Evaluating Concussion Nondisclosure in College Athletes using a Health Disparities Framework and Appreciation for Social Determinants of Health

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Examining Concussion Nondisclosure in College Athletes using a Health Disparities Framework and Consideration of Social Determinants of Health

Abstract:

Context: There is limited research concerning the relationship between social determinants of health, including race, healthcare access, socioeconomic status (SES), and physical environment; and, concussion nondisclosure in college-athletes. However, in high school athletes, disparities have been noted, with Black athletes attending under-resourced schools and lacking access to an athletic trainer (AT) disclosing fewer concussions.

Objective: To investigate whether concussion nondisclosure disparities exist by 1) race, 2) SES, and 3) AT healthcare access prior to college; and to understand the differential reasons for concussion nondisclosure between Black and White college-athletes.

Design: Cross-sectional

Setting: College athletics

Participants: 735 college-athletes (84.6% White, 15.4% Black)

Main Outcome Measures: Participants completed a questionnaire that directly assessed concussion nondisclosure, including reasons for not reporting a suspected concussion. With the premise of investigating social determinants of health, race was the primary exposure of interest. The outcome of interest, nondisclosure, was assessed with a binary (yes/no) question, “Have you
ever sustained a concussion that you did not report to your coach, athletic trainer, parent, teammate, or anyone else?”

**Results:** Overall, among White and Black athletes 15.6% and 17.7% respectively reported a history of concussion nondisclosure. No significant differences were found by race for distributions of history of concussion nondisclosure (p=0.57). Race was not associated with concussion nondisclosure when evaluated as an effect modification measure or confounder; and, no significant associations were noted by SES or high school AT access. Differences by race for reported reasons for nondisclosure were found for: “At the time I did not think it was a concussion” (p=0.045) and “I thought my teammates would think I am weak” (p=0.03) with Black athletes reporting these more frequently than White athletes.

**Conclusions:** These data help to contextualize race and its intersection with other social determinants of health that could influence concussion nondisclosure outcomes in college-athletes.

**Key Words:** social determinants of health, race, concussion nondisclosure, health disparities

**Key Points:**

- Our findings differ from those in the high school age group which suggests racial disparities concerning nondisclosure may be improved from high school to college due to the medical and personnel infrastructure available in the collegiate environment.

- Race was examined as an effect modification measure and confounder. Race was not associated with nondisclosure in these models; however, other factors such as being
female was associated with lower odds of nondisclosure while having a previously diagnosed concussion and higher concussion knowledge were associated with higher odds.

- This study can serve as an example for larger scale community-based interventions as it suggests that equal and equitable access to resources, including an AT, can mitigate concussion nondisclosure.
INTRODUCTION

An athlete’s ability to identify and immediately report a head/brain injury is paramount for facilitating proper management and more favorable recovery outcomes.\textsuperscript{1,2} Recent evidence suggests collegiate\textsuperscript{1} and adolescent athletes\textsuperscript{3} delaying concussion reporting take longer to recover compared to those who were more rapidly removed from activity. Although concussion resources highlight the dangers of playing while concussed and encourage athletes to immediately report their injuries, there is a sizable portion of college-athlete concussions that go unrecognized and undisclosed.\textsuperscript{4,5} Further, previous literature suggests that the issue of concussion nondisclosure may not be rooted in a lack of injury comprehension in this population, as college-athletes tend to have favorable levels of concussion knowledge.\textsuperscript{6}

Previous college-athlete studies consider differences in concussion reporting based upon sex/gender, sport participation, diagnosed concussion history, and injury knowledge.\textsuperscript{4,5,7} But, studies with intention to ascertain the relationship between social determinants of health (SDOH) [e.g., \textit{upstream factors}\textsuperscript{8} such as race, healthcare access, socioeconomic status (SES), physical environment] and concussion nondisclosure in this population are rare. Upstream SDOH are social factors that can have direct or indirect effects on health, and play a fundamental causal role in understanding health outcomes.\textsuperscript{8} The only study broaching such topics in the college setting suggests no observed differences in concussion reporting intentions or behaviors between college-athletes from high- versus mid-SES households.\textsuperscript{9} This study did not consider low-SES due to a lack of sample diversity and did not consider any other SDOH; therefore, more research is needed.

There are a number of foundational studies, in adolescent populations, regarding the interplay between different SDOH and concussion knowledge and reporting. When considering
race, previous literature concluded that White high school (HS) athletes have higher concussion symptom knowledge compared to their Black peers, and this same disparity was observed in parents of HS athletes. In addition to knowledge, a previous study by Wallace et al. noted differences in concussion reporting by race. Results indicated that Black HS athletes recalled and reported less concussive events compared to White athletes; a reason for not reporting was linked to not recognizing a concussive event as a concussion. The authors discussed this decrease in concussion reporting by Black HS athletes may be related to symptom recognition disparities that ultimately stem from environmental/structural (e.g. low SES, Title I schools, residential segregation) and healthcare access (e.g. on-site sports medicine healthcare) inequities that have subsequently limited concussion education programming. This philosophy is supported by previous results that athletes attending urban, Title I HSs had poorer concussion knowledge than athletes from suburban, non-Title I schools. Additionally, HS athletes lacking access to an athletic trainer (AT) were less knowledgeable about concussions than those with AT access.

While SES and healthcare access were factors identified concerning knowledge differences, these SDOH were not linked to more or less favorable injury reporting behaviors in HS athletes. However, it is unclear if these trends continue into college sport participation.

On an all-encompassing level, race, and the resulting structural racism, has been identified as the SDOH that is a root cause of health inequalities. The intersection of race with the spectrum of SDOH has the potential to magnify health disparities. One example of structural racism is residential segregation in which there is a separation of Black and White communities. These residential differences shape health as access to healthcare, quality of neighborhoods, healthcare utilization, and quality of schools are associated with adverse health outcomes. Notably, among college-athletes, 81,100 (16%) of all National Collegiate Athletic
Association (NCAA) participants identify as Black; however, the majority of Black athletes participate in higher-risk concussion sports such as football and men’s and women’s basketball compared to sports such as tennis, swimming/diving, rowing, and fencing. Before these sociodemographic inequities and barriers can be reduced, eliminated, and overcome, we must first establish the extent of the disparities.

To do this, we incorporated the use of the Health Disparities Research Framework outlined by Kilbourne at al.\textsuperscript{18} that includes three phases: detecting, understanding, and reducing. Using this comprehensive framework, alongside consideration of SDOH, can provide opportunities for the design of interventions that can improve health and reduce disparities in concussion-related outcomes. Thus, the aim of this study was to investigate concussion nondisclosure in college-athletes using a health disparities framework. We specifically sought to detect if there are disparities in concussion nondisclosure by 1) race, 2) SES, and 3) sports medicine (AT) healthcare access prior to college, and to understand the potential differential factors related to concussion reporting between Black and White college-athletes.

METHODS

Participants

The Institutional Review Board at XXX approved this study prior to initiation of data collection. A cross-sectional survey was administered to male and female NCAA athletes at seven participating universities (Division-I, n=4; Division-II, n=2; Division-III, n=1) within 3 geographic regions of the US (Midwest, East, Southeast). College-athletes were eligible to participate if they were currently participating in an NCAA sport and were ≥ 18 years old. Exclusionary factors included those who indicated being an international student, those who sustained a concussion in the previous three-months, or were experiencing prolonged issues (e.g.,
lingering symptoms, undergoing treatment) related to a previous concussion. We used these exclusionary criteria to decrease the potential bias a recent injury experience may have on survey responses. The final convenience sample included 735 athletes.

**Instrumentation and Variables of Interest**

A questionnaire was adapted from previously published research, and, most participants completed it within 15-20 minutes. The questionnaire included sections to understand demographics, self-reported medical history, followed by concussion perceptions, knowledge, and reporting behaviors. An in-depth explanation of examination of concussion perceptions and knowledge are described in previous publications. Demographics included: age, sex, race/ethnicity, history of free-or-reduced lunch (FRL) in high school (yes/no), current academic year, current sport, total years of participation in their current sport (overall and at the collegiate level), NCAA Division, and access to an AT while in HS (yes/no). Finally, participants were asked about a previous history of concussion diagnosis with a binary (yes/no) question: “Have you ever been diagnosed with a concussion by a doctor or AT?”

With the premise of investigating SDOH, race was the primary exposure of interest. We only evaluated racial comparisons between athletes that self-identified as White and Black (75% of all participants) because these two racial groups comprised the majority of participants in the NCAA, and few individuals from other racial/ethnic groups participated. Additional SDOH included FRL and HS AT access. FRL is a proxy widely used in education literature and is an indicator of lower SES. Finally, because all participating athletes had access to an AT at their college/university, sports medicine healthcare access prior to college was accessed using HS AT access.
The primary outcome was concussion nondisclosure. Nondisclosure was assessed with a binary (yes/no) question: “Have you ever sustained a concussion that you did not report to your coach, athletic trainer, parent, teammate, or anyone else?” Athletes then noted, from a preset list of 16 reasons, all the reasons for not reporting a concussion or potential concussion symptoms (e.g., ‘I thought my coach would get mad,’ ‘At the time I did not think it was a concussion,’ ‘I thought my teammates would think I’m weak,’ ‘I did not think it was a serious injury,’ ‘My team was going to the playoffs when it happened,’ ‘I did not want to let my team down,’ etc.) Athletes could select more than 1 reason.

**Procedures**

Study team members made first contact with ATs at each participating institution to inform them of the study aims and procedures. We then worked in conjunction with the sports medicine teams at each site to schedule data collection sessions prior to or following athletic team activities. At each session, a research team member presented prospective participants with an informed consent form, verbally described the study, and was available to answer questions regarding the survey. College-athletes who agreed to participate completed the survey using a smart device or pencil-and-paper depending upon site-specific resources. Electronic surveys were administered using Qualtrics (Provo, UT). Trained research assistants recorded paper-and-pencil responses into this database, with a random comparison assessment employed to certify accurate survey entry.

**Statistical Analysis**

Descriptive statistics (i.e., frequencies and percentages) were calculated for athlete characteristics. Chi-square tests assessed differences in the distributions of diagnosed concussion
history and history of concussion nondisclosure by: first, race (White, Black); and then race
coupled with FRL (White/FRL; White/no FRL; Black/FRL; Black/no FRL) and HS AT access
(White/access; White/no access; Black/access; Black/no access).

Next, multivariable logistic regression models identified SDOH associated with
concussion nondisclosure. In order to fully assess the role of race (White vs. Black), an a priori
plan was established to assess for race as an effect measure modifier first, and then a
confounder. To assess for effect measure modification, separate models were run for White and
Black athletes. For each, Model 1 included only FRL (yes vs. no) and HS AT access (yes vs. no)
as predictors. Model 2 further added sex, diagnosed concussion history (yes vs. no), and
concussion symptom knowledge (1-point increase on scale) as predictors. Given small sample
sizes and the concerns about low statistical power, it was decided to rely on an “eyeball test” vs.
statistical tests to assess effect measure modification (i.e., did findings at face value seem
different?). If effect measure modification was not found, then race was included in a model as a
confounder with all athletes combined. For these analyses, Model 1 explored race as the sole
predictor; Model 2 added FRL and HS AT access; and Model 3 added sex, diagnosed concussion
history, and concussion symptom knowledge. All adjusted ORs with 95% confidence intervals
excluding 1.00 were deemed significant.

Last, among athletes that self-reported concussion nondisclosure, frequencies were
provided regarding the reported reasons for which nondisclosure occurred. Chi-square tests
assessed whether distributions by race differed. P-values <0.05 were deemed statistically
significant.

RESULTS
A total of 735 college-athletes (Black n=113/735, 15.4%; White n=662/735, 84.6%) were included in the study (Table 1). Overall, 30.2% and 25.7% of White and Black athletes respectively indicated a previous diagnosed concussion history; 15.6% and 17.7% respectively reported a history of concussion nondisclosure. No significant differences were found by race for distributions of diagnosed concussion history (p=0.33) and history of concussion nondisclosure (p=0.57; Table 2). No further differences were found when further assessed by FRL and HS AT access.

**Logistic Regression Models with Social Determinants of Health**

Table 3 presents results from analyses with race as an effect modifier. FRL and HS AT access were not associated with concussion nondisclosure within White or Black athletes. Reporting a previous diagnosed concussion history was associated with increased odds of concussion nondisclosure among White (OR=2.59; 95%CI: 1.65,4.07) and Black athletes (OR=5.76; 95%CI: 1.97,16.80). In addition, females were less likely than males to report concussion nondisclosure among White athletes (OR=0.42; 95%CI: 0.26,0.68); findings were similar among Black athletes but were not significant (OR=0.31; 95%CI: 0.03,2.98). Likewise, increased concussion symptom knowledge was associated with increased odds of concussion nondisclosure among White athletes (1-unit increase OR=1.08; 95%CI: 1.01,1.15); findings were similar among Black athletes but were not significant (OR=1.08, 95%CI: 0.95,1.24).

Although there were small variations in findings between White and Black athletes, follow-up models were conducted to examine race as a confounder (Table 4). In Model 3, increased odds of concussion nondisclosure was not associated with race (OR=1.04; 95%CI: 0.57,1.91), FRL (OR=1.07; 95%CI: 0.59,1.96), and HS AT access (OR=0.71; 95%CI: 0.39,1.29). The odds of concussion nondisclosure decreased with being female vs male.
(OR=0.41; 95%CI: 0.26,0.67); increased with reporting a previous diagnosed concussion
(OR=2.97; 95%CI: 1.96,4.50), and increased concussion symptom knowledge (1-unit increase
OR=1.07; 95%CI: 1.01,1.14).

**Reasons for Concussion Non-Disclosure**

The most common reasons for nondisclosure for Black athletes were: “I did not want to
let my team down” (n=15/20, 75.0%), followed by “At the time I did not think it was a
concussion” (n=13/20, 65.0%), and “I did not want to lose playing time” (n=12/20, 60.0%; Table
5). The most common reasons for non-disclosure among White athletes were: “I did not want to
miss a game” (n=70/97, 72.2%), “I did not want to lose playing time” (n=69/97, 71.1%), and “I
did not want to let my team down” (n=53/97, 54.6%). Differences in distribution by race for
reasons for nondisclosure were found for: “At the time I did not think it was a concussion”
(White: 38.1% vs. Black: 65.0%; p=0.045) and “I thought my teammates would think I am
weak” (White: 24.7% vs. Black: 50.0%; p=0.03).

**DISCUSSION**

This study aimed to investigate concussion disclosure in college-athletes using a health
disparities framework with a specific focus on the influence of race, SES, and sports medicine
healthcare access prior to college. The current study is one of the first to explore race as an effect
modifier where we observed, although small, varied effects for White and Black athletes
concerning concussion nondisclosure. Given the small differences, this study also examined race
as a confounder. Race was not associated with nondisclosure in these models; however, other
factors such as being female was associated with lower odds of nondisclosure while having a
previously diagnosed concussion and higher concussion knowledge were associated with higher
odds. This approach provided a more comprehensive understanding of how factors at various
levels of the socioecological model, in union with the Pyramid of Influence,$^{23}$ may impact nondisclosure; and, are similarly supported by previous literature among college-athletes.$^9$,$^{24,25}$ These findings provide foundational information to support further exploration of race and the influence of other SDOH on concussion nondisclosure.

Alongside our primary purpose, we explored basic demographic differences between Black and White athletes as these factors may provide underpinning differences associated with diagnosed concussion history and nondisclosure. The overall sample was weighted more heavily towards first-year athletes. As such, our study findings may be reflective, in this subset, of their more recent HS experiences, versus the full college experience that may be reported by athletes further along in their college careers. Our sample consisted largely of White athletes; however, the proportion of first-year students was similar across Black and White athletes. Additionally, previous studies in first-year athletes observe similar findings to those further in their college careers.$^{24,26}$ While Black and White athletes were similar in many aspects of the study sample, a higher proportion of Black athletes played Division I (55.8% vs. 35.2%), were male (89.4% vs. 54.3%), and reported having FRL in HS (43.4% vs 9.3%). Several of these differences may be the result of recruitment strategies and potential response bias to the survey. However, the FRL differences may illustrate potential disparities prior to arriving to college that can influence concussion-related outcomes and nondisclosure. When examining associations between diagnosed concussion history as well as nondisclosure by FRL status and HS AT access, no distinct differences were observed between Black and White college-athletes. These findings indicate there may be other factors that mediate or moderate the influence of structural and SDOH in this population as these findings differ from those in the HS athletic setting.$^{12}$
Data from the NCAA indicate that a majority of Black-athlete participants, across divisions, are concentrated into a fewer number of sports. Notably, most of the Black athletes (92.0% vs 69.3%) in the current sample participated in higher concussion risk sports such as football and basketball. Collectively, these data highlight sport-based differences and could be related to Black athletes having less of an opportunity, or access to more affluent sports throughout their lifetime; and, this difference is a relevant edifice for concussion disclosure interventions designed for sports that may have higher Black representation. When racial demographics in HS and college athletics are monitored, Black athletes tend to frequent higher membership in contact sports than their White counterparts; and, this difference may underlie historical racial discrimination, affordability of certain sports, and limited accessibility to sport-specific infrastructure (e.g. golf course, tennis court, swimming pool) in residential spaces. Such inequitable access condenses a Black athlete’s opportunity to participate in various sports. This can also be seen historically in the U.S. social context where Black athletes were excluded from college and professional sports due to racial segregation. Black athletes were banned from participation in sports at certain institutions until there was an influx of civil rights policy and legislation passed to lawfully prohibit discrimination on the basis of race. Until that point, schools and consequently sports, were segregated which allowed for institutions to exclude Black athletes from participation. This ostracizing from athletic competition discouraged the Black community from participating in certain sports, further marginalizing the Black community from the White majority due to certain sports being unavailable.

**Statistical Models to Assess Nondisclosure**

We first examined factors associated with nondisclosure to better evaluate race as an effect measure modification using two stepwise models for each racial group separately. First, a
model only including defined SDOH, and a second including those SDOH and personal characteristics. For Black athletes, only reporting a previous diagnosed concussion was associated with concussion nondisclosure. Whereas, among White athletes, being female was associated with lower odds of nondisclosure; and, having a previous diagnosed concussion and higher concussion knowledge were associated higher odds of nondisclosure. These findings in White athletes are similar to previous work among college-athletes in this space concerning factors related to nondisclosure. The lack of associations in the Black athletes may be due to sample size, as many associations were trending in a similar direction to White athletes. However, these approaches provide insight into considerations examining race utilizing effect measure modification techniques as many of the findings we see in previous work may be driven by associations in one race and may not reflect trends across heterogeneous racial identities. These data provide one of the first examinations of racial influence on these outcomes; and, utilizing such methods may serve as a foundation for future research and outcome interpretation.

The second set of models included race as a confounder alongside other variables of interest. These models included unadjusted and adjusted approaches, including: 1) race alone, 2) race and defined SDOH, and 3) race, SDOH, and personal characteristics. In these three models, race was not significantly associated with nondisclosure. However, being female was associated with lower odds of nondisclosure. Having a concussion history and higher concussion knowledge were each associated with greater odds of nondisclosure. Our findings, specifically those concerning race, differ significantly from findings in the HS age group, with fewer Black athletes reporting concussive events compared to their White peers. This discrepancy is important as it highlights potential differences between HS and college-athletes. A noteworthy difference is that not all HS athletes have the opportunity to go onto participate in college
athletics, and that may include athletes with nondisclosure. Also, it is possible many of the
disparities concerning disclosure are improved from HS to college due to the medical and
personnel infrastructure available in the collegiate environment. Given that a high percentage of
the Black athletes in the current sample were Division I athletes, this may be even more relevant
because differences across divisions can influence how sports medicine departments are
financed, staffed, and supported. Moreover, it is possible that sampling differences, including a
smaller sample of Black athletes, broader geographical reach, and no apparent disparity in HS
AT access by race in our study, limited lateral comparisons of our findings and previous work
with HS athletes. Investigating how this infrastructure may improve such outcomes, or other
disparities that may exist, outside of those within the college environment is important for more
thorough understanding.

**Reasons for Concussion Nondisclosure**

Although reasons for concussion nondisclosure were somewhat similar between White
and Black athletes, Black athletes were more likely to not disclose concussion events, in attempts
to assimilate to their environment, simply because they did not want their teammate to think they
were being weak (50%) compared to their White counterparts (24%). This supports research that
indicates athletics has a reputation for encouraging athletes to be “tough” by ignoring possible
injury. Black athletes also indicated they did not disclose some instances of concussion because
at the time they “did not think it was a concussion” (65%) more often than White athletes
(38.1%). This echoes previous research that identifies disparities in concussion symptom
knowledge. Black athletes report poorer concussion symptom knowledge than White athletes;
and appear to obtain concussion information from different sources. There are a multitude of
overlapping individual and interpersonal factors at play influencing concussion nondisclosure, as
the pressure to conform to societal, cultural, and environmental norms may also be an important factor in concussion nondisclosure. This perspective stems from college athletics upholding the ideal of camaraderie and teamwork as essential to sport success, but also encourages a covert culture of nondisclosure due to various pressure sources and expectations. This culture of nondisclosure is continuously displayed through the actions and/or inactions of athletes’ concussion reporting behaviors and in the action, inaction, or pressure from college athletic stakeholders. Specifically, Black athletes could have battled these pressures, in addition to barriers related to their race (e.g. discrimination, negative stereotypes, microaggressions) that can negatively impact their experiences as college-athletes, or their decision to disclose a concussion.

**Contextualizing Nondisclosure with the Health Disparities Framework**

While the results of our study help us better understand nondisclosure between Black and White college-athletes, ultimately, these findings can help to begin efforts required to reduce disparities. Reducing, as defined in the Health Disparities Framework, can include clinical and protective interventions, translational approaches, dissemination or policy change. Combining this framework with the socioecological model and Pyramid of Influence can help to achieve health equity pertaining to concussion. At the foundational or distal level of the health impact pyramid, SES is a strong determinant of health; and, mechanisms to reduce poverty, resource inequities, and poor healthcare access come with the greatest population impact. However, more intermediary and proximal levels of the health pyramid that include changing individuals’ context to make healthy decisions, and education initiatives, require more individual effort to improve health. Thus, behavior change interventions or policies for concussion nondisclosure that only include or evaluate concussion knowledge or individual-level factors, and do not
address foundational SES and/or environment/structural factors that influence health-related decision making, will only benefit a limited amount of people. This may be of greater importance at the youth-sport and HS levels where there are vaster community-based inequities. For example, in our study, we were unable to replicate findings from studies completed with racially diverse HS athletes\textsuperscript{12} suggesting that more equality at the college setting to support concussion disclosure, including equitable access to healthcare resources and similar environmental/structural circumstances between Black and White athletes (i.e. no existing structure of residential segregation or place-based SES disparities) could be contributing to the narrowed disparity gap in college-athletes. This can serve as an example for larger scale community-based interventions as it demonstrates that equal and equitable access to resources, including an AT, could help to mitigate concussion nondisclosure disparities.

This study has several limitations. First, convenience sampling limited our ability to calculate an accurate response rate. Also, this study was only inclusive of nondisclosure data on Black and White athletes, limiting generalizability to other ethnically diverse groups. However, we believe this study to be foundational to research on SDOH related to concussion nondisclosure in college-athletes; and, with that, we acknowledge that we had limited data on Black athletes that reported a nondisclosure. This limitation potentially affects statistical power and effect size estimates. Thus, being mindful of individuals not included or represented in this research, more data with greater Black athlete representation, as well as other minoritized groups, is needed. Also, there are inherent limitations to using proxies such as FRL to measure SES. Future work should aim to better understand SES measures in college-athletes. Finally, this study only assessed reasons for not reporting a concussion, and limitations to survey-based research to measure these items could affect response biases. There are likely other factors not
measured in this study contributing to reporting behaviors, such as personality and peer pressure resistance that can be threaded into future investigations. To fill gaps in the current literature, research should focus on collecting more mixed methodological data, with a sociodemographic and/or socioecological lens to better understand the nuances of concussion disclosure, and nondisclosure, throughout different college-athlete demographics.

A host of internal and external factors can influence an athlete’s concussion reporting behavior; and, it is important to note the complex nature of how race and its intersection with other SDOH could significantly influence concussion nondisclosure. Being subjected to more SDOH across one’s lifetime naturally leads to a greater chances of health inequities and disparities. Concluding this study, 15.6% and 17.7% White and Black athletes respectively reported a history of concussion nondisclosure but no significant differences were found by race for distributions of history of concussion nondisclosure. Race was not associated with concussion nondisclosure when evaluated as an effect modification measure or confounder; and, no significant associations were noted by SES or HS AT access. However, differences by race in reasons for nondisclosure linked to concussion awareness and peer perceptions were noted.

Considering the diversity of college athletics, there is both an opportunity, and a need, to identify and mitigate the disparities in concussion nondisclosure among White and Black athletes to improve and tailor healthcare initiatives aimed to reduce nondisclosure. College athletics may be a way to provide Black athletes access to equitable healthcare resources that they may not have had access to prior to their college athletic careers. Strategies to tackle the evaluation of current procedures and policy to reconstruct and improve concussion interventions for each athletic population being served are warranted in hopes of encouraging a culture of sport that reflects the significance of concussion disclosure.
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Table 1. Characteristics of sample of collegiate athletes (n=735)

| Characteristic                | White athletes (n=622) | Black athletes (n=113) | Characteristic                | White athletes (n=622) | Black athletes (n=113) |
|-------------------------------|------------------------|------------------------|-------------------------------|------------------------|------------------------|
| Sex                           |                        |                        | NCAA Division                 |                        |                        |
| Male                          | 338 (54.3)             | 101 (89.4)             | Division I                    | 219 (35.2)             | 63 (55.8)              |
| Female                        | 284 (45.7)             | 12 (10.6)              | Division II                   | 319 (51.3)             | 49 (43.4)              |
| Age (years)                   |                        |                        | Division III                  | 84 (13.5)              | 1 (0.9)                |
| 18                            | 147 (23.6)             | 29 (25.9)              | Years playing sport<sup>a</sup> |                        |                        |
| 19                            | 174 (28)               | 25 (22.3)              | 0 to 5                        | 49 (8)                 | 6 (5.5)                |
| 20                            | 130 (20.9)             | 25 (22.3)              | 6 to 10                       | 242 (39.3)             | 44 (40.4)              |
| 21                            | 125 (20.1)             | 21 (18.8)              | 11 to 15                      | 247 (40.2)             | 47 (43.1)              |
| 22 and over                   | 46 (7.4)               | 12 (10.7)              | 16 and over                   | 77 (12.5)              | 12 (11)                |
| Missing                       | 1                      |                        | Missing                       | 7                      | 4                      |
| Year in college               |                        |                        | Sport contact level           |                        |                        |
| 1st                           | 188 (30.2)             | 30 (26.5)              | Contact                       | 431 (69.3)             | 104 (92)               |
| 2nd                           | 174 (28)               | 29 (25.7)              | Basketball                    | 39 (6.3)               | 21 (18.6)              |
| 3rd                           | 122 (19.6)             | 22 (19.5)              | Field hockey                  | 22 (3.5)               | 0                      |
| 4th                           | 111 (17.8)             | 21 (18.6)              | Football                      | 112 (18)               | 68 (60.2)              |
| 5th                           | 17 (2.7)               | 6 (5.3)                | Ice hockey                    | 34 (5.5)               | 0                      |
| Graduate student              | 10 (1.6)               | 5 (4.4)                | Lacrosse                      | 103 (16.6)             | 0                      |
| Had FRL in HS                 |                        |                        | Soccer                        | 60 (9.6)               | 8 (7.1)                |
| Yes                           | 58 (9.3)               | 49 (43.4)              | Water polo                    | 22 (3.5)               | 2 (1.8)                |
| No                            | 564 (90.7)             | 64 (56.6)              | Wrestling                     | 39 (6.3)               | 5 (4.4)                |
| Had access to an AT in HS     |                        |                        | Limited contact               | 77 (12.4)              | 5 (4.4)                |
| Yes                           | 508 (81.7)             | 93 (82.3)              | Baseball/softball             | 58 (9.3)               | 2 (1.8)                |
| No                            | 114 (18.3)             | 20 (17.7)              | Volleyball                    | 19 (3.1)               | 3 (2.7)                |
| History of diagnosed          |                        |                        | Non-contact                   | 114 (18.3)             | 4 (3.5)                |
| sport-related concussion      |                        |                        | Bowling                       | 8 (1.3)                | 0                      |
| Yes                           | 188 (30.2)             | 29 (25.7)              | Cross country                 | 29 (4.7)               | 1 (0.9)                |
| No                            | 434 (69.8)             | 84 (74.3)              | Golf                          | 9 (1.4)                | 0                      |
| History of concussion         |                        |                        | Rowing                        | 15 (2.4)               | 0                      |
| nondisclosure                 |                        |                        | Swing and dive                | 17 (2.7)               | 0                      |
| Yes                           | 97 (15.6)              | 20 (17.7)              | Tennis                        | 23 (3.7)               | 2 (1.8)                |
| No                            | 525 (84.4)             | 93 (82.3)              | Track and field               | 13 (2.1)               | 1 (0.9)                |

<sup>a</sup> Only considers sport that participant plays in college
Table 2. Distributions of history of diagnosed and non-disclosed sport-related concussions

|                                | History of diagnosed sport-related concussion | History of concussion nondisclosure |
|--------------------------------|-----------------------------------------------|-----------------------------------|
|                                | n     | n (%) | p-value | n (%) | p-value |
| All White athletes             | 622   | 188 (30.2) | 0.33 | 97 (15.6) | 0.57 |
| All Black athletes             | 113   | 29 (25.7) |       | 20 (17.7) |       |
| White athletes, HS FRL         | 58    | 16 (27.6) | 0.75 | 10 (17.2) | 0.92 |
| White athletes, no HS FRL      | 564   | 172 (30.5) |       | 87 (15.4) |       |
| Black athletes, HS FRL         | 49    | 12 (24.5) |       | 9 (18.4) |       |
| Black athletes, no HS FRL      | 64    | 17 (26.6) |       | 11 (17.2) |       |
| White athletes, HS AT access   | 508   | 159 (31.3) | 0.15 | 83 (16.3) | 0.22 |
| White athletes, no HS AT access| 114   | 29 (25.4) |       | 14 (12.3) |       |
| Black athletes, HS AT access   | 93    | 27 (29.0) |       | 19 (20.4) |       |
| Black athletes, no HS AT access| 20    | 2 (10.0) |       | 1 (5.0) |       |
Table 3. Odds and ratios predicting sport-related concussion nondisclosure, with race as an effect measure modifier

| Characteristic                  | Odds ratios and 95% confidence intervals | White athletes | Black athletes |
|--------------------------------|------------------------------------------|----------------|---------------|
|                                |                                          | Model 1        | Model 2       | Model 1        | Model 2       |
| Had FRL in HS                  |                                          |                |               |                |               |
| Yes                            | 1.15 (0.56, 2.35)                        | 1.10 (0.53, 2.34) | 0.98 (0.32, 2.92) | 0.94 (0.32, 2.76) |
| No                             | 1.0 (ref)                                | 1.0 (ref)      | 1.0 (ref)     | 1.0 (ref)      |
| Had access to an AT in HS      |                                          |                |               |                |               |
| Yes                            | 1.0 (ref)                                | 1.0 (ref)      | 1.0 (ref)     | 1.0 (ref)      |
| No                             | 0.72 (0.39, 1.32)                        | 0.82 (0.44, 1.53) | 0.21 (0.01, 1.49) | 0.26 (0.03, 2.27) |
| Sex                            |                                          |                |               |                |               |
| Male                           | --                                       | 1.0 (ref)      | --            | 1.0 (ref)      |
| Female                         | --                                       | 0.42 (0.26, 0.68) | --            | 0.31 (0.03, 2.98) |
| Concussion history             |                                          |                |               |                |               |
| Yes                            | --                                       | 2.59 (1.65, 4.07) | --            | 5.76 (1.97, 16.80) |
| No                             | --                                       | 1.0 (ref)      | --            | 1.0 (ref)      |
| Concussion symptom knowledge   |                                          |                |               |                |               |
| 1-unit increase                | --                                       | 1.08 (1.01, 1.15) | --            | 1.08 (0.95, 1.24) |

NOTE: Models are run separately for white athletes and black athletes to assess effect measure modification. Model 1 includes only free/reduced lunch in HS status and access to an AT in HS as predictors. Model 2 further adds sex, diagnosed concussion history, and concussion symptom knowledge as predictors.
Table 4. Odds and ratios predicting sport-related concussion nondisclosure, with race as a confounder

| Characteristic                        | Odds ratios and 95% confidence intervals |
|---------------------------------------|------------------------------------------|
|                                       | Model 1 | Model 2 | Model 3 |
| Race                                  |         |         |         |
| White                                 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| Black                                 | 1.16 (0.69, 1.98) | 1.12 (0.63, 1.98) | 1.04 (0.57, 1.91) |
| Had FRL in HS                         |         |         |         |
| Yes                                   | --      | 1.11 (0.62, 1.98) | 1.07 (0.59, 1.96) |
| No                                    | --      | 1.0 (ref) | 1.0 (ref) |
| Had access to an AT in HS             |         |         |         |
| Yes                                   | --      | 1.0 (ref) | 1.0 (ref) |
| No                                    | --      | 0.62 (0.35, 1.10) | 0.71 (0.39, 1.29) |
| Sex                                   |         |         |         |
| Male                                  | --      | --      | 1.0 (ref) |
| Female                                | --      | --      | 0.41 (0.26, 0.67) |
| Diagnosed Concussion history          |         |         |         |
| Yes                                   | --      | --      | 2.97 (1.96, 4.50) |
| No                                    | --      | --      | 1.0 (ref) |
| Concussion symptom knowledge          |         |         |         |
| 1-unit increase                       | --      | --      | 1.07 (1.01, 1.14) |

NOTE: Model 1 includes only race as a predictor. Model 2 further adds FRL in HS status and access to an AT in HS as predictors. Model 3 further adds sex, diagnosed concussion history, and concussion symptom knowledge as predictors.
Table 5. Reported reasons for nondisclosure of sport-related concussions

| Possible reasons for non-disclosure                                                      | White athletes (n=97) | Black athletes (n=20) | p-value |
|------------------------------------------------------------------------------------------|-----------------------|-----------------------|---------|
| I thought my coach would get mad.                                                        | 28 (28.9)             | 4 (20)                | 0.58    |
| I did not want to go to the doctor.                                                       | 44 (45.4)             | 7 (35)                | 0.46    |
| I thought my parents would be upset.                                                      | 12 (12.4)             | 2 (10)                | >0.99   |
| I did not want to lose playing time.                                                      | 69 (71.1)             | 12 (60)               | 0.42    |
| I was worried I would have to miss school and get behind on my school work.               | 28 (28.9)             | 2 (10)                | 0.1     |
| At the time I did not think it was a concussion.                                          | 37 (38.1)             | 13 (65)               | 0.045   |
| I thought my teammates would think I am weak.                                             | 24 (24.7)             | 10 (50)               | 0.03    |
| I did not think it was a serious injury.                                                   | 39 (40.2)             | 11 (55)               | 0.32    |
| I did not have health insurance and couldn’t go to the doctor.                            | 3 (3.1)               | 1 (5)                 | 0.53    |
| I didn't want to let my team down.                                                       | 53 (54.6)             | 15 (75)               | 0.13    |
| I was worried I would have to miss school and get behind on my school work.               | 28 (28.9)             | 2 (10)                | 0.1     |
| My team was going to playoffs when it happened.                                           | 17 (17.5)             | 2 (10)                | 0.52    |
| I thought my coach would think I am weak.                                                  | 26 (26.8)             | 8 (40)                | 0.28    |
| I had an exam or project due at school that I did not want to make up.                     | 4 (4.1)               | 2 (10)                | 0.27    |
| I was concerned it would impact my chances of playing professional sports.                 | 7 (7.2)               | 4 (20)                | 0.09    |

Of the 622 white and 113 black athletes, 97 (15.6%) and 20 (17.7%) athletes, respectively, reported having a history of concussion nondisclosure.