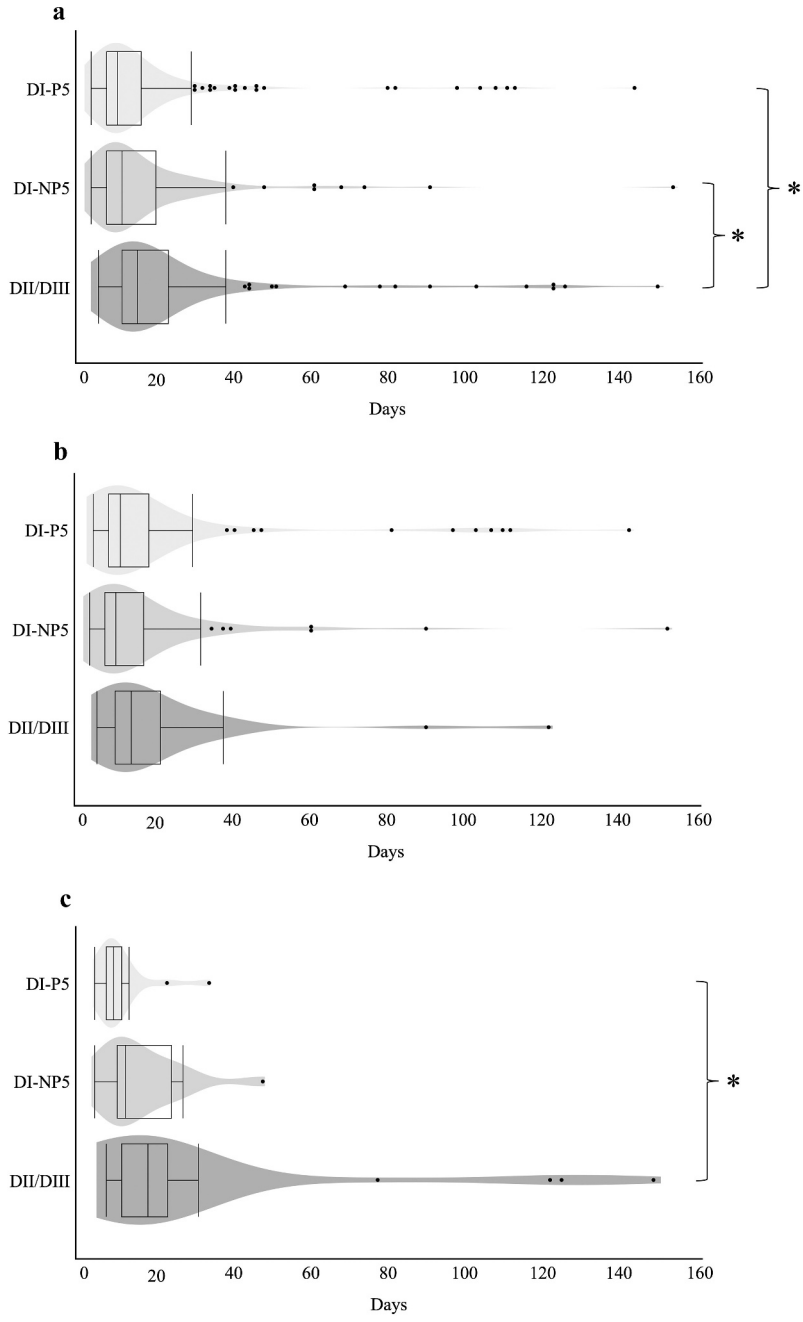

Figure 5. Time (days) from date of injury to return to sport by collegiate athletic department classification for a) overall cases, b) football cases, and c) women's lacrosse and soccer cases. *$p < 0.001$.

Table 3. Athletic training staff sizes.

	Median (minimum, maximum)[a]			
Group	# Full-Time ATs	# Athletes	Athlete:AT	Relative Athlete:AT
Division I Power 5	18 (12, 22)	599 (475, 828)	34 (26, 59)	Reference
Division I Non-Power 5	9 (8, 12)	397 (332, 524)	46 (32, 52)	1.4
Division II/III	5 (2, 6)	427 (225, 515)	86 (85, 112)	2.5

Abbreviations: AT, athletic trainer.
[a]Group median was derived from the 5-year means reported by each participating institution from 2015–16 to 2019–20.

providers who are able to evaluate and recognize a concussion (25. Inadequate athletic training coverage may limit direct observations of a concussion and/or make it more challenging for athletes to seek care. Baugh et al. (19 reported that overall injury rates and non-time-loss injuries were lower at NCAA schools with greater patient loads (i.e., higher athlete to staff

ratios), indicating a potential barrier to timely and appropriate injury diagnosis. Moreover, Galucci et al. (18) noted significantly higher levels of full- and part-time athletic training coverage at Division I schools compared to those at Division II, Division III or National Association of Intercollegiate Athletics (NAIA) levels of competition. Athletic trainers from Division II/III schools in this study cared for approximately 2–2.5 times more athletes per person than their Division I counterparts, which may have contributed to delayed concussion diagnoses at the Division II/III level. Having fewer athletic trainers suggests that more practices and competitions may occur without adequate athletic training coverage; thus, injuries sustained in these sessions may not be observed by an athletic trainer and readily managed. Without athletic training staff present for injury surveillance, concussion recognition often becomes the sole responsibility of athletes and coaches, which introduces additional errors associated with nondisclosure. Research has demonstrated that reliance on patient self-reporting may lead to missed diagnoses or mismanagement of concussions (26).

In addition to disparities in athletic training coverage, access to other sports medicine professionals (e.g., physicians) was likely another discriminating factor between Division I and Division II/III schools and may have contributed to delays in diagnosis, return to sport or both among Division II/III athletes. For schools that rely on physicians to diagnose or clear athletes with a concussion for return to sport, physician access can be a rate-limiting step and prolong the concussion management process (27). Previous research demonstrates that Division I schools are more likely than those in Division II to have a physician on staff (17). Rankin (16) reported sharply greater budgets for major football Division I schools, which were equivalent to Division I Power 5 schools in our analysis. These findings mirror immense disparities in athletic department budgets of participating schools in this study, with Division I Power 5 schools spending, on average, nearly 30 times more than Division II/III institutions (Table 2). While many athletic department expenses are allocated for salaries, personnel and scholarships, providing additional sports medicine resources for athlete care is to be expected.

A decade ago, it was common for most collegiate athletes to return to sport within 10 days following a concussion (28,29); more recently, however, investigators have reported a median return to sport duration of 12.8 days in this population, though approximately 15% are not cleared within 28 days post-injury (30. The increased time for collegiate athletes to be cleared to return to sport has been associated with a greater understanding of concussion and its physiological recovery (31,32). In the current study, collegiate athletes had comparable median return to sport times of 10 and 11 days at the Division I Power 5 and Division I Non-Power 5 level, respectively, whereas Division II/III athletes' median return to sport time was 15 days.

Several investigations have reported that early concussion diagnosis and care is associated with less severe symptoms and faster recovery (12,33,34). In our study, delayed diagnosis was also associated with an extended recovery. Athletes from Division II/III schools were diagnosed with their concussion later and had a prolonged return to sport (4–5 days on median) compared to their Division I counterparts. Interestingly, Division II/III athletes also had a longer period from symptom resolution to return to sport, which contributed to their protracted clearance from time of injury. It is unknown if their delayed diagnoses adversely affected their physiological recovery following symptom resolution. An alternative explanation to Division II/III athletes having slower recoveries could be that Division I athletes may have progressed through their return to sport protocols more rapidly, perhaps facilitated by more robust athletic training staff supervision or greater demands to return to competition. The latter could be influenced by media exposure, earning potential through name, image and likeness opportunities, institutional pressure or other factors that may be more prevalent at Division I schools, particularly those that compete at the Power 5 level. However, assuming that Division I status and influence is more predominant in football compared to women's lacrosse and soccer (i.e., media presence and revenue generation), the observation that relative to Division I athletes, return to sport was delayed to a greater extent (5–8 days on median) in Division II/III female lacrosse and soccer players than Division II/III football players (3–4 days on median) suggests that undue pressure for Division I athletes to return to sport sooner was not a strong driver of our findings.

Our subgroup analyses of football and women's lacrosse and soccer revealed that observed differences in clinical timelines of concussion diagnosis and recovery by NCAA division varied by sex, sport or both. For example, across all sports, median time to diagnosis was 1 day later for Division II/III athletes versus Division I athletes, who were typically diagnosed on the day of injury. However, there was no difference in median time to diagnosis for football players, whereas Division II/III female lacrosse and soccer players had a median time to diagnosis 2 days later than their Division I counterparts. Furthermore, Division II/III female lacrosse and soccer players' median time from injury to return to sport was 2 days longer on median compared to Division II/III football players and was also more protracted relative to their Division I counterparts (5–8 days longer for Division II/III women's lacrosse/soccer vs. 3–4 days for Division II/III football, respectively). We did not capture sport-specific athletic training information, so we are unable to conclude that delayed diagnosis and return to sport were related to disparate athletic training coverage across divisions by sport or identify the extent to with these differences were a function of sex, sport or their interaction. However, if athletic training coverage was less robust for Division II/III women's lacrosse and soccer than football, this would be consistent with our overall hypothesis. Clearly, additional research is needed to better understand

how sports medicine coverage and clinical care provided by schools with varying resources may differentially impact the health of collegiate athletes with concussion.

Limitations

As this was a retrospective analysis, injury assessments and documentation were not standardized across sites, and some sites had inconsistent internal processes from year to year. This resulted in many cases having missing or incomplete information. While the total case count was sufficient to perform the planned analyses for this study, many documented concussions that occurred at participating sites during the study period were excluded. Also, all concussions in this analysis were treated as equal and did not consider severity (e.g., symptom burden) or other mitigating factors such as concussion history, head impact characteristics, etc. Furthermore, demographic characteristics such as sex, race, and sport were not independently considered in our overall analysis. However, our subgroup analyses using football-only cases and women's lacrosse and soccer cases controlled for sex and sport and had comparable race and ethnic compositions. These subgroup analyses confirmed differences in clinical concussion timelines across NCAA divisions, while also identifying additional disparities related to sex, sport or both that are consistent with unequal access to athletic training coverage and sports medicine resources, warranting further investigation. Still, it is possible that important determinants of concussion diagnosis and recovery were unaccounted for, including factors inherently different between NCAA divisions, which may have impacted our findings. Additionally, we did not attempt to delineate differences in concussion management approach and any such differences were not factored into the analyses. In terms of athletic training coverage, only full- and part-time athletic trainers were reported, and we did not account for athletic training students. Finally, the schools and cases presented here are relatively small samples and may not be representative of all schools from a particular division. Thus, reported differences should be approached from that perspective until larger, prospective studies can be performed.

Conclusions

Concussion diagnosis and recovery timelines of collegiate athletes varied by NCAA classification; however, differences across divisions were not consistent by sport or sex. Overall, Division II/III athletes had delayed diagnoses and returned to sport later than athletes from Division I schools. It is unknown if these disparities had any adverse consequences on the injured athletes' health or well-being. NCAA Division I schools had greater athletic training coverage and sports medicine resources than their Division II/III counterparts, which may have contributed to the observed differences. Our findings support a possible benefit of increasing athletic training availability for concussion management in collegiate athletics.

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. and Michael J. Larson, Ph.D. (Brigham Young University), Erica Beidler, Ph.D. (Duquesne University), James Day, Ed.D. (Augustana University), Kristin Wilmoth, Ph.D., 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), Monique Pappadis, Ph.D. (The University of Texas Medical Branch), 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., Daniel Rosenblum, M.Ed., Donna Broshek, Ph.D. and Rachel Smetana, Ph.D. (University of Virginia), Tenesha Helm (Lynchburg University), Samuel Walton, Ph.D. and Jessie Oldham, Ph.D. (Virginia Commonwealth University) as well as the NCAA collegiate athletes who contributed to this dataset. We would also like to express our gratitude to Jordan Rodu, Ph.D. from the University of Virginia for providing statistical consultation on this manuscript.

Disclosure statement

JER has received funding from the Medical Technology Enterprise Consortium. All other authors report there are no competing interests 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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