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Athletic Trainers' Concussion-Assessment and Concussion-Management Practices: An Update

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Context: Athletic trainers (ATs) are often the first health care providers to conduct concussion assessments and carry out postinjury management. Best practices for concussion evaluation and management have changed rapidly in recent years, outdating previous reports of ATs' concussion practices.

Objective: To examine ATs' current concussion-assessment and -management techniques.

Design: Cross-sectional study.

Setting: Web-based survey.

Patients or Other Participants: A random convenience sample of 8777 ATs (response rate = 15.0% [n = 1307]; years certified = 15.0 ± 10.6) from the National Athletic Trainers' Association membership.

Main Outcome Measure(s): Survey Web links were e-mailed to prospective participants, with 2 follow-up e-mails sent by the National Athletic Trainers' Association. The survey collected demographic information, the number of concussions assessed, the concussion-recovery patterns, and the assessment and return-to-participation (RTP) decision-making methods used.

Results: The ATs reported assessing a median of 12.0 (range = 0–218) concussions per year. A total of 95.3% (953/1000) ATs cited clinical examination as the most frequently used concussion-assessment tool, followed by symptom assessment (86.7%; 867/1000). A total of 52.7% (527/1000) ATs described a 3-domain minimum multidimensional concussion-assessment battery. Published RTP guidelines were the most common RTP decision-making tool (91.0%; 864/949), followed by clinical examination (88.2%; 837/949). The ATs with master's degrees were 1.36 times (95% confidence interval [CI] = 1.02, 1.81) more likely to use a 3-domain concussion-assessment battery than ATs with only bachelor's degrees ($\chi^2 = 4.44$, $P = .05$). Collegiate ATs were 2.12 (95% CI = 1.59, 2.84) and 1.63 (95% CI = 1.03, 2.59) times more likely to use a 3-domain concussion-assessment battery than high school and clinic-based ATs, respectively ($\chi^2 = 26.29$, $P < .001$).

Conclusions: Athletic trainers were using the clinical examination, standardized assessment tools, and a 3-domain concussion-assessment–battery approach more frequently in clinical practice than previously reported. However, despite practice improvements, nearly half of ATs were not using a 3-domain minimum concussion-assessment battery. Clinicians should strive to implement multidimensional concussion assessments in their practices to ensure optimal diagnosis and management.

Key Words: sports medicine, mild traumatic brain injury, evaluation, diagnosis

Key Points

- Athletic trainers were using concussion-assessment and return-to-participation methods consistent with current recommendations more frequently than previously reported.
- Despite global improvements, athletic trainers need to increase their use of a multidimensional concussion-assessment battery and discontinue using outdated tools, such as concussion-severity scales.
- Athletic trainers need to annually review their concussion-assessment strategies and return-to-participation policies to ensure they are using the tools and guidelines with the best evidence.

Concussion-evaluation and -management best practices have evolved substantially over the last 2 decades. Since the first International Conference on Concussion in Sport in 2001,[1] multiple groups[2–6] have published consensus statements or concussion-management best-practice guidelines. Consensus statements calling for changes to clinical practice are released periodically as new evidence emerges, but whether clinical practice is actually changing to reflect these updates remains unknown.

Certified athletic trainers (ATs) play a critical and unique role in concussion assessment and management. They are typically the only health care providers managing concussions from initial injury identification through full recovery and are often the first health care providers conducting concussion assessments and return-to-participation procedures. Athletic trainers are employed across all levels of sport and job settings; almost 68% of secondary schools in the United States have at least part-time access to their services.[7,8] They play a vital role in proper concussion management. Therefore, ATs must remain abreast of the most current concussion-assessment and -management techniques and continually strive to remain updated on the latest best-practice guidelines and evidence.

Researchers[9–11] have examined ATs' concussion-assessment and -management strategies, but numerous management recommendations and laws have changed since these reports were published. Since the most recent assessment and management study in 2013,[9] the National Athletic

Trainers' Association (NATA) has published a new position statement,[2] the International Conference on Concussion in Sport has published 2 consensus statements,[3,12] collegiate[4] and high school[5] sport associations have put forward practice guidelines, and every state has enacted or modified legislation to effect change in concussion health care.[13] Searching PubMed from December 2013 to present using the term *concussion* AND *sport* NOT (*Review* OR *Systematic*), we found that more than 1900 original, peer-reviewed concussion research studies have been published since the last examination of concussion practices, highlighting the rapid pace of changes regarding our knowledge of concussions. The NATA's position statement[2] and the International Conference on Concussion in Sport consensus documents[3,12] have provided clinicians with succinct, current best practices in concussion assessment and management and are freely available online. Whereas these consensus and position statements have been available for some time, how ATs are incorporating these recommendations and those from more than 1900 studies into their clinical practices is unknown. Therefore, the primary purpose of our study was to examine current concussion-assessment and -management techniques among ATs across the United States in all job settings. Our secondary purpose was to examine if practices differed based on key demographic features, such as years of clinical experience, college degree(s) attained, and work setting.

METHODS

Participants

A random convenience sample of 8777 certified and student certified ATs' e-mails were obtained from the NATA membership survey database. The survey was administered in February 2018. At that time, NATA certified and student certified membership totaled 33 410,[14] representing 62.8% of total certified ATs (33 410/53 166 ATs; L. Northup, written communication, July 2018). Participants were randomly sampled across all work settings and regions of the United States except Guam, and respondent sampling was not restricted based on common e-mail domains. Participants were included if they were either certified members or certified student members of the NATA and excluded if they did not consent to participate in the survey or indicated they were not ATs. All participants provided informed consent before the initiation of the online survey module, and this study was deemed exempt by the University of Georgia Institutional Review Board.

Instrumentation

A Web-based survey was created using an online survey tool (Qualtrics Inc, Provo, UT) that asked participants about their current concussion-assessment and -management techniques. The survey took 15 minutes on average to complete, and all responses remained anonymous. This survey was modified from previously published surveys[9–11] and used select-all-that-apply, multiple-choice, open-ended, and short-answer item responses. Every effort was made to keep the survey as similar as possible to the most recently published survey,[9] but changes were necessary to account for updated practice guidelines and assessments. The survey underwent content validation by 4 content experts to ensure appropriate item constructs and clarity. Next, the survey was piloted with 17 ATs to ensure online survey function and collect survey feedback. After gathering feedback from the pilot data, we constructed the final survey.

We used survey display logic that displayed a series of items based on whether a participant selected a specific response. For example, detailed items asking about the use of computerized neurocognitive testing (eg, "Please specify which computerized neurocognitive test(s) you use to assess and diagnose concussion," or, "Do you currently examine each individual computerized neurocognitive test for a valid score?") would only be displayed if the participants indicated using computerized neurocognitive testing in their practices. If computerized neurocognitive testing was not used, subsequent items regarding computerized neurocognitive testing were not displayed. Given the logical display functions used, the survey item total ranged from 23 to 41 depending on the responses. Participants could choose not to answer items and could move to the next item. The survey allowed only 1 attempt per participant to ensure that individuals did not complete the survey multiple times.

First, the survey asked participants about their demographic information (degree[s] earned, years certified as an AT, years of clinical experience, and primary and additional employment settings). Second, participants were instructed to estimate the number of concussions diagnosed in each sport for which they provided medical coverage and asked about additional characteristics of the concussions (eg, total number of concussions involving amnesia, loss of consciousness, or requiring >10 days to become asymptomatic and whether athletes were referred to neurologists or neuropsychologists). Third, respondents were asked which tools and methods they used to assess, manage, and determine the return to participation after concussion, with numerous follow-up items displayed if the display logic criteria were met.

Procedures

To each of the randomly generated e-mail addresses, the NATA sent an e-mail that included a cover letter, an informed consent form, and a Web link to complete the online survey from a computer or any mobile device. A follow-up e-mail was sent from the NATA to the original e-mail sample at 3 and 6 weeks after the initial contact date, regardless of whether the participant had completed the survey. The survey was active for a total of 8 weeks, and all partial survey completions were recorded.

Data Analysis

Data from the online survey tool were exported for data analysis. Upon inspection, we noted that some participants created a range or fraction of the number of concussions occurring in each sport. In these cases ($<0.001\%$), the average value within the participant's range was calculated, and all fractions were rounded to the nearest whole number. Descriptive statistics and χ^2 tests of association with an α level set a priori at .05 were conducted using SPSS (version 24; IBM Corp, Armonk, NY). Given the numerous potential comparisons, χ^2 analyses were limited to the

most frequent demographic factor comparisons between levels of education (bachelor's versus master's degree) and years of clinical experience (median split of <10 versus ≥10 years) and among primary work settings (high school versus collegiate versus clinical) on use of a concussion battery (symptom checklist, balance assessment, and neurocognitive examination) for injury assessment and return-to-participation decision making. If we observed χ^2 values that were statistically different, we conducted odds ratios to examine the likelihood of the compared outcome and calculated 95% confidence intervals (CIs). The false discovery rate was controlled by using the Benjamini-Hochberg procedure,[15,16] with adjusted *P* values presented. Given that participants were allowed to continue to the next survey item without responding to the preceding item or to discontinue the survey at any time, items had varying participant response rates that did not equal the total sample size.

RESULTS

Fifty-two of the 8777 e-mails were undeliverable (ie, invalid e-mail addresses), resulting in a sample of 8725 individuals. Of the 8725 individuals, 1331 initiated the online survey. Twelve individuals did not consent to participate, and 12 more individuals indicated they were not ATs, resulting in a response rate of 15.0% (1307/8725). A total of 818 ATs (62.6%) completed more than 90% of their prompted survey items. Total years of certification, highest degree earned, primary work setting, current AT practice status, and primary sport medical care coverage data are provided in Table 1.

Concussion Characteristics

A total of 12 981 concussions were observed each year by 836 ATs, with an average of 16.0 ± 15.0 (median = 12.0; range = 0–218) concussions reported per respondent. The highest number of concussions per year was reported in football (31.2%; n = 4045), followed by women's soccer (11.5%; n = 1496) and men's soccer (9.5%; n = 1236). Of the 12 981 concussions, 12.8% (n = 1662) involved any duration of loss of consciousness and 24.6% (n = 3196) involved either retrograde or anterograde amnesia. The ATs commented that 41.0% (n = 5325) of concussions required more than 10 days for symptoms to resolve and 11.7% (n = 1514) required more than 6 weeks. Approximately 56.2% (n = 7300) of concussions required more than 10 days for an athlete to return to full participation, and 14.2% (n = 1847) required more than 6 weeks.

Concussion Assessment

Clinical examination was used by 95.3% (953/1000) of ATs for concussion assessment and was the most common assessment method used; 86.7% (867/1000) of ATs used symptom-assessment tools, and 85.3% (853/1000) used balance assessments (Figure 1). Concussion-severity grading scales were used by 8.0% (80/1000) of ATs. A 3-domain minimum concussion-assessment battery that comprised at least symptom, balance, and neurocognitive evaluations was used by 52.7% (527/1000) of ATs and a 2-domain minimum concussion-assessment battery by 86.4% (864/1000) of ATs. Of the 867 ATs who selected symptom-assessment tools, the symptom checklist included in the Standardized Concussion Assessment Tool (SCAT) was used by 81.8% (n = 709) and was the most frequently used symptom checklist (Figure 2A). A total of 853 ATs indicated that they assessed balance, with 78.7% (n =

Table 1. Sampled Athletic Trainers' (ATs') Demographics

Characteristic	Mean ± SD
Certification, y	15.0 ± 10.6
Clinical experience, y	12.6 ± 9.5
Time since working clinically, y	7.8 ± 7.9
	Frequency (%)
Degree[a] (n = 1304)	
Bachelor's	342 (26.4)
Master's	875 (67.5)
Clinical doctorate	19 (1.5)
Doctor of philosophy or education	57 (4.4)
Doctor of medicine	3 (0.2)
Other	342 (26.4)
Practice status (n = 1301)	
Working as an AT	1069 (82.2)
Not working as an AT	232 (17.8)
Primary work setting (n = 1286)	
High school athletics	462 (35.3)
Division I collegiate athletics	189 (14.5)
Division II collegiate athletics	74 (5.7)
Division III collegiate athletics	92 (7.0)
Other collegiate athletics	71 (5.4)
Sports medicine clinic	123 (9.4)
General hospital setting	20 (1.5)
Professional athletics	33 (2.5)
Corporate health	2 (0.2)
Military setting	1 (0.1)
Industrial setting	12 (0.9)
Academic department (education/faculty)	86 (6.6)
Fitness center	3 (0.2)
Personal trainer	6 (0.5)
Other	112 (8.6)
Sport(s) for which ATs provided medical care[b] (n = 1056)	
Men's sports	
Basketball	625 (47.8)
Football	594 (45.4)
Soccer	561 (42.9)
Baseball	532 (40.7)
Track and field	487 (37.3)
Wrestling	377 (28.8)
Lacrosse	214 (16.4)
Other	181 (13.8)
Ice hockey	113 (8.6)
Women's sports	
Basketball	576 (44.1)
Soccer	570 (43.6)
Volleyball	532 (40.7)
Softball	519 (39.7)
Track and field	485 (37.1)
Other	228 (17.4)
Lacrosse	187 (14.3)
Field hockey	104 (8.0)
Gymnastics	101 (7.7)
Ice hockey	55 (4.2)
Rowing	37 (2.8)

[a] Participants could select all degrees that applied.
[b] Participants provided care to multiple sports, resulting in the frequency total exceeding 100%.

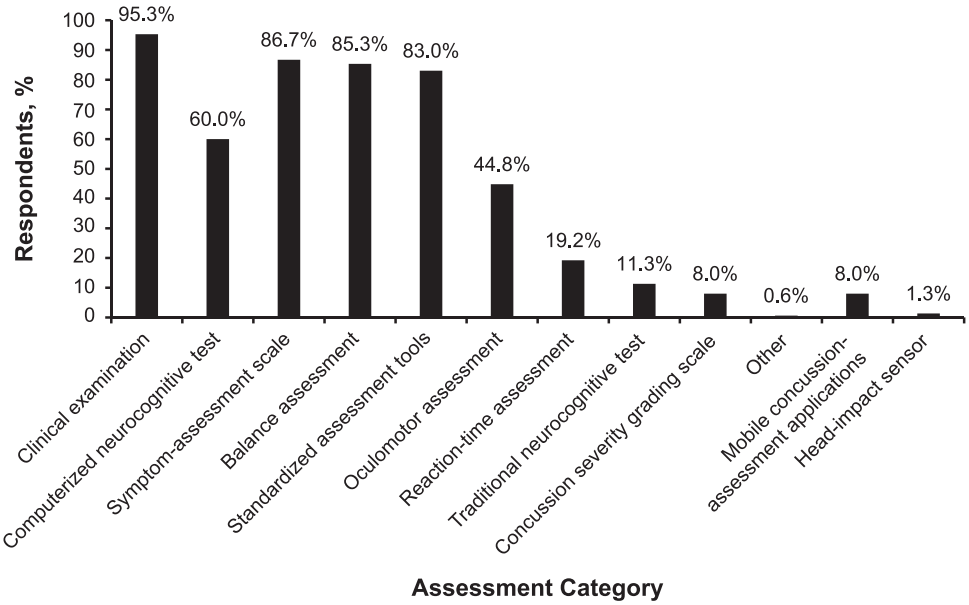


Figure 1. Frequency of assessment methods used for concussion diagnosis (n = 1000). Participants selected all methods they used ("Select all that apply") for concussion assessments, resulting in cumulative percentages that were >100%.

671) using the Balance Error Scoring System[17] (Figure 2B). The SCAT5 was the most commonly selected standardized assessment tool used (57.3% [476/830]; Figure 2C), and 83.5% (501/600) of ATs conducted computerized neurocognitive testing via the Immediate Postconcussion Assessment and Cognitive Test (ImPACT; ImPACT Applications, Inc, Pittsburgh, PA; Figure 2D).

Of the 60% (600/1000) of ATs who stated computerized neurocognitive testing was performed, 74.8% (n = 449) indicated that they examined each test for a valid score when asked, "Do you currently examine each individual computerized neuropsychological test for a valid score?" Of these 449 ATs, 92.0% (n = 413) required patients to retake the test if it was deemed invalid. When the same 60% of ATs were asked, "What method(s) do you use to determine if impairment is present on computerized neuropsychological testing? (Select all that apply)," 93.7% (n = 562) specified that impairment was determined. Of these 562 ATs, 66.4% (n = 373) indicated impairment was determined by "Comparing the domain score percentile of the postinjury test to the baseline test," 65.3% (n = 367) indicated *Valid or invalid indicator on the test report,* 43.8% (n = 246) indicated *Any worse performance in 1 or more test domain compared to baseline,* 36.8% (n = 207) indicated *Reliable Change Index (RCI)*, and 8.7% (n = 49) indicated *Other*." Approximately 78.8% (642/815) of ATs believed they should be trained to administer traditional (paper-and-pencil) neurocognitive tests to assess a patient with a concussion, and 93.0% (n = 758) believed they should be trained to administer computerized neurocognitive tests.

Concussion Management

The NATA's 2014 position statement on sport concussion[2] was the return-to-participation guideline selected most often (61.3%; 579/944), followed by the International Conference on Concussion and Sport's consensus statements published in 2017[3] (36.9%; 348/944) and 2013[12] (15.8%; 149/944). Most ATs indicated that the final decision for returning an athlete to participation was made by the team physician (41.3%; 385/932), followed by the AT (37.1%; 346/932) and the primary care physician (14.5%; 135/932). The coach, player, or parent was selected as primarily responsible for final return-to-participation decisions by 0.3% (3/932) of ATs. When asked which parties were at least partially involved in the return-to-participation decision, ATs reported they were the group involved most frequently (Table 2). For postconcussion consultation, 56.7% (462/815) of ATs reported having access to a neuropsychologist, and 41.8% (340/814) had access to a neurologist. For every 10 concussions managed, ATs reported that they would refer an average of 3.2 ± 2.7 patients to a neuropsychologist and 3.3 ± 2.8 patients to a neurologist. For determining when to return an athlete to participation, return-to-participation guidelines (91.0%; 864/949) were cited most often, followed by the clinical examination (88.2%; 837/949; Figure 3).

Table 2. Individuals Involved in Making the Return-to-Participation Decision (n = 949)

Personnel Category	No.[a] (%)
Athletic trainer	890 (93.8)
Team physician	626 (66.0)
Primary care physician	366 (38.6)
Player	220 (23.2)
Parent	175 (18.4)
Neurologist	164 (17.3)
Neuropsychologist	78 (8.2)
Coach	68 (7.2)
Other	37 (3.9)
Neurosurgeon	14 (1.5)
Military personnel	0 (0.0)

[a] Participants could select >1 individual who was involved in the return-to-participation decision, resulting in the total number (n = 2638) exceeding the total sample size for this survey item.

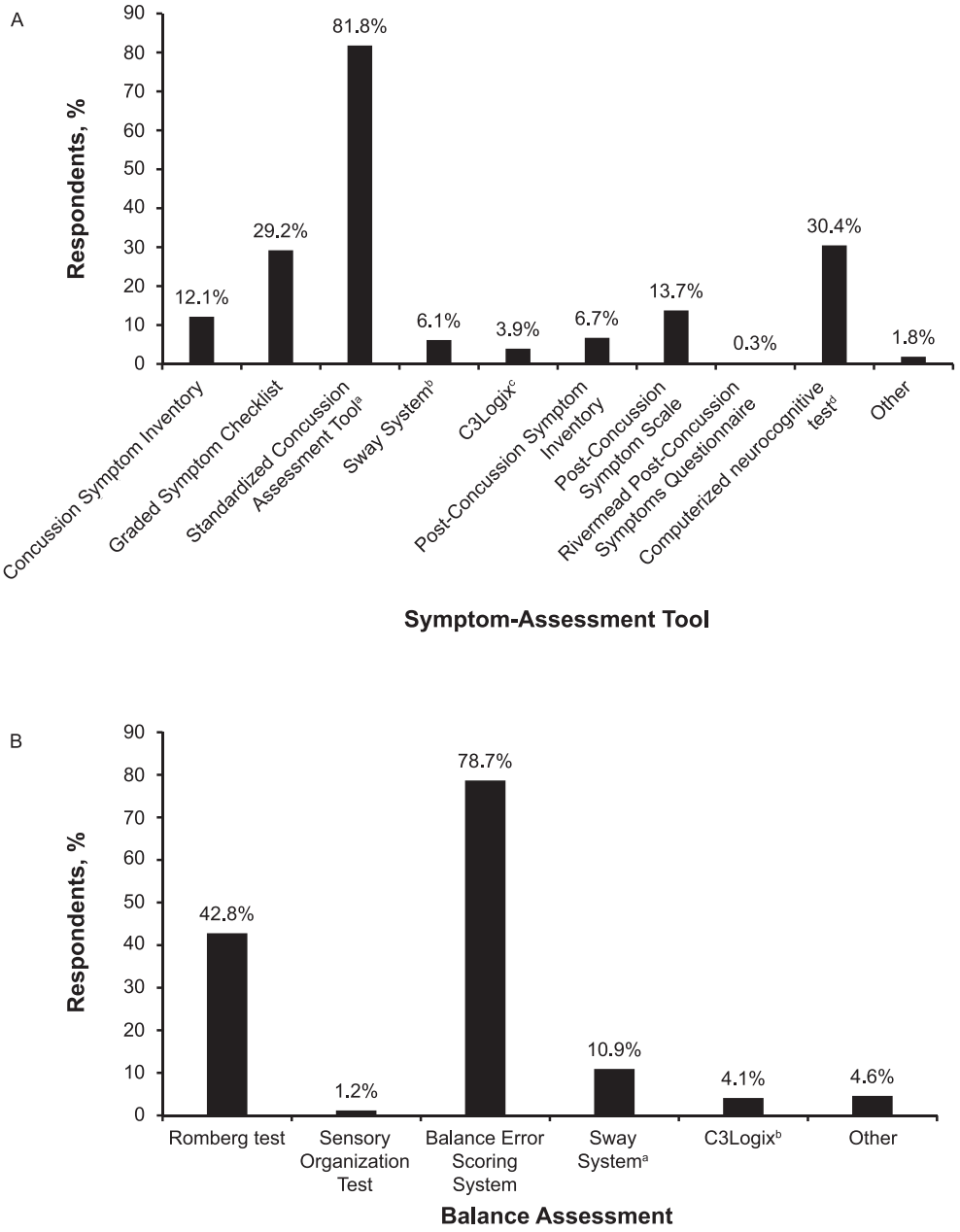
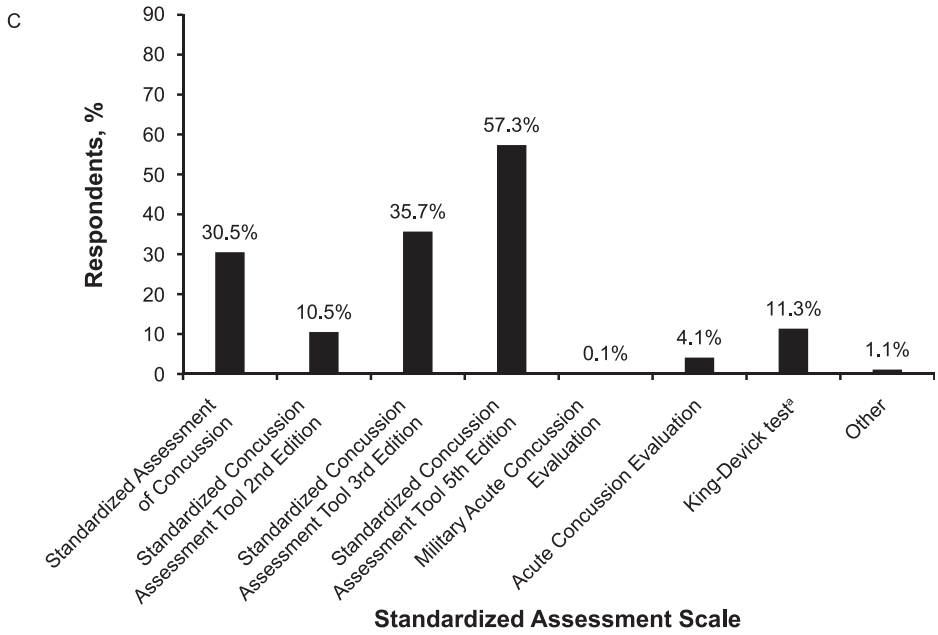


Figure 2. Frequency of concussion-assessment tools used by type. A, Symptom-assessment tool. [a] Symptom checklist in the Standardized Concussion Assessment Tool. [b] Sway Medical, Aledo, TX. [c] Cleveland, OH. [d] Symptom inventory in the computerized neurocognitive test. B, Balance assessment. [a] Sway Medical, Aledo, TX. [b] Cleveland, OH. Continued on next page.

Comparison of Education Level, Practice Setting, and Clinical Experience

We observed a significant association between the level of education and the use of a 3-domain minimum concussion-assessment battery comprising at least symptom, balance, and neurocognitive evaluations ($\chi^2 = 4.44$, $P = .05$) and return-to-participation decision making ($\chi^2 = 6.74$, $P = .02$). Athletic trainers with a master's degree were 1.36 times (odds = 1.02 versus 0.75; 95% CI = 1.02, 1.81) more likely to use the 3-domain minimum concussion battery for assessment and 1.58 times (odds = 0.43 versus 0.27; 95% CI = 1.12, 2.24) more likely to use it for return-to-participation decision making than ATs with a bachelor's degree. Athletic trainers working in any form of collegiate setting were 2.12 (odds = 1.46 versus 0.69; 95% CI = 1.59, 2.84) and 1.63 (odds = 1.46 versus 0.90; 95% CI = 1.03, 2.59) times more likely to use the 3-domain minimum concussion-assessment battery than high school and clinic-based ATs ($\chi^2 = 26.29$, $P < .001$). Similarly, collegiate ATs were 2.37 (odds = 0.57 versus 0.24; 95% CI = 1.69, 3.31) and 1.20 (odds = 0.57 versus 0.48; 95% CI = 0.71, 2.00) times more likely to use a 3-domain minimum concussion-assessment battery for return-to-participation decision making than high school and clinic-based ATs ($\chi^2 = 26.53$, $P < .001$). We did not find an association between years of clinical experience and use of the concussion-assessment battery ($P = .30$) or return-to-participation decision making ($P = .09$).



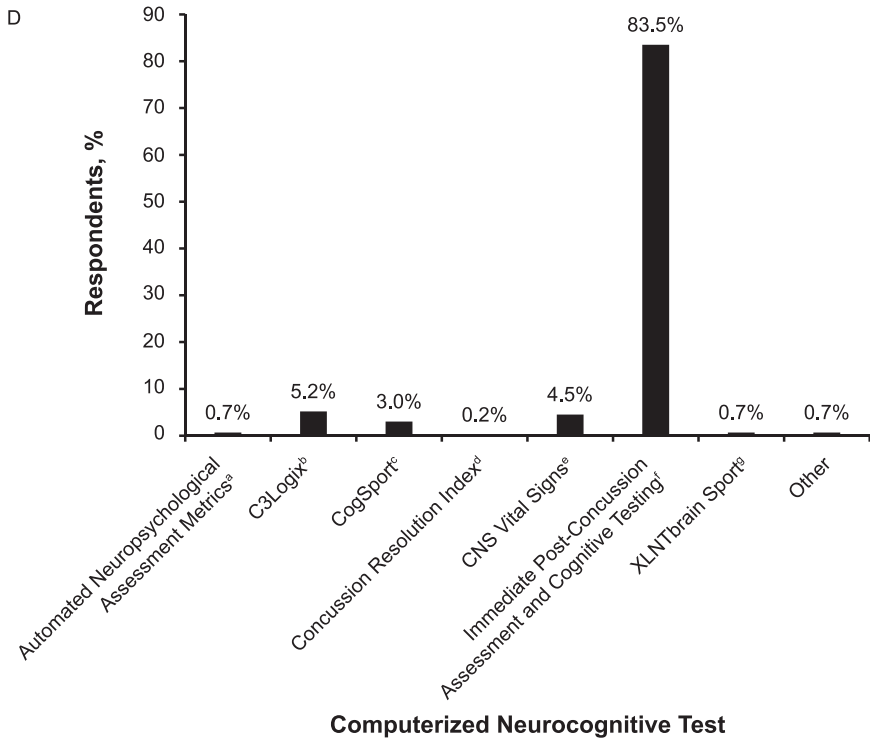


Figure 2. Continued from previous page. C, Standardized assessment scale. [a] King-Devick Technologies, Inc, Oakbrook Terrace, IL. D, Computerized neurocognitive test. [a] Vista LifeSciences, Parker, CO. [b] Cleveland, OH. [c] CogState, New Haven, CT. [d] Headminder, Inc, New York, NY. [e] CNS Vital Signs, LLC, Morrisville, NC. [f] ImPACT Applications, Inc, Pittsburgh, PA. [g] National Harbor, MD.

DISCUSSION

Our study provides updated insight into the current health care practices of ATs' assessment and treatment of concussions. Our findings suggested that ATs were using recommended techniques and capitalizing on objective measures more often than previously reported.[9–11] However, despite global improvements, our results also highlight the following key areas in which ATs' concussion practices need improvement: increased use of a multidimensional concussion-assessment battery (specifically neurocognitive testing during assessment and return-to-participation decision making) and elimination of outdated tools, such as concussion-severity grading scales and the SCAT2. Lastly, we found that ATs working in a high school or clinic setting used a 3-domain minimum concussion battery less often for assessment and return-to-participation decision making than those in collegiate settings.

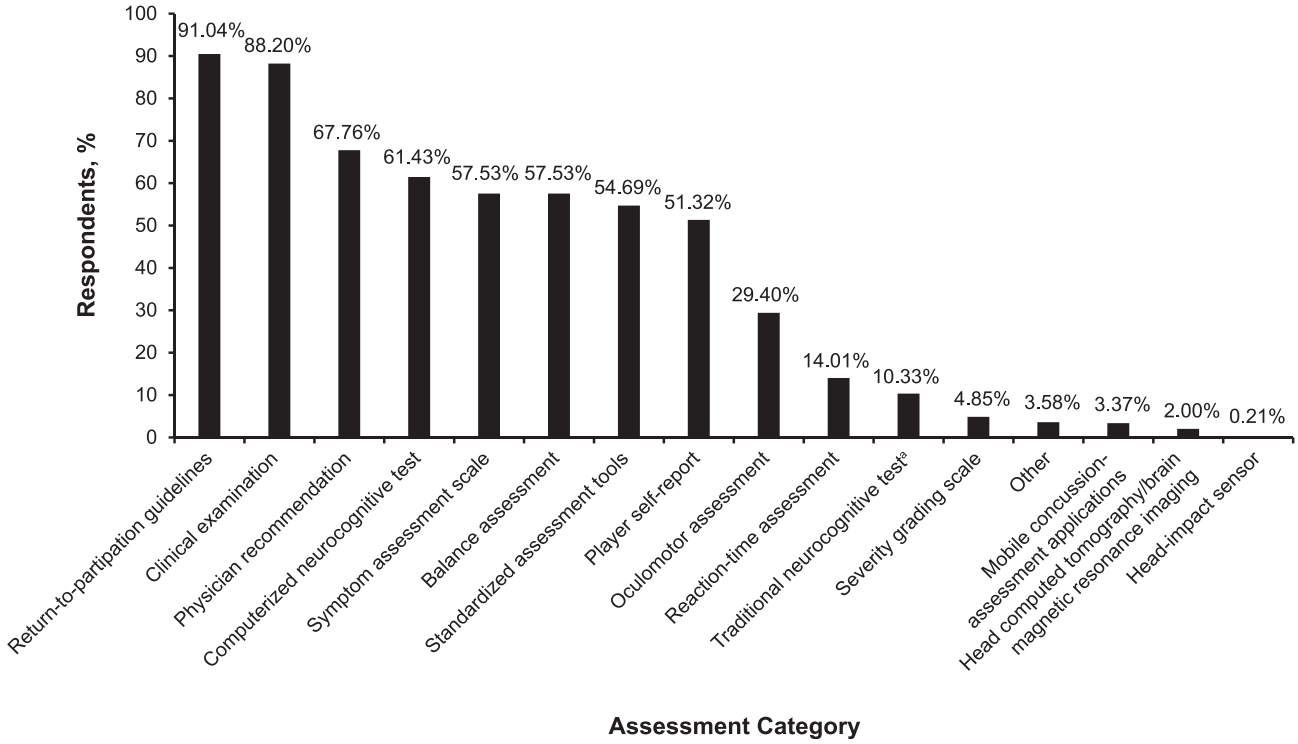


Figure 3. Assessment methods used by athletic trainers to determine return to participation. Participants selected all methods they used ("Select all that apply") to determine when a patient was ready to return to participation, resulting in cumulative percentages that were >100%. [a] Paper and pencil.

Concussion Characteristics

The number of concussions reported annually was higher than previously described.[9–11] Athletic trainers noted an average of 16.0 concussions diagnosed per year, compared with 10.7 in 2013,[9] 8.2 in 2005,[10] and 7.0 in 2001.[11] This trend is comparable with epidemiologic reports showing increases in diagnosed concussions each year; however, the increase was likely due to improved diagnostic capabilities, recognition, and reporting behaviors rather than more occurrences.[18–20] A larger proportion of concussions from our sample was reported to take more than 10 days for symptom resolution (41.0%) and return to participation (56.2%) compared with 30.1 and 39.0%, respectively, in 2013.[9] One explanation for a higher proportion of longer concussion recoveries is that more ATs reported greater familiarity with current guidelines and following return-to-participation guidelines than in previous studies.[9,10] Our sample also commented that 11.7% of concussions took more than 6 weeks for signs and symptoms to resolve, which was within the range of 7.4%[21] and 16.1%[22] reported for postconcussion syndrome. Authors[21,22] have defined *postconcussion syndrome* as symptoms for more than 4 weeks, and definitions vary based on the duration and quantity of symptoms, even among the *Diagnostic and Statistical Manual of Mental Disorders*, fourth edition[23]; *Diagnostic and Statistical Manual of Mental Disorders*, fifth edition[24]; and *International Classification of Diseases-10*.[25] Athletic trainers should consider the proportion of individuals who may experience recovery obstacles when reassessing and managing concussions to minimize patient frustration and provide reassurance throughout recovery.

Concussion-Assessment and -Management Methods

Numerous new concussion-assessment tools have been developed, highlighting how important it is to periodically assess current health care practice and where improvements can be made. The use of computerized neurocognitive testing has increased from approximately 15% in 2005[10] to 44% in 2013[9] and 60% in our study (Figure 4A). In addition, 78.8% and 93.0% of ATs in our sample believed they should be trained to use traditional (paper-and-pencil) neurocognitive tests and computerized neurocognitive tests, respectively. Athletic trainers are among the first health care professionals whom an athletic patient may see, which may allow for prompt neurocognitive testing after injury. The problem, however, is that traditional neurocognitive testing requires extensive training in administration and interpretation techniques that are currently not taught in athletic training education programs. Our findings may bring ATs' concerns and beliefs about current and future clinical competencies to the attention of the Board of Certification.

Overall, our results suggested that ATs were improving in the concussion-assessment methods used, with approximately 53% of ATs using at least a 3-domain concussion-assessment battery approach compared with 21% in 2013[9] and 3% in 2005[10]; a similar trend was observed when comparing a 2-domain concussion battery approach (Figure 4A). Despite this more than twofold improvement, our results also indicated that 47% of ATs did not use a 3-domain concussion-assessment battery and were not implementing best-practice recommendations in their clinical settings. Athletic trainers need to strive to implement a multidimensional battery into their concus-

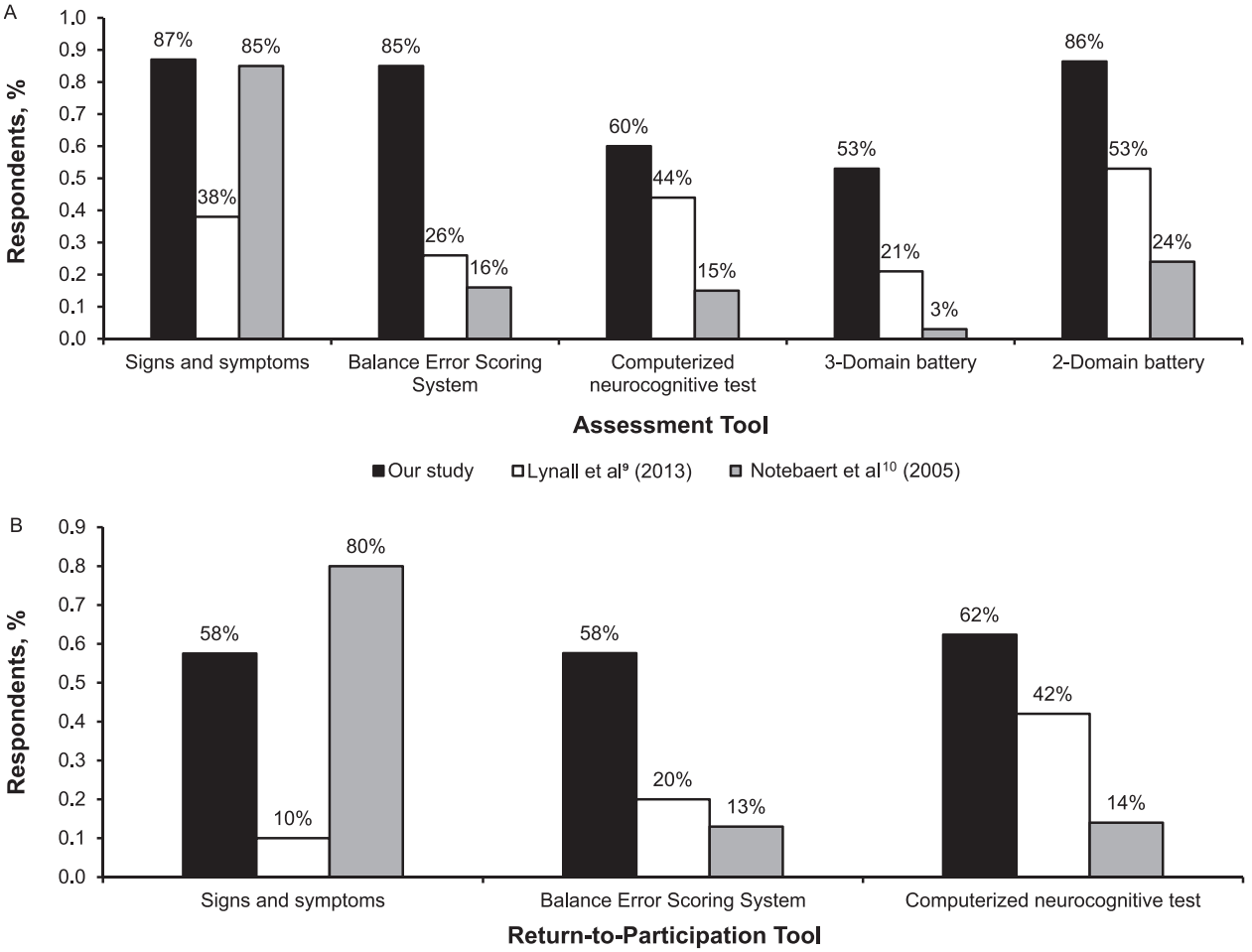


Figure 4. Athletic trainers' use of, A, concussion-assessment and, B, return-to-participation tools in our study and previous studies.[9,10]

sion-assessment and -management practices to ensure proper diagnostic and return-to-participation decision making. Not implementing the recommended concussion-assessment and -management techniques could result in misdiagnoses, which could lead to prolonged recovery and possible long-term consequences for athletes and potential litigation against the AT and other involved health care professionals.

In our study, return-to-participation decision making also appeared to have improved compared with previous reports (Figure 4B).[9,10] Athletic trainers were using recommended concussion-assessment tools for return-to-participation decision making more frequently than previously reported, with the exception of signs-and-symptoms assessments (80% in 2005[10] versus 58% in our study). The less frequent use of signs-and-symptoms assessments may be partially explained by the limited availability of objective assessment tools in 2005 and the typical inclusion of a computerized signs-and-symptoms assessment in current computerized neurocognitive tests.

Global improvements in concussion-assessment and -management techniques may be credited to heightened concerns and scrutiny surrounding concussion care, which have guided every state in the United States to enact laws that influence concussion health care since 2014.[13] Numerous concussion-practice guidelines[2–6] have been published and are freely available, and this may be a strong contributing factor to advances in practice. Athletic trainers should continue to use the guidelines set forth in position statements from organizations such as the NATA[2] and the International Conference on Concussion in Sport[3] to promote optimal health care and safety for patients.

Whereas great strides in incorporating recommended assessment methods have been made, some assessment techniques are still being applied despite being outdated or their use discouraged in practice. The use of concussion-severity grading scales has decreased from approximately 53% in 2013 to 8.0% in our study, suggesting that best recommendations are changing practice. Despite these improvements and calls from experts for their elimination from clinical practice since 2005,[26] concussion-severity grading scales are still being implemented. Similarly, 10.5% of respondents indicated they still used the SCAT2, which was replaced by the SCAT3 in 2013 and the SCAT5 in 2017.[27] Though the SCAT series assessment tools are similar, their differences can influence clinical decision making. For example, the SCAT2 includes loss of consciousness and balance problems as scoring components for the main assessment score and contains outdated patient instructions (eg, physical and mental rest until asymptomatic) in the document.[28] Clinicians should aim to implement current evidence-based practices from recent consensus

statements and expert-recommended concussion-assessment tools to ensure that proper assessment and patient management are provided.

The Romberg test was reported to be used by 42.8% of ATs during concussion assessments, but limited evidence exists to support its clinical utility for this purpose.[29] Clinicians should aim to use validated and currently recommended balance tests, such as the Balance Error Scoring System, to ensure that balance is being accurately assessed. Lastly, only 1.3% of ATs indicated they used head-impact sensors in some manner for concussion assessment. Whereas the technology is ever evolving, head-impact sensors, to date, have demonstrated overall low diagnostic utility for concussion.[3,30] Athletic trainers should critically review protocols and policies annually with all sports medicine stakeholders to ensure that evidence-based methods are used and clinicians remain knowledgeable about concussions.

Concussion-Assessment and -Management Differences Among Practice Settings

Our secondary research aim was to address whether differences in concussion-assessment and -management techniques were present based on key AT demographic factors. We observed differences among education levels and practice settings but not clinical experiences for using a 3-domain minimum concussion battery approach for the initial injury assessment and return-to-participation decision making. Athletic trainers with master's degrees were more likely to use a complete concussion-battery approach for the initial assessment and return to participation than ATs with only bachelor's degrees. Similarly, ATs in any collegiate setting were more likely to use a concussion battery for the initial injury assessment and return-to-participation decision making than ATs in a high school setting. These findings may be due to ATs with master's degrees potentially having more exposure to reading and applying research studies and to evidence-based medicine than those with only bachelor's degrees.[31] Another potential explanation is that many ATs with master's degrees work in the collegiate setting, in which the National Collegiate Athletic Association and university sports medicine programs pursue strong policies for concussion health care, typically have a larger team of health care providers, and may more easily implement multidimensional assessments. Despite differences among groups, the odds of using a concussion battery among all group comparisons were low overall. The odds of using a 3-domain minimum concussion battery for return-to-participation decision making were $\leq$0.57 among all groups, highlighting clear discrepancies between best-practice guidelines and actual clinical practice. Athletic trainers in all settings should aim to implement multidimensional concussion batteries not only in their acute injury assessments but also in their return-to-participation assessments to ensure that clinical recovery has occurred.

These findings highlighted potential deficits in concussion education at the undergraduate level. Recently, Wallace et al[32] reported that more than 80% of athletic training education programs were teaching tools included in the 3-domain minimum concussion battery, but not all were providing hands-on experience with those tools. In addition, almost 30% were not teaching students about return-to-participation progressions.[32] Educators should strive to remain up to date on concussion practices to ensure that the information is disseminated to future clinicians, and clinicians should aim to implement current recommendations in practice.

LIMITATIONS

Our study had several limitations inherent to the survey-based study design and methods employed. The survey was potentially subject to recall and social desirability biases by participants. In addition, we could not assess the effort exerted during the survey, so we assumed that all respondents answered as honestly and accurately as possible. Respondents may not have understood certain items due to the impossibility of our explaining each item to each respondent. However, the research team provided contact information in the informed consent section and instructed participants to inquire if they had any questions, and participants could omit a response to any survey item. Our survey had a relatively low response rate of 15% compared with the response rate of 33% reported by Lynall et al[9] and 34% reported by Notebaert and Guskiewicz.[10] The lower response rate may be due to our survey taking on average 15 minutes to complete compared with previous surveys that took 10 minutes. Yet our response rate was similar to the rates of previous investigators[33] who examined other health care professionals. Regardless of the response rate, our study provided the largest sample size and most comprehensive analysis of concussion-assessment and -management techniques among ATs in all work settings to date. Lastly, the overall socioeconomic status of institutions and available financial resources were not assessed in this survey and may have influenced our findings. For example, computerized neurocognitive testing is often plagued with expenses that limit its implementation and ultimately the clinical use of a multidimensional concussion-assessment battery.

CONCLUSIONS

Athletic trainers reported using concussion-assessment and return-to-participation methods consistent with current recommendations more frequently than in previous studies. We observed global improvements in concussion assessment and management, with ATs using multidimensional concussion-battery approaches twice as often as in the past, suggesting that ATs were adapting and implementing best practices. Though improvements are being made, ATs should remain cognizant that current recommendations are always evolving and emphasize staying up to date on the best evidence. Standardized assessment tools, such as concussion-severity grading scales and the SCAT2, should be immediately discontinued from practice.[28] Athletic trainers should prioritize, at minimum, annually reviewing their concussion-assessment strategies and return-to-participation policies in comparison with current consensus guidelines to ensure they are using the concussion-assessment tools and return-to-participation guidelines with the best evidence.

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