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Clinical practices in collegiate concussion management

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Abstract

Background—In recent years, sports leagues and sports medicine experts have developed guidelines for concussion management. The extent to which current clinical practice is consistent with guideline recommendations is unclear. At the collegiate level, there have been few examinations of concussion management practices and the extent to which meaningful differences across divisions of competition exist.

Purpose—To examine current practices in concussion diagnosis and management at NCAA member colleges. To explore the extent to which current practices reflect current recommendations for concussion diagnosis and management. To determine whether there are differences in management patterns across divisions of competition.

Design—Cross-sectional survey.

Methods—We sent an electronic questionnaire to sports medicine clinicians at all NCAA member colleges during September and October 2013. We asked clinicians about baseline assessments, diagnosis and management practices, return-to-play protocols, the perceived prevalence of under-diagnosis, and basic demographic information.

Results—Approximately 30% (n=866) of contacted clinicians, representing nearly 50% (n=527) of NCAA member colleges, responded to the questionnaire. Pre-participation baseline examinations were administered at the majority of schools (95%), but most (87.5%) administered baseline assessments only to selected, high-risk athletes. Computerized neurocognitive testing and balance assessments were most commonly used as pre-season baseline and post-injury

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assessments. Multi-modal examination in line with NCAA and other guidance was only used at a minority of institutions. Athletic trainers most commonly administered and interpreted the pre-season baseline examination. Most clinicians reported that their institution's practices were in line with NCAA guidelines during the first 24-hours of an athlete's concussion diagnosis, with exact percentages varying across measures. Differences across divisions of competition included: shorter return-to-play time at Division I schools than Division III schools (Division I=9.13 days, Division III=10.31 days) and more frequently referring concussed athletes to a physician within 24-hours of diagnosis at Division I schools.

Conclusion—Concussion management at many U.S. colleges incorporates elements recommended by current guidelines; however, there is room to improve. Increasing the use of a multi-modal baseline and post-injury examination will elevate the concussion care provided to college athletes and better align with best practice guidance.

Key Terms

concussion; clinical practice; best practices; health policy; college

Introduction

Concussion identification, symptom management, and return-to-play decision making are important and multifactorial processes with direct impacts on athlete health and well-being. The science regarding the optimal medical management of concussion continues to evolve. (e.g., [16–18]) Most states and sports organizations, including the National Collegiate Athletic Association (NCAA), have instituted some form of concussion-related policy based on their interpretation of the available evidence.([2,10]) In 2010, the NCAA put forth its "Concussion Policy and Legislation".([20]) This policy requires that institutions have a concussion management plan that includes the following components: concussion education for student-athletes, including their responsibility to report symptoms; removal from play and evaluation by a medical professional if exhibiting concussion signs or symptoms; a policy prohibiting an athlete diagnosed with a concussion from resuming athletic activity for at least the remainder of the calendar day; and a requirement that any athlete diagnosed with a concussion receives clearance from a physician or physician designee prior to returning to play. Beyond these four tenets, the NCAA provides additional suggestions regarding concussion identification and management best practices in their Sports Medicine Handbook 2013–2014.([20]) These best practice guidelines include the following recommendations: institutions should conduct a baseline assessment for athletes in specific high-risk sports prior to participation; the same baseline assessment tools should be used post injury; at minimum, the baseline should include a symptom checklist, a cognitive assessment, and a balance test; neuropsychological testing can be an effective additional tool, best administered and interpreted by a neuropsychologist or, if one is not available, a trained team physician; athletes should be monitored for deterioration after suspected concussion; written instructions should be provided to athletes or, preferably, their roommates or guardians; and return-to-play should follow a stepwise graduated return process.([20])

Since the time of data collection, the NCAA has also released Inter-Association Concussion Guidelines,([21]) which includes many of the same elements of their 2013 best practice

guidelines and is based largely on the position statements and consensus-based recommendations of other relevant stakeholder groups such as the National Athletic Trainers' Association (NATA; 4), the American Academy of Neurology (AAN; 8), the American Medical Society for Sports Medicine (AMSSM; 9), and the Concussion in Sport Group (CISG; 16–18). Thus, the analysis of whether schools included elements of the NCAA's 2013 best practice guidelines reflects on whether the schools, at the time of data collection, were in line with what the NCAA recommends today. Given the rapidly evolving understanding of concussions and best practices for concussion management, the need to understand and incorporate up-to-date management strategies is imperative. Despite a variety of guidelines from which college sports medicine clinicians can draw when structuring their institution's concussion management practices, there has been little examination of the extent to which these recommendations are reflected in the concussion management practices implemented on college campuses.

An initial evaluation of compliance with the required elements of the NCAA concussion policy showed significant between-institution variability, with some institutions fully in compliance, others lacking a concussion management plan in any capacity, and others missing required components of the plan (e.g. annual athlete concussion education).([3]) This initial investigation did not examine the day-today concussion management practices at NCAA member schools and whether they were in line with existing best practice guidance from the NCAA or other medical or sport-governing bodies.

To date, only two studies focused specifically on concussion assessment and management practices in the college sports medicine setting. Kelly and colleagues reported concussion management patterns in a sample of clinicians who provide care to athletes at NCAA Division I schools using data gathered in the 2010–2011 academic year.([11]) The encouraging results from this study indicated that majority of responding clinicians used a multi-faceted approach to concussion assessment and many were aware of recent position statements and best practice guidance on concussion assessment and management.([11]) A recent study by Buckley et al. examined the concussion management practices of clinicians at Division II and Division III schools in the 2012–2013 academic year.([5]) With 755 responding clinicians, this study found a relative lack of multi-modal baseline testing among clinicians at Division II and Division III institutions, with more prevalent multi-faceted examination occurring for acute examination. Both studies provide important detail about the concussion assessment and management practices of clinicians at NCAA-affiliated schools, but do not address some of the more recent best practice recommendations and their anonymous data collection did not allow for school-level analyses or an understanding of school-level representation. Other studies conducted regarding concussion management practices have spanned multiple employment settings, and included clinicians providing care to athletes at multiple levels of competition,([6,7,15,22]) making specific comparisons of collegiate concussion management practices inappropriate.

The primary aim of this study was to examine the routine concussion management practices of sports medicine clinicians (e.g., athletic trainers and team physicians) at NCAA member-schools. Secondarily, this study examines the extent to which these practices align with the best-practice guidelines put forth by the NCAA, which are largely based on expert-

consensus statements such as those from the NATA,([4]) the AAN,([8]) the AMSSM,([9]) and the CISG.([16–18]) A third aim of this study was to examine whether there were differences in concussion management practices at different levels of competition (Divisions I, II, and III) within the NCAA.

METHODS

Procedure

Survey items were developed based on language from the NCAA's Concussion Policy and Legislation (2010) and its best practice guidelines (2013). Questions were then reviewed by members of the target population for content and clarity and pilot testing was conducted in a small sample. Revisions were made based on information gathered through this process. Then, sports medicine clinicians at all NCAA member institutions were sent a recruitment email for a larger study of collegiate concussion management and compliance through a distribution list of the NCAA Sport Science Institute. The initial recruitment email was sent to 2935 collegiate sports medicine clinicians, and two additional "reminder" emails were sent at approximately two week intervals. Within the email was a description of the study and a link to an online questionnaire hosted on the secure Qualtrics Survey platform (Provo, Utah). All participants provided informed consent prior to participation. Questionnaires were completed during September and October 2013. All research activities were approved by the Institutional Review Boards at Harvard School of Public Health and Boston University Medical Campus.

Measures

Demographic characteristics—Participants were asked their position on the sports medicine staff (head athletic trainer, athletic trainer, physician, or other), the name of their school, and the NCAA division of competition in which the majority of their school's teams compete (I, II, or III).

Pre-Season concussion practices—Participants were asked whether the sports medicine team at their school obtained a concussion history from athletes prior to the start of the season and if so, whether testing was performed on all athletes or just those considered to be at high risk. They were also asked whether any teams at their school completed a pre-season baseline assessment; a frequency (e.g., annual baseline examination) was not specified. Those who answered that teams at their school completed a pre-season baseline assessment were subsequently asked what was included in the baseline assessment, who interpreted the baseline assessment, and which teams completed the baseline assessment. For each of the baseline administration questions, participants were asked to select all responses that applied from a list of relevant options drawn from NCAA and other guidelines. Participants were also provided with the option to select "other" and write in a response.

Concussion evaluation and management practices—Participants were asked what their athlete's concussion diagnosis and recovery monitoring process entailed, and could select multiple options from a list of responses. In addition, participants were asked to

estimate the average number of days from concussion diagnosis to full return-to-play clearance, as well as the percentage of concussions sustained by athletes at their school that they believe go undiagnosed, whether due to underreporting or other reasons.

Statistical Analyses

School-level data—Although surveys were answered at an individual-level, responses were grouped at the school-level to prevent overrepresentation of schools with multiple respondents, or, conversely, underrepresentation of schools with only one respondent. As a result, a category of "mixed responses" was created to represent instances where individuals within the same school had conflicting answers to the same question. These "mixed responses" were analyzed as a third category of possible institution-level responses.

Additional concussion practice definitions—Tools that could be used for similar purpose were classified into superordinate categories. "Any SCAT" represents any individual/school that employed Sport Concussion Assessment Tool (SCAT) 1, SCAT 2, or SCAT 3; "Any computerized cognitive test" represents any individual/school that utilized the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT), Automated Neuropsychological Assessment Metrics (ANAM), or ANAM-Sports Medicine Battery (ASMB); "any non-computerized cognitive test" represents as any individual/school that utilized the Standardized Assessment of Concussion (SAC), other standardized non-computerized assessments, or other standardized cognitive assessments; "Any Cognitive Test" represents any individual/school that used any computerized or non-computerized cognitive test, or any SCAT tool (as it incorporates cognitive testing); "Any Balance Test" represents any individual/school that performed the Balance Error Scoring System (BESS) test, modified BESS test, or other standardized balance assessments.

To capture whether schools were adhering to the best practices outlined in the 2013 NCAA Guidelines, combination variables were created. For baseline assessment we created the following measure: any individual/school that utilized Any Balance testing in conjunction with Any Cognitive test. For the assessment and management of the concussion, we created the following measures: any individual/school that utilized any balance testing, any cognitive test, and symptom checklist together; any individual/school that utilized any SCAT along with any Computerized Cognitive Test; any Computerized Cognitive Test together with any other testing.

Descriptive statistics are provided to outline patterns in common concussion management practices among respondents. Pearson correlations were used to examine whether there was an association between the use of a specific concussion-related examination at baseline and its use for recovery monitoring. Chi-squared tests were used to examine differences in binary or categorical variables across divisions of competition, using standardized residuals to describe specific categorical differences ($z>|1.96|$ indicating statistical significance). The distribution of continuous variables was assessed. Number of tools used during concussion diagnosis and recover management as well as percentage of concussions suspected to have gone undiagnosed were log-transformed for normality. Simple linear regression was used to examine difference in mean values of continuous variables by division of competition;

Division I was selected as the referent category. Differences between responding and non-responding schools were assessed using publicly available data gathered from the United States Department of Education. Logistic regression was used to assess whether the presence of a football team, division of competition, athletics department revenues, size of athlete population, or size of undergraduate student body were significantly associated with whether or not a school was represented in the study. Athletics department revenues and size of undergraduate student body were transformed using log base 2 for normality and ease of interpretation; exponentiated β values are provided to illustrate effect size. Statistical analyses were performed in SPSS v. 20 and R v. 3.2.2 using an α of 0.05 or less to indicate statistical significance.

Results

Sample

Of the 2935 clinicians who were contacted regarding the study, 908 (31%) participated. Only those clinicians responding to the specific questions described below (n=866; 30%) were included in these analyses. Most respondents were staff athletic trainers (Table 1). Participants represented nearly half of all NCAA member institutions (Table 1), including schools in all 50 states and the District of Columbia. All NCAA divisions of competition were included, with Division I schools having the greatest representation. Represented schools included 228 schools with the majority of teams competing in Division I, 119 schools with the majority of teams competing in Division II, and 180 schools with the majority of teams competing in Division III. The number of respondents and the number of represented schools vary across questions due to skip patterns and because respondents were not required to answer every question in order to proceed with the survey.

To the extent possible, responding schools were compared to non-responding schools using publicly available information (Appendix). On average, schools with a football team were almost twice as likely to be represented in the study compared to schools without football teams ($\beta=1.77$, $p<0.001$). Schools in Division I were significantly more likely than schools in Division II ($\beta=0.36$, $p<0.001$) or III ($\beta=0.39$, $p<0.001$) to respond to the survey. Controlling for the presence of a football team, and division of competition, as the number of intercollegiate athletes at as school increased so, too, did the odds that it would be represented in the survey ($\beta=1.63$, $p<0.001$). Again, controlling for the presence of a football team and the division of competition, each doubling of the undergraduate student body size was associated with 1.24 times the odds that a school was represented in the study ($\beta=1.24$, $p<0.001$) and each doubling in the athletics revenues was associated with a small but significant increase in the odds of being represented in the survey ($\beta=1.00$, $p<0.001$).

Concussion history—Respondents representing 508 schools responded to the question asking whether or not they obtained a concussion history from their athletes. Respondents at the majority of schools (86.8%) indicated that prior to the start of the competitive season they obtained a concussion history from all athletes, with respondents from only 5% of schools indicating a concussion history is only obtained from some of the athletes. Respondents from a small minority of schools indicated that they did not obtain a

concussion history from their athletes (1.2%) or had mixed responses to this question (7.3%). There were no significant differences between respondents from different NCAA divisions as to whether a pre-season concussion history was obtained.

Pre-season baseline testing—Respondents at the vast majority of institutions (95.1%) indicated that athletes at their school complete pre-season baseline testing. Only 22.5% of schools, however, obtain pre-season baseline testing for all athletes; respondents from 10.9% of schools gave mixed responses with some clinicians indicating that all athletes received baseline testing and others indicating only some of the school's athletes received baseline testing.

Only respondents who indicated that a baseline examination was conducted at their institution (n=483) proceeded to answer the more detailed questions about administration, interpretation, and assessment tools detailed below. The mean number of individuals selected as involved in administering the baseline was 1.26 (SD=0.49) and the mean number of individuals selected as involved in interpreting the baseline was 1.51 (SD=0.63). Respondents at nearly all institutions indicated that an athletic trainer administered the baseline exam, with most selecting only the athletic trainer as having this responsibility. In contrast, although respondents at over three-quarters of schools indicated that the athletic trainer was involved in interpreting baseline assessments at their schools, the team physician was selected by respondents as being involved in interpreting baseline testing at a substantial proportion of schools (Table 2). Respondents from Division I schools were significantly more likely to indicate that a physician administered the baseline exam than respondents at Division II or III schools (9.2% for Division I, 2.9% for Division II, 1.9% for Division III; χ^2 482(4)=36.58, p<0.001). Respondents from Division I schools were significantly more likely to indicate that a neuropsychologist interpreted the baseline exam than respondents at Division II or III schools (5.5% for Division I, 1.0% for Division II, 1.2% for Division III; χ^2 483(4)=20.428 p<0.001).

Measures used in the preseason baseline varied. Most school use computerized neurocognitive assessments; many use balance assessments and symptom checklists at baseline (Table 3). Under half of schools use a multi-modal assessment including both a balance test and a cognitive assessment. There were no significant differences across divisions of competition in the specific tools administered at baseline. The frequency of baseline testing (e.g., annually v. once per college athletic career) was not measured.

Concussion diagnosis and recovery monitoring—Respondents representing 504 schools provided information on the tools included in athletes' concussion diagnosis and recovering monitoring. The use of symptom checklists (85.3%) and computerized neurocognitive assessments (76.0%) was commonly reported (Table 3). Additionally, respondents at nearly half of schools (47.0%) indicated using at least one cognitive test, at least one balance assessment, and a symptom checklist during concussion diagnosis and recovery monitoring. On average, respondents from Division I schools selected more tools as involved in their concussion diagnosis and recovery management practices than respondents from Division II (mean tools per division: Division I=3.57, SD=1.10; Division II=3.14, SD=1.15; Division III=3.53, SD= 1.24; F=6.092, p=0.002). There was a significant

positive correlation between the use of a tool at baseline and the use of that same tool at follow up for nearly all concussion management tools (Pearson's correlation coefficient ranged from 0.309 to 0.801, depending on the tool, all $p<0.001$, data not shown). Respondents from Division III schools were significantly more likely than respondents from Division I or II to indicate that they use non-computerized cognitive testing as part of diagnosis and recovery management (24.1% for Division I, 23.2% for Division II, 35.7% for Division III; (χ^2 504(4)=26.38, $p<0.001$). There were no other significant division-level differences in concussion diagnosis and recovery monitoring tools.

24 Hours Following Concussion Diagnosis—Clinicians representing 507 schools responded to questions related to the initial 24 hours following an athlete's concussion diagnosis. Respondents at nearly all schools indicated that concussed athletes are prohibited from resuming participation in practices or games. Respondents from most schools indicated that athletes are encouraged to limit their exposure to stimuli such as cell phones, television, and computers, to abstain from alcohol and recreational drugs, and to limit academic activities. Just under two-thirds of institutions had respondents indicate that written instructions were provided to the athletes and about the same number indicated that these instructions were provided to a roommate or teammate. Just over half of represented institutions had respondents indicate that athletes received serial monitoring for deterioration; a similar number of institutions referred concussed athletes to a physician within the first 24 hours (Table 4). On average respondents from Division I schools reported more recommendations followed within the 24-hours following a concussion diagnosis (mean=7.20, SD=1.49) than respondents at Division II (mean=6.49, SD=1.66, $p<0.001$) and Division III (mean=6.72, SD=1.47, $p=0.002$) schools ($F=9.46$, omnibus $p<0.001$). A larger proportion of Division II schools had all respondents choose not to indicate that they encouraged athletes to limit academic activities in the 24 hours following a concussion diagnosis, compared to Division I schools (8.9% from Division I, 21.9% of Division II, χ^2 507(4)=20.005, $p<0.001$; 16.5 from Division III). Respondents from Division I schools were significantly more likely to indicate that they referred an athlete to a physician in the 24 hours following a concussion diagnosis (66.5% from Division I, 46.5% of Division II, 36.1% from Division III; χ^2 507(4)=75.78, $p<0.001$). A larger proportion of Division II schools had all respondents choose not to indicate that they provided referral to academic accommodations in the 24 hours following an athletes concussion diagnosis, compared to Division I schools (31.7% from Division I, 64.9% of Division II, χ^2 507(4)=53.46, $p>0.001$; 56.2% from Division III).

Responding clinicians estimated that the average time between concussion diagnosis and full return to play clearance for athletes was 9.6 days (SD=3.7). Respondents from Division I schools indicated a significantly shorter period between concussion diagnosis and full return to play clearance, on average, than respondents from Division III schools (Division I=9.13 days, SD=3.30; Division III=10.31 days, SD= 4.14; $p=0.001$; Division II=9.34 days, SD=3.17; $F=5.16$, omnibus $p=0.006$). On average, respondents indicated that they suspect approximately 12.5% (SD=11.26) of the concussions sustained by athletes at their institution go undiagnosed, on average, due to underreporting or other reasons. There were no

significant differences in these estimates about under-diagnosis across divisions of competition (p=0.98).

Discussion

With representation from approximately half of all NCAA member schools, we found that most, but not all participating institutions appear to be following at least some of the NCAA's best practice recommendations for concussion management. During the pre-season period, nearly all institutions conducted baseline testing with their athletes; however, fewer reported that all athletes on campus undergo baseline assessments. Assessments used during baseline exam varied. Computerized neurocognitive testing was the most common component used in baseline assessment. Some version of the SCAT, a symptom checklist, and a balance assessment, most commonly the BESS, were also frequently used at baseline. The individual tests used are in line with best practice recommendations by the NCAA Sports Medicine Handbook. However, these 2013 best practices generally outline that a multimodal approach is taken, most generally including a balance test and a cognitive test in combination. When examining whether schools in our sample were including both of these modalities, only 39.7% of schools combine any of the queried balance and cognitive tests and administer them at baseline. The 2013 NCAA guidelines and suggested best practices do not require that all athletes complete a pre-season baseline exam.([20]) Although it may not be necessary for all athletes, particularly those in low-risk sports, to undergo baseline testing, this examination could be useful if a concussion occurs. Future research is needed to examine whether baseline testing athletes who participate in sports with low risk of concussion is a medically-indicated and practically-useful endeavor.

Consistent with 2013 NCAA best practices ([20]), nearly 90% of respondents reported using symptom checklists for concussion diagnosis and recovery monitoring. Respondents representing approximately half of the schools in this study (51.6%) reported using a balance assessment for concussion diagnosis and recovery monitoring. The BESS or modified BESS were selected most frequently. Over half of respondents reported using a version of the SCAT as part of concussion diagnosis and recovery monitoring. Many guideline and best practice recommendations indicate, again, that a multi-faceted approach to concussion diagnosis and management is warranted.([4,8,9,18,21]) Within our sample representatives from nearly half of the schools indicated that they use any balance testing, any cognitive test, and symptom checklist together for concussion diagnosis and management. An alternative combination of tests that could meet the requirements set forth in the best practice guidance, using Any SCAT along with Any Computerized Cognitive Test, was reported by more than a third of schools in this study. Ensuring that institutions are using a multi-modal approach to concussion diagnosis and management is an area with room for improvement, which may increase the sensitivity and specificity of concussion diagnosis and recovery management across U.S. colleges.([23]) Further, NCAA best practice recommendations indicate that tests used at baseline should also be used for diagnosis and management of concussion.([20]) It is encouraging, therefore, that most tests that were used at a given institution for baseline examination were also likely to be used at that institution for diagnosis and recovery management.

The use of computerized neurocognitive testing for concussion management was common. Neuropsychological testing is suggested by 2013 NCAA best practices; however, the combination of a symptom checklist, cognitive assessment, and balance assessment is described as essential.([20]) If it is included in baseline testing or concussion management, guidelines recommend that computerized neurocognitive testing be utilized as part of a comprehensive concussion management plan that includes other clinical testing; all position statements and consensus guidelines state that computerized testing should not be used in isolation as a diagnostic tool or as the sole return-to-play decision-making tool.([4,8,9,18]) In our sample, however, 30 respondents from 25 schools reported using only computerized neurocognitive testing as their baseline pre-injury examination and 13 respondents at 12 schools reported using only computerized neurocognitive testing during diagnosis/recovery monitoring. Additionally, although computerized neurocognitive testing was widely used, it was much less common that a neuropsychologist or other specialized clinician was involved in administration or interpretation of this testing. It should be noted that some computerized neurocognitive tests include a symptom checklist; thus, it is possible that those schools that only selected computerized neurocognitive testing may have obtained symptom information from their athletes.

The vast majority of respondents indicated that concussed athletes are prohibited from resuming sports participation within 24-hours of injury (98.2%). Although the language of this question does not directly align with the NCAA policy that athletes may not participate in athletic activity on the same calendar day as the concussive injury, it is concerning that any athlete who is officially diagnosed with a concussion would be cleared to resume play within 24 hours. More specifically, it is the recommendation of the major consensus guidelines ([4,8,9,18]) as well as the NCAA best practices that a graduated return to play model be utilized for all athletes diagnosed with a concussion. When using a graduated return to play protocol, athletes who are diagnosed with a concussion progress through five steps, after a period of 24 hours of physical rest. Many recommendations suggest that athletes progress from one step to another each day. Thus, the “minimum” time from injury to full return to play clearance would be approximately 5–6 days if these recommendations were followed. The NCAA Concussion Policy, which states that athletes diagnosed with concussion may not return to play until the next calendar day, appears inconsistent with current recommendations, including its own, which suggest graduated return-to-play with each step generally taking 24 hours. It is encouraging, however, that the estimated mean return to play time was 9.6 days, which may allow for the full graduated return-to-play progression to occur.

Respondents representing the majority of schools in this study indicated that they provided athletes diagnosed with a concussion with written instructions (63.7%), and a similar number of respondents and schools indicated that they provided these instructions to the athlete’s roommate or teammate during the first 24 hours following injury. Both are 2013 NCAA best practices. It is encouraging that the majority of institutions are engaging in this practice as recommended by the NCAA; however, there is still room for improvement. Additionally, at just over half of represented institutions (51.3%) athletes diagnosed with a concussion receive serial monitoring for deterioration, another 2013 NCAA best practice

guideline. This too, represents an area where collegiate sports medicine clinicians can improve their practices to align more closely with NCAA best practice recommendations.

Respondents estimated the 12.5% of concussions sustained by their athletes going undiagnosed. This figure is substantially lower than recent estimates of concussion under-reporting by collegiate athletes that suggest approximately half of concussions—or more—sustained by collegiate athletes may not be reported and consequently go undiagnosed.(e.g., [1], [12], [13], [14], [24]) At present, identifying symptomatic individuals relies, at least in part, on honest disclosure of symptoms by the athlete. Although the multimodal concussion examination recommended in all best practice guidelines improves the objectivity of the diagnosis, concussion identification remains challenging.

This results of this study are largely in line with previous findings.([5],[11]) Compared to previous research, we were able to make some novel across-division comparisons, finding, for example, a significantly shorter reported return-to-play time at Division I schools compared to Division III schools. The reason for this difference could be a relatively larger number of medical providers at Division I schools leading to earlier diagnosis, and improved injury recovery. Alternatively, Division I schools have a larger athlete population,([19]) and their concussive injuries may come to athletes in a broader range of sports altering the nature of the injuries themselves. It is also possible that the higher level of competition at Division I schools compared to Division II or III schools leads to greater pressure to return athletes to play more quickly.

One novel aspect of this study is the ability to match respondents within a school and understand the extent to which their practices, or understanding of the requirements of their school's concussion management policy, aligns with their colleagues. The category of mixed responses represents school-level variable in which respondents do not provide the same answer to a given question. In some cases there was significant disagreement between respondents (Tables 2, 3, and 4). For example, at 12.3% of schools respondents disagreed whether balance testing was used during diagnosis and recovery management (Table 3). The discrepancies represented in the mixed responses category could be due to different understandings of the school's concussion management policy, individualization of concussion care across cases, or some combination thereof. Future research should investigate the extent to which within-institution differences in concussion care occur due to variable implementation of the concussion management plan versus appropriate use of clinical judgement and individualization of care across concussion cases.

Limitations

Although all institutions with teams participating in NCAA competition were included in the sampling frame, not all institutions were represented among the respondents. The decision to respond may have been associated with an individual's attitudes towards, or an institution's focus on, concussion safety, thus biasing the sample. Division I programs with larger athletics revenues, athletic population, and undergraduate student body were more likely to respond to the survey. Therefore, our results may not be generalizable to smaller schools with smaller athletics programs. Furthermore, we were unable to analyze response rates by

specific clinicians (e.g., head athletic trainers, team physicians) as the relevant denominators were not provided when the NCAA SSI emailing list was used. In addition, as with all surveys, responses may have been affected by social desirability bias. Additionally, it is possible that since the time that respondents completed the questionnaire they or their institution have updated their policies or practices to be better aligned with existing guidance.

Conclusion

NCAA member institutions are largely engaging in concussion management practices that are consistent with best practice guidelines. There are, however, some opportunities for improvement. By targeting these opportunities when devising concussion management protocols and implementation strategies, NCAA schools can further improve the care they provide to their athletes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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What is known

Concussion science and related clinical practice are rapidly evolving. Existing evidence suggests concussion management practices at NCAA colleges are in line with some best practice recommendations.

What this study adds

This is the first study to collect concussion management practice data from clinicians at all three NCAA Divisions of competition, allowing for division-level comparisons. Similarly, this is the first study to collect data identifiable at the school level, allowing for school-level analyses. We find practices largely in line with guidance that existed at the time of data collection, with some divisional differences and areas of possible improvement.

Table 1

Respondent and represented school characteristics

	Respondents	Division I (% Total)	Division II (% Total)	Division III (% Total)
All Clinicians	866	456 (52.7%)	157 (18.1%)	253 (29.2%)
Staff Athletic Trainers	756	374 (49.5%)	143 (18.9%)	239 (31.6%)
Physicians	102	76 (74.5%)	13 (12.7%)	13 (12.7%)
Other clinicians[1]	8	6 (75.0%)	1 (12.5%)	1 (12.5%)
	Schools (% Surveyed)	**Division I (% Surveyed)**	**Division II (% Surveyed)**	**Division III (% Surveyed)**
Unique Schools	527 (49.4%)	228 (66.1%)	119 (39.7%)	180 (29.4%)

Total percentages of Division I, II, and III physicians do not sum to 100 due to rounding.

[1]Other clinicians included rehabilitation specialists, physical therapists (PT), and dual credentialed AT/PT that served primarily in the PT role.

Table 2

Individuals involved in administration and interpretation of baseline testing at NCAA schools

	Administration[1] n(%)			Interpretation[2] n(%)		
Individual Selected	**All Yes**	**All No**	**Mixed**	**All Yes**	**All No**	**Mixed**
Athletic Trainer	469 (97.3)	9 (1.9)	4 (0.8)	385 (79.7)	51 (10.6)	47 (9.7)
Athletic Training Student	57 (11.8)	399 (82.8)	26 (5.4)	3 (0.6)	479 (99.2)	1 (0.2)
Coach	3 (0.6)	478 (99.2)	1 (0.2)	1 (0.2)	482 (99.8)	0 (0)
Team Physician	26 (5.4)	434 (90.0)	22 (4.6)	191 (39.5)	226 (46.8)	66 (13.7)
Neurologist	1 (0.2)	478 (99.2)	3 (0.6)	16 (3.3)	453 (93.8)	14 (2.9)
Neuropsychologist	2 (0.4)	477 (99.0)	3 (0.6)	15 (3.1)	455 (94.2)	13 (2.7)

[1] 780 individuals from 482 schools responded to questions regarding who administered baseline

[2] 779 individuals from 483 schools responded to questions regarding who interpreted baseline

Table 3

Institution-level measures used at baseline and for diagnosis/recovery management

	Baseline[1] n(%)			Diagnosis/Management[2] n(%)		
Specific Tool	**All Yes**	**All No**	**Mixed**	**All Yes**	**All No**	**Mixed**
Computerized Cognitive	**400 (82.6)**	**70 (14.5)**	**14 (2.9)**	**386 (76.6)**	**99 (18.8)**	**19 (3.8)**
ANAM	2 (0.4)	481 (99.4)	1 (0.2)	2 (0.4)	500 (99.2)	2 (0.4)
ASMB	1 (0.2)	482 (99.6)	1 (0.2)	2 (0.4)	500 (99.2)	2 (0.4)
ImPACT	396 (81.8)	73 (15.1)	15 (3.1)	383 (76.0)	103 (20.4)	18 (3.6)
Non-Computerized Cognitive	**76 (15.7)**	**383 (79.1)**	**25 (5.2)**	**140 (27.8)**	**310 (61.5)**	**54 (10.7)**
Other cognitive test	4 (0.8)	470 (97.1)	10 (2.1)	15 (3.0)	472 (93.7)	17 (3.4)
Other neurocog	3 (0.6)	477 (98.6)	4 (0.8)	16 (3.2)	469 (93.1)	19 (3.8)
SAC	70 (14.5)	391 (80.8)	23 (4.8)	117 (23.2)	345 (68.5)	42 (8.3)
Balance testing	**198 (40.9)**	**253 (52.3)**	**33 (6.8)**	**260 (51.6)**	**182 (36.1)**	**62 (12.3)**
BESS	116 (24.0)	327 (67.6)	41 (8.5)	148 (29.4)	298 (59.1)	58 (11.5)
Modified BESS	51 (10.5)	400 (82.6)	33 (6.8)	73 (14.5)	385 (76.4)	46 (9.1)
Other balance testing	18 (3.7)	455 (94.0)	11 (2.3)	39 (7.7)	444 (88.1)	21 (4.2)
King Devick	**10 (2.1)**	**471 (97.3)**	**3 (0.6)**	**11 (2.2)**	**488 (96.8)**	**5 (1.0)**
Any SCAT	**108 (22.3)**	**347 (65.8)**	**29 (6.0)**	**262 (52.0)**	**199 (39.5)**	**43 (8.5)**
SCAT	68 (14.0)	416 (86.0)	0 (0)	155 (30.8)	348 (69.2)	0 (0)
SCAT2	41 (8.5)	418 (86.4)	25 (5.2)	111 (22.0)	345 (68.5)	48 (9.5)
SCAT3	57 (11.8)	406 (83.9)	21 (4.3)	133 (26.4)	337 (66.9)	34 (6.7)
Symptom checklist	**148 (30.6)**	**263 (54.3)**	**73 (15.1)**	**430 (85.3)**	**27 (5.4)**	**47 (9.3)**
Other	**27 (5.6)**	**436 (90.1)**	**21 (4.3)**	**48 (9.5)**	**418 (82.9)**	**38 (7.5)**
Multi-Modal: balance + cognitive[3]	**192 (39.7)**	**255 (52.7)**	**37 (7.6)**			
Multi-Modal: any SCAT + comp. cognitive[4]				**191 (37.9)**	**270 (53.6)**	**43 (8.5)**
Multi-modal: balance + cognitive + symptom[4]				**237(47.0)**	**201 (39.9)**	**66 (13.1)**

[1] The number of schools with respondents answering questions regarding baseline = 483

[2] The number of schools with respondents answering questions regarding diagnosis/management = 504

[3] Combination category was only evaluated for baseline

[4] Combination category was only evaluated for diagnosis/management

Table 4

Institution-level occurrences within 24 hours of an athlete's concussion diagnosis

Post-concussion determination	All Yes, n(%)	All No, n(%)	Mixed, n(%)
Prohibited from resuming practice or game	498 (98.2)	3 (0.6)	6 (1.2)
Provided with written instructions about concussion management	323 (63.7)	124 (24.5)	60 (11.8)
Instructions given to roommate, teammate	330 (65.1)	110 (21.7)	67 (13.2)
Serial monitoring for deterioration	260 (51.3)	171 (33.7)	76 (15.0)
Encouraged to limit academic activities	378 (74.6)	73 (14.4)	56 (11.0)
Encouraged to limit exposure to other stimuli	478 (94.3)	14 (2.8)	15 (3.0)
Abstain from alcohol or recreational drugs	462 (91.1)	21 (4.1)	24 (4.7)
Referred to a physician	263 (51.9)	189 (37.3)	55 (10.8)
Referred to individual to assist with academic accommodations	180 (35.5)	240 (47.3)	87 (17.2)