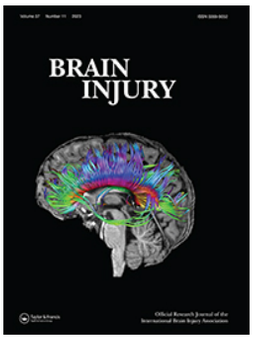

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Racial identity and concussion diagnosis and recovery trajectories in collegiate athletes: a LIMBIC MATARS investigation

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ABSTRACT

Objective: To determine if there were concussion diagnosis and recovery disparities between collegiate athletes with Black and White racial identities.

Design: Retrospective cohort study.

Methods: Concussion information was extracted from NCAA athlete medical files at LIMBIC MATARS member institutions from the 2015–16′ to 2019–20′ academic years. A total of 410 concussions from 9 institutions were included that provided all independent (i.e. racial identity of Black or White) and dependent variable information (i.e. dates of injury, diagnosis, symptom resolution, and return to sport) that were analyzed using Mann-Whitney U tests. The sample consisted of 114 (27.8%) concussions sustained by Black athletes and 296 (72.1%) sustained by White athletes.

Results: The overall sample had a median of 0 days between injury occurrence to diagnosis, 7 days to symptom resolution, and 12 days to return to sport. No significant timing differences were observed for concussion diagnosis ($p = .14$), symptom resolution ($p = .39$), or return to sport ($p = 0.58$) between collegiate athletes with Black versus White racial identities.

Conclusions: These findings may reflect equitable access to onsite sports medicine healthcare resources that facilitate concussion management in the collegiate sport setting. Future work should explore these associations with a larger and more diverse sample of collegiate athletes.

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Brain injury; college sports; health disparity; injury recovery; social determinants of health

Introduction

Concussion is a mild traumatic brain injury that has been frequently documented among collegiate sports. Recent research estimates 4 concussions occurring per every 10,000 athlete-exposures (1). Collision and contact sports, such as tackle football, ice hockey, and soccer, have the highest concussion rates in collegiate athletics, however, brain injury risk is not exclusive to those sports (1,2). Collegiate athletes who sustain a concussion may experience acute cognitive and neurological alterations, time missed from sport, social isolation from peers, and may be at increased risk for subsequent concussion and musculoskeletal injury (3–5). Early injury recognition, removal from play, and initiation of clinical management is paramount for optimizing recovery, return to school, and return to play outcomes (6,7).

There are many moderating factors that influence concussion diagnosis and recovery in collegiate athletes, including biological sex (8,9), prior concussion history (2), and preexisting medical conditions such as ADHD (10,11) and migraine (12). Further, social determinants are often fundamental to the cause of health inequalities that disproportionately disadvantage underrepresented racial and ethnic groups to a greater degree than the non-Hispanic, White population (13). Social determinants, including socioeconomic status (14,15), education (16), social support (17), and access to healthcare resources (18–20), have been documented as playing a role in concussion care, recovery times, and long-term outcomes in a variety of populations. However, the role and influence of race as a social construct and determinant of health in those who have experienced a concussion has received considerably less attention.

The underlying causes of racial disparities in healthcare access, quality, and outcomes are structural (i.e., related to work, access to healthcare, and education) and cultural racism (i.e., related to imagery or stereotyping in everyday life) that systematically supports a pattern of unfair resource allocation that provides unearned advantages to the dominant racial group in society (21). Racial gaps in health continue to persist

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overtime and these health disparities have been documented across many disciplines (e.g., psychology, neurology, immunology, obstetrics, cardiology, child development) (22,23). Further, prior studies have provided initial evidence of disparities between Black and White athletes related to this injury. Specifically, Black athletes may be less likely to report a suspected concussion (24,25) and have less knowledge of concussion signs and symptoms than White athletes (26,27). Additionally, compared to their White peers, Black adolescent athletes are at greater risk of returning to play prematurely (28). However, research on race and clinical outcomes following concussion remains underrepresented among collegiate studies with only one known investigation concluding that there were no racial differences in symptom resolution or return to play times in a very small cohort of football players (29). This gap within the literature is likely due, in part, to a lack of reporting of racial identities in research on collegiate athletes. This becomes more consequential when considering the racial demographic data of NCAA athletes. Black male athletes are disproportionately represented in football (Black males represent 40% of NCAA football players vs. 12% of US population (30,31); which has the highest frequency of concussion in collegiate athletics (2,32). Therefore, coupled with potential racial differences in injury disclosure and knowledge, Black collegiate football players may be subject to a greater burden of injury and more pronounced disparities in concussion-related outcomes compared to other collegiate athletes. Given the ambiguous nature of concussions and the diverse racial demographics of athletes that participate in collision and contact sports, especially football, a thorough examination of racial disparities in concussion awareness approaches, management practices, and health outcomes is warranted.

Multiple explanations for disparities in concussion management have been put forward using the socio-ecological framework inclusive of race as a social determinant of health. Important findings from the adolescent literature include Black athletes having less access to concussion-related preventative education and healthcare resources (24), less favorable attitudes toward concussion diagnosis and treatment (33), increased utilization of public health insurance (28), and less adherence to healthcare provider recommendations (34). All of these factors are facilitated by the historical and systemically prejudiced paradigms of discrimination within the US healthcare and education systems at large that may inhibit early concussion identification and/or negatively impact recovery outcomes. For example, in two separate studies, Wallace (27,35) found that Black high school athletes and their parents had less knowledge about concussion signs and symptoms than White athletes and their parents, and these differences were broadened by the absence of an athletic trainer within the school system (36). This is indicative of inequitable access to a licensed healthcare provider resulting in unequal health-related educational and care opportunities between Black and White peers. However, it remains unclear how these variables may influence concussion care among collegiate athletes.

There is an immediate need to identify if social determinants of health, like race, hinder early and accurate concussion symptom reporting, diagnosis, and/or treatment in collegiate athletes, potentially inhibiting the achievement of optimal health outcomes. This study leveraged a multi-site database of concussions sustained by collegiate athletes to determine if disparities in diagnosis and recovery trajectories exist between (I) a full sample of collegiate athletes with Black or White racial identities, and (II) a subsample analyses of only collegiate football athletes with Back or White racial identities. Additional moderating variables that may interact with race and impact concussion diagnosis and recovery, such as sport type, biological sex, previous concussion history, and a history of depression or anxiety, were also considered. Informed by previous literature in adolescent populations (24,36), we hypothesized for both purposes (I and II), that the time between injury occurrence and diagnosis would be longer for Black collegiate athletes compared to White collegiate athletes, but that Black collegiate athletes would achieve symptom resolution and return to sport quicker than their White counterparts.

Methods

Study design

We used a retrospective cohort study design of concussions previously sustained by NCAA collegiate athletes at LIMBIC Military and Tactical Athlete Research Study (LIMBIC MATARS) member institutions. The master dataset consisted of 1,311 diagnosed cases of concussion from 11 contributing NCAA institutions.

Data acquisition procedures

The lead investigators at each contributing institution collaboratively determined and operationally defined a list of demographic, sport, sports medicine coverage, and post-concussion outcome variables, known as common data elements, to be retrospectively extracted. Data use agreements, confidentiality disclosure agreements, and institutional review board approval were established for each site that was facilitated by the co-principal investigator (JER) from the University of Virginia. The agreed upon common data elements were then extracted from athlete medical records at each institution for concussions that occurred during the academic years of 2015–16' through 2019–20.' Rationale for ending data collection during the 2019–20' sport season was based on the COVID-19 pandemic disruptions that occurred starting in March 2020 in the US.

The number of common data elements contributed by each institution varied. Each site contributed the common data elements that were documented as part of their institution's pre-established pre-participation examination and concussion management policies and procedures. The extracted concussions were clinically diagnosed and documented by licensed sports medicine healthcare providers (i.e., athletic trainers) based upon consensus definitions at the time of injury (7,37). Each of the contributing institutions had a minimum of two or more athletic trainers to provide on-campus medical care for their collegiate athletes. While no participating university reported the absence of athletic training coverage, immediate access (i.e., sideline

coverage) was variable based on institution (e.g., Division I as compared to Division II) and sport (e.g., football [i.e., collision sport] vs volleyball [i.e., non-contact]). Regardless, athletic trainers at all participating sites were involved with concussion identification, management, and the return to sport protocol leading to full clearance.

Each concussion case represented a singular injury event, therefore, if an athlete sustained two concussions during the study period this was represented as two different concussion cases within the master datafile. Each concussion case and site was assigned unique identification numbers to ensure anonymity throughout the data collection process. After individual institutional data extraction, each site submitted a deidentified excel file of their documented concussions. The co-principal investigator (JER) then aggregated all submitted concussion cases into a master dataset that was circulated to all LIMBIC MATARS member institution researchers to be used for analyses. The methods of the LIMBIC MATARS consortium have been more comprehensively detailed elsewhere (*cite methods paper – under review*).

Study variables and data preparation

The primary independent variable of interest for the current study was racial identity (dichotomized: Black or White). This common data element was acquired through pre-participation physical examination documents used for clinical purposes by each member site. Options for the 'Race and Ethnicity' common data element in the master dataset were consistent with those reported by the NCAA (30) and recognized by the National Institutions of Health (38), which included American Indian or Alaska Native, Asian, Black, Hispanic or Latino, Native Hawaiian or Other Pacific Islander, and White. Based upon the resultant sample sizes, we only included concussion cases that occurred to either Black or White collegiate athletes as there were not enough injuries for the inclusion of other racial and ethnic identities. Two of the nine LIMBIC MATARS contributing institutions did not include racial identity data, and were subsequently excluded from the analyses of the present study. It is also notable that 1 contributing institution was a US Department of Education-Accredited HBCU (Virginia Union University).

The dependent variables of interest were post-concussion clinical milestones, including from the time of injury occurrence to 1) diagnosis (Dx), 2) symptom resolution (SR), and 3) return to sport (RTS). Date of Dx was defined as the date of diagnosis of a concussion by an athletic trainer or physician. Date of SR was operationalized as the date when an athlete reported symptom free following their concussion or when they began the RTS protocol. The inclusion of the initiation of the RTS protocol is consistent with the more recent definition of 'symptom resolution at rest' as defined in the International Concussion in Sport Group guidelines as being asymptomatic or 'symptom free' following a concussion may not be realistic for all athletes (39). Date of RTS was defined as the date that an athlete returned to sport following a diagnosed concussion which was inclusive of the completion of a RTS protocol. We only included concussion cases that provided data for all timepoints.

Statistical analysis

Data were analyzed using SPSS version 26.0 (Armonk, NY). Descriptive statistics and frequencies by race were computed. Statistical racial identity group differences for demographic variables were determined with an independent T-test (i.e., age) and Chi square analyses (i.e., biological sex, sport type, history of previous concussion, history of anxiety or depression). Data for all dependent variables were not normally distributed and violated assumptions of homogeneity of variance ($p < .05$ for Shapiro Wilk's and Levene's tests), accordingly, nonparametric statistical approaches were deployed. We completed a series of preliminary Kruskal Wallis analyses by race to determine the potential influence of biological sex (male; female), previous concussion history (yes; no), and a history of anxiety or depression (yes; no) on the days from injury occurrence to 1) Dx, 2) SR, and 3) RTS. The results of these preliminary comparisons revealed no meaningful interactive effects on any diagnosis or recovery outcomes of interest. Therefore, these factors were not further considered. Independent Mann-Whitney *U* tests were used to compare the median days from injury occurrence to 1) Dx, 2) SR, and 3) RTS between collegiate athletes with Black and White racial identities. Mann-Whitney *U* tests were performed on both the full sample and on a subsample of concussions that occurred in football athletes only. Statistical significance for all analyses was set at $p < .05$ *a priori*.

Results

Of the original sample of 1044 extracted concussions, 410 (39.3%) injury cases were included in analyses following screening for independent and dependent variable availability (Figure 1). The resultant sample consisted of 114 (27.8%) concussions sustained by Black athletes and 296 (72.2%) concussions sustained by White athletes (Table 1). Additionally, 46.6% ($n = 191$) of the included concussion cases occurred in football, with Black football players sustaining 89 (46.6%) injuries and White football players sustaining 102 (53.4%) injuries. There were racial identity group differences by biological sex and sport type (Table 1).

The overall sample had a median (IQR) of 0 (0, 1) days between injury occurrence and Dx, 7 (4,13) days to SR, and 12 (8,20) days to RTS. The football subsample had a median of 0 (0, 1) days between injury occurrence and Dx, 7 (4,13) days to SR, and 11 (8,20) days to RTS. When comparing racial identity for all cases, there were no significant differences observed between Black and White collegiate athletes in time from injury occurrence to Dx ($p = .14$), SR ($p = .39$), or RTS ($p = .58$; Figure 2). The same was true for Black and White collegiate football players for days from injury occurrence to Dx ($p = .96$), SR ($p = .95$), and RTS ($p = .88$). Table 2 provides dependent variable summary statistics by racial identity for all included concussion cases and the football-only concussion subsample.

Discussion

This was one of the first studies to investigate the role of racial identity in time to concussion diagnosis and recovery in

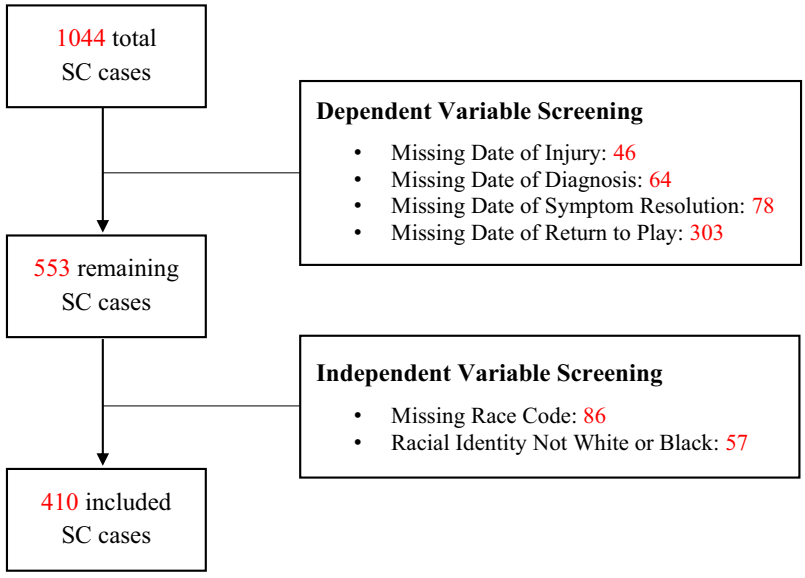

Figure 1. Overview of the data preparation process.

Table 1. Demographics of included concussion cases by racial identity.

	Racial Identity (total *n* = 410)		
	Black n = 114 (27.8%)	White n = 296 (72.2%)	*P* value
Age (mean±SD)	20.02 ± 1.4 years	19.87 ± 1.4 years	.746
Biological Sex			<.001
Female	18 (4.4%)	143 (34.8%)	
Male	96 (23.4%)	153 (37.3%)	
Sport Type			<.001
Non-Contact	3 (.01%)	82 (20.0%)	
Contact	22 (5.3%)	112 (27.3%)	
Collision (Football Only)	89 (21.7%)	102 (24.8%)	
History of Previous Concussion			.426
Yes	47 (11.4%)	126 (30.7%)	
No	62 (15.1%)	181 (44.1%)	
Missing	5 (1.1%)	21 (5.1%)	
History of Anxiety or Depression			.206
Yes	11 (2.6%)	20 (4.8%)	
No	73 (17.8%)	219 (53.4%)	
Missing	30 (7.3%)	57 (13.9%)	

Percentages are reflective of the total n. *P* values are reflective of the results of the T-test (i.e., age) and Chi square analyses (i.e., biological sex, sport type, history of previous concussion, history of anxiety or depression) for group differences.

a multi-site sample of collegiate athletes. We initially hypothesized that the time between injury occurrence and clinical Dx would be longer for Black collegiate athletes compared to White collegiate athletes, but our results suggested there were no differences in Dx timing by racial identity. Our study findings also refuted our additional hypotheses that Black collegiate athletes would report SR and RTS sooner than White collegiate athletes. Overall, we did not observe any racial identity concussion diagnosis or recovery timeline disparities in our sample of collegiate athletes. This was true when we considered the entire sample of extracted concussions together, as well as those occurring in football athletes only.

Previous literature has identified differences in concussion nondisclosure and sign and symptom knowledge by race in collegiate athletes that could potentially contribute to a delay in injury management (25,26). Specifically, Black collegiate athletes were significantly more likely to report that they did not disclose a suspected concussion because they did not recognize that they had sustained a concussion at the time of injury (26). This closely corresponds to the finding that Black collegiate athletes have less knowledge of common concussion signs and symptoms (e.g., dizziness, difficulty concentrating, memory loss) compared to their White counterparts (26). While compelling to conceptualize how this impacts concussion identification and management, these factors ultimately did not appear to impede the timely diagnosis and care initiation for concussions sustained by Black collegiate athletes in this study. The majority of concussions were diagnosed on the same day the injury occurred (60.9%), and this happened even more frequently in the subsample of concussions sustained during football participation (70.1%). Given the importance of immediate recognition and removal from play on optimizing concussion recovery outcomes (6), the lack of racial identity

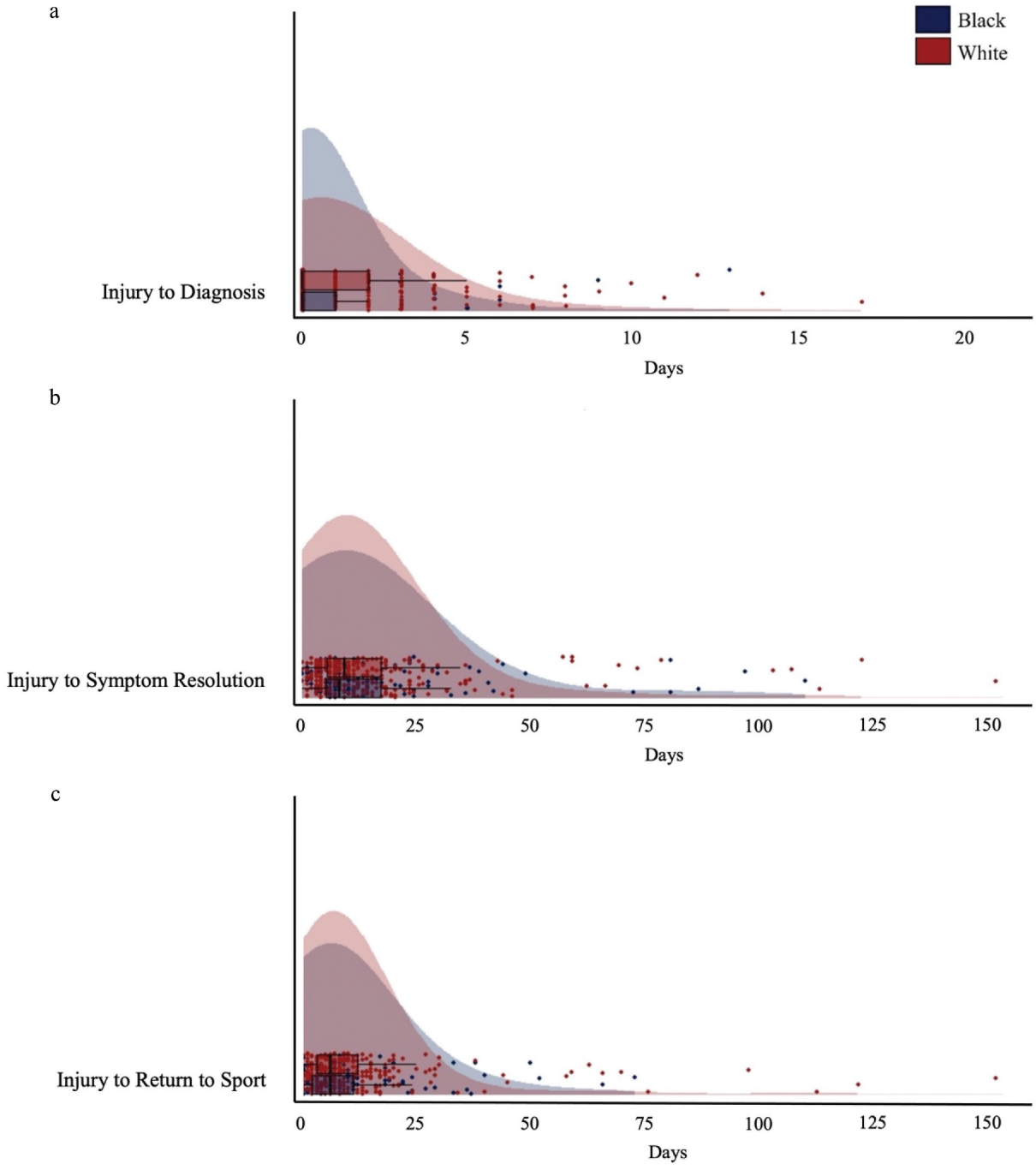

Figure 2. Raincloud plots (including frequency curves, box plots, and scatter plots) representing the dependent variables of time (in days) from date of injury to (A) diagnosis, (B) symptom resolution and (C) return to sport, among black (navy blue) and White (red) collegiate athletes. Frequency curves and scatter plots detail the frequency and spread of the data, the box plot purports the minimum (Q1–1.5*IQR), the Interquartile range (IQ), including the 25th percentile (Q1), median, and 75th percentile (Q3), and maximum (Q1 + 1.5*IQR) for the spread of the data.

differences related to diagnosis timing in this sample are highly favorable.

Moving away from diagnosis and into the post-injury management and recovery process, we again must consider the role that health literacy may play in one's ability to accurately identify and report concussion signs and symptoms. A recent pediatric study (28) concluded that young Black athletes reported to be symptom free in significantly fewer days than young White athletes. While theorizing this finding, the researchers (28) noted that concussion knowledge racial disparities observed in this population (27) may be one contributing factor to the symptom resolution timing differences they found. Previous research has identified concussion knowledge discrepancies between Black and White athletes at both the high school (27) and collegiate levels (26). However, we did not observe result similarities for SR racial differences in our collegiate sample compared to those previously found in a younger athlete sample where Black athletes reported SR a median of 12.3 days post-concussion versus 21 days for White athletes (28). Our results found a median of 7 days

Table 2. Summary statistics for racial identity comparisons of concussion diagnosis and recovery outcomes.

	All Included Concussion Cases					
	Black Racial Identity ($n = 114$)		White Racial Identity ($n = 296$)		Group Comparison	
Days from Injury to …	Md	IQR	Md	IQR	U	*p-value*
Dx	0	0, 1	0	0, 2	15474.50	0.14
SR	7	3, 12	7	4, 13	15960.00	0.39
RTS	11	8, 20	12	9, 20	16284.00	0.58
	Football Only Concussion Cases					
	Black Racial Identity ($n = 89$)		White Racial Identity ($n = 102$)		Group Comparison	
Days from Injury to …	Md	IQR	Md	IQR	U	*p-value*
Dx	0	0, 1	0	0, 1	4523.50	0.96
SR	8	3, 12	7	4, 13	4516.00	0.95
RTS	11	8, 20	11	8, 19	4481.50	0.88

Md = Median, IQR = Interquartile Range (25th percentile, 75th percentile), Dx = Diagnosis, SR = Symptom Resolution, RTS = Return to Sport.

from the time of injury occurrence to SR for our sample of concussions cases sustained by Black and White collegiate athletes. Our findings are similar to one collegiate athlete study by Mihalik et al. (29) that did not find any symptom resolution timing differences between Non-Hispanic White ($n = 18$) versus Black ($n = 16$) American football players. Additionally, while shorter than those reported in pediatric populations (28,40), our median 7-day symptom resolution timeline is fairly consistent with what has previously been reported in the collegiate concussion literature (41,42). The congruency of concussion SR timing between Black and White collegiate athletes observed in our study is positive evidence that supports that the presence of sports medicine healthcare may potentially mitigate racial inequities at this level of competition.

Similar to our concussion SR findings, the results of our investigation did not identify any racial identity differences regarding RTS timing. We observed medians of 11 and 12 days from date of injury to RTS for Black and White athletes, respectively. For football players specifically, we observed 11 median days for both Black and White racial identities. Our overall findings closely mimic those of a recent study of 185 collegiate athletes that also reported a median of 11 days of total time loss from participation due to a concussion (42), as well as those by the NCAA-DOD CARE Consortium that reported a median duration of 12.8 days until return to participation across all athletes from all sports (9). It is challenging to truly situate our findings with previous investigations as the larger collective of existing collegiate athlete concussion literature rarely captured or considered racial identity in analyses. Mihalik (29) established previously there were no RTS time differences in concussions occurring to Non-Hispanic White versus Black American football players. Beyond this, there are a few studies of concussion recovery in adolescent athletes that include race as a potential modifying factor. In two studies by Aggarwal (43,44) results indicated that 13–19 year-olds from an underrepresented racial identity group recovered faster than White patients (13 versus 18 median days to return to play clearance) and that Hispanic and Black race predicted shorter concussion return to play clearance times compared to White race (11 versus 19 days). Additionally, while not specific to return to sport timing, another investigation found evidence of potential concussion racial disparities, as Black adolescent patients (5–18 years old) were more frequently referred for further specialty care compared to White patients (34). Overall, we did not observe similar differences in time to RTS or recovery by racial identity in our sample of collegiate athletes that has been found in younger populations.

The null findings from our study are favorable. It is plausible that the collegiate athletics environment neutralizes the barriers that may contribute to the race-related concussion recovery disparities observed during youth and high school athletic participation. At this level of sport, collegiate athletes typically have access to consistent, on-campus healthcare resources, particularly among higher concussion risk sports such as football. The mere presence of full-time athletic trainers in the collegiate sport setting is a privilege that is comparatively only afforded to 35% of secondary schools nationally (45). Athletic trainers are highly skilled sports medicine healthcare providers that are specially trained to immediately identify and manage concussions at the time of injury. Additionally, athletic trainers work under and directly collaborate with sports medicine physicians to facilitate optimal care for their patients in real time. It is also common practice for institutions to provide or partially assist collegiate athletes in acquiring health insurance if they did not have it upon arrival to campus. Where it may take days or weeks for an adolescent athlete to receive a follow-up concussion assessment by a qualified healthcare provider (if available) and begin treatment, this process is greatly expedited for collegiate athletes based upon the current standards of sports medicine healthcare provided to them at this level. Such access to clinical care may offset the presence of social determinants of health-related barriers that may have previously inhibited them from being able to seek care. These could include financial constraints related to health insurance or medical service fees, a lack of transportation to and from healthcare facilities, or an absence of quality healthcare providers directly in their hometown neighborhoods. Thus, sports medicine healthcare in collegiate athletics may demonstrate a proof of concept that providing a consistent, equitable standard of concussion care could reduce health

disparities, improve health outcomes, and be a model for achieving these goals in other settings.

Limitations and future directions

This study was not without limitations. A major strength of our study is that the included data on concussion cases are a true representation of the current clinical management practices of collegiate sports medicine healthcare providers from a geographically diverse sample of institutions. As such, our results yielded respectable external validity but lower internal validity. Inherent to the retrospective medical chart review approach we used came a lack of control regarding the standardization of assessment tools, approaches to concussion diagnosis, and management practices between participating institutions. While the data extraction process included all concussion cases occurring to both men and women participating in all NCAA-sanctioned sports, there was a lack of or very small sample sizes for some racial identity groups. Additionally, we did not consider the social construct of ethnicity. Due to this, our investigation was limited to only assessing concussion diagnosis and recovery trajectories between Black and White collegiate athletes, and we cannot extrapolate our findings to those with other racial identities. Furthermore, it is notable that our sample only included 20 concussions sustained by Black female athletes (4.4% of the entire sample). While small, this frequency is consistent with the NCAA demographic information (30) from our study period that indicated Black females make up 5% of collegiate athletes each year, which warranted their inclusion. Future research should develop partnerships with colleges and universities with greater representation of collegiate athletes from underrepresented racial and ethnic identity groups that were not included in this study (e.g., American Indian or Alaska Native, Asian, Hispanic or Latino, Native Hawaiian or Other Pacific Islander). Future work must also consider the intersection of multiple different social determinants of health and their collective impact on concussion health literacy, disclosure behaviors, assessment approaches, management practices, and ultimately recovery trajectories at the collegiate sport level. Moreover, culturally responsive care may be further informed by including the demographic identities of health care professionals to mitigate inadvertent biases in managing concussion among diverse athletes.

Conclusions

We did not observe any differences in Dx, SR, or RTS timelines between concussion cases sustained by Black and White collegiate athletes included in this investigation. Therefore, racial identity health disparities related to concussion outcomes identified in pediatric athletic populations may not persist into collegiate sport participation. These findings provide evidence that there may be equitable sports medicine healthcare practices related to concussion diagnosis and management in the collegiate sport setting, which may be a byproduct of the access to on-site sports medicine healthcare resources afforded to collegiate athletes that are not present at lower levels of athletic competition. The findings of this study should be further examined in a larger sample of ethnically and racially diverse college athletes that represent institutions in geographically diverse regions.

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Disclosure statement

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