Journal of Adolescent Health 56 (2015) 91–97

JOURNAL OF ADOLESCENT HEALTH

www.jahonline.org

Original article

The Effectiveness of a Web-Based Resource in Improving Postconcussion Management in High Schools

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Article history: Received April 1, 2014; Accepted August 15, 2014
Keywords: Concussion; High school; Web-based training; School-based health care

A B S T R A C T

Purpose: Because many sports concussions happen during school-sponsored sports events, most state concussion laws specifically hold schools accountable for coach training and effective concussion management practices. *Brain 101: The Concussion Playbook* is a Web-based intervention that includes training in sports concussion for each member of the school community, presents guidelines on creating a concussion management team, and includes strategies for supporting students in the classroom.
Methods: The group randomized controlled trial examined the efficacy of *Brain 101* in managing sports concussion. Participating high schools (N = 25) were randomly assigned to the *Brain 101* intervention or control. Fall athletes and their parents completed online training, and *Brain 101* school administrators were directed to create concussion management policy and procedures.
Results: Student athletes and parents at *Brain 101* schools significantly outperformed those at control schools on sports concussion knowledge, knowledge application, and behavioral intention to implement effective concussion management practices. Students who had concussions in *Brain 101* schools received more varied academic accommodations than students in control schools.
Conclusions: *Brain 101* can help schools create a comprehensive schoolwide concussion management program. It requires minimal expenditures and offers engaging and effective education for teachers, coaches, parents, and students.

IMPLICATIONS AND CONTRIBUTION

Given the legislative mandates and increased school liability for child safety in the area of concussion, it is important to develop evidence-based cost-effective approaches to knowledge transfer and exchange in concussion management. Results from this randomized controlled trial suggest that the *Brain 101* intervention is one such approach.

Adolescent sports-related concussion accounts for nearly 15% of all reported injuries among high school athletes [1]. Most of those concussions happen during school-sponsored events. The high incidence of concussion has led to greater public awareness, changes in medical recommendations for evaluation and management [2], and concussion management laws in all 50 states. Most concussion laws mandate training for coaches, immediate removal from play when a concussion is suspected, and specific

Conflicts of Interest: The authors have no conflicts of interest to disclose.
Information on clinical trials can be found at ClinicalTrials.gov (Identifier NCT01978795).

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1054-139X/
http://dx.doi.org/10.1016/j.jadohealth.2014.08.011

requirements for when an athlete is allowed to return to activity [3,4].

Consensus has been established regarding field management of concussion and return to activity [5], and there have been a range of educational efforts in this area. One early resource was the Centers for Disease Control (CDC) "Heads Up" kit [6]. Initial data suggested that toolkit use was associated with gains in coach knowledge and awareness of concussion severity and increased efforts to minimize risks [7,8]. Similar increases in knowledge have been reported with education efforts targeting youth [9,10]. Over the past few years, several online education courses [6,11,12] have been developed and promoted to high school and youth sports coaches. Although education can increase knowledge regarding concussion, effective concussion management requires significant behavioral and cultural shifts among all school members: coaches, school and athletic administrators, educators, counselors, parents, and students. Schools need practical tools and guidelines to manage the academic aspects of concussion.

This article reports the findings of a randomized controlled trial of a schoolwide intervention, *Brain 101: The Concussion Playbook*. The Web-based program includes sports concussion training and resources for educators, coaches, students, and parents. The study's hypotheses were

(1) Use of the *Brain 101* Web site by athletes and parents will result in "increased knowledge" of concussion management compared with controls.
(2) Use of the *Brain 101* Web site will result in increased athlete and parent behavioral intention to implement effective concussion management practices compared with controls.
(3) Use of the *Brain 101* Web site will positively affect concussion management practices (i.e., seen by health care professional, returned to full activity, classroom accommodations provided).

Methods

Participants

Participating schools were recruited through the Oregon School Activities Association. Criteria for participation included (1) a registered athletic trainer (AT) on staff or contracted by school for services; (2) school access to a high-speed Internet connection, and (3) agreement to expose all students participating in Fall sports to the training. Because the study represented normal educational practices, it was deemed exempt by the ORCAS Institutional Review Board.

The Oregon concussion law, which went into effect in 2010, mandates annual coach education on concussion and specific guidelines regarding removal from play and safe return to activity [13]. Thus, coaches at all participating schools received concussion education and should have been aware that any athlete suspected of having a concussion must be removed from play until receiving medical clearance. Oregon law does not mandate concussion education for parents or students.

Sample size was determined based on Murray's [14] discussion of power and assumed an intracluster correlation coefficient (ICC) between .05 and .15. Twenty-five schools participated in the study (13 intervention and 12 control). From participating schools, 4,804 Fall student athletes (2,264 intervention and 2,180 control) and 1,004 of their parents (445 intervention and 559 control) completed study instruments. A summary of demographic characteristics is provided in Table 1.

Instruments

Athlete survey. Athlete knowledge of sports concussion was measured using items from two validated instruments [15,16] and additional items derived from the *Brain 101* training program. The survey included eight true/false items (e.g., *you have to be hit on the head to have a concussion*) and identification of 18 correct or incorrect signs and symptoms of concussions (e.g., *sleep problems*). A composite knowledge score represented the proportion of correctly answered items and had an ICC of .089.

Knowledge application was assessed with six scenarios involving sports concussions (Appendix A). Each scenario was assessed with a five-point scale (1 = strongly disagree,

Table 1
Demographic characteristics for schools, Fall student athletes, and their parents

	Intervention (n = 13)		Control (n = 12)	
	Mean	SD	Mean	SD
School				
Size (n)	1,517.7	348.6	1,474.9	541.8
Free or reduced lunch	42.2	22.1	49.5	20.6
Hispanic	19.2	16.0	25.0	17.9
Race				
American-Indian/Alaskan Native	1.5	.7	1.3	1.07
Asian	4.9	4.8	5.8	5.2
Black or African-American	4.9	8.0	9.7	16.0
White or Caucasian	62.8	18.6	52.9	20.3
Multiracial	5.5	2.9	4.2	1.9
Fall Student Athletes				
Sex (female)	44.1	22.8	44.2	23.9
Grade				
9th/Freshman	32.7	19.7	26.6	13.6
10th/Sophomore	23.9	14.5	27.6	22.7
11th/Junior	20.1	11.7	22.6	12.2
12th/Senior	23.3	21.4	23.2	11.0
Hispanic	19.6	22.7	18.9	13.0
Race				
American-Indian/Alaskan Native	2.6	4.2	1.6	1.6
Asian	3.4	3.7	5.4	4.8
Native Hawaiian or Pacific Islander	4.1	11.2	1.9	1.8
Black or African-American	7.4	13.5	15.9	22.8
White or Caucasian	64.0	28.6	57.1	26.3
Multiracial	8.5	6.1	8.8	4.9
Other race	10.0	14.6	9.3	7.3
Parents of Fall Student Athletes				
Sex (female)	61.5	48.7	63.6	48.2
Hispanic	8.0	27.2	6.5	24.6
Race				
American-Indian/Alaskan Native	.7	8.4	1.3	11.3
Asian	2.1	14.5	5.2	22.2
Native Hawaiian or Pacific Islander	.5	6.9	1.9	13.5
Black or African-American	2.8	16.6	4.8	21.4
White or Caucasian	85.3	35.4	79.8	40.2
Multiracial	3.1	17.3	4.4	20.6
Other race	5.5	22.7	2.6	15.9

All descriptive summaries are aggregated to the school level, the level of randomization. Student summaries are based on 2,624 student athletes from intervention schools and 2,180 from control schools. Parent summaries are based on 445 parents of student athletes from intervention schools and 559 from control schools.
All data are mean percentages with the exception of school size.
SD = standard deviation.

5 = strongly agree). An average score was computed across the six scenarios ($\alpha = .75$) and had an ICC of .027.

Because intention to report concussion has been identified as an important outcome [17,18] and is theoretically linked to behavior change [19,20], survey items also assessed it for self or peer with four items (e.g., how likely is it that you would tell your coach if you thought you had a concussion, even if you thought your team might lose if you did not play?) using a five-point scale (1 = very unlikely, 5 = very likely). An average score was computed across the six scenarios ($\alpha = .76$) and had an ICC of .001.

Parent survey. Survey content was based on two standardized instruments and *Brain 101* program content [12,21–23]. The knowledge items included identification of 18 correct or incorrect signs and symptoms of concussions. A composite knowledge score represented the proportion of correctly answered items and had an ICC of .027.

Knowledge application was assessed with 10 scenarios involving sports concussions (Appendix A). Agreement or disagreement with each scenario was assessed with a five-point scale (1 = strongly disagree, 5 = strongly agree). An average score was computed across the six scenarios ($\alpha = .72$) and had an ICC of .036.

Behavioral intention toward responding to a sports concussion situation was assessed with 10 items, each corresponding to 1 of the 10 knowledge application scenarios (e.g., if this was your daughter, how likely is it that you would take her to get checked out by a health care professional?) with a five-point scale (1 = very unlikely, 5 = very likely). An average score was computed across the 10 scenarios ($\alpha = .68$) and had an ICC of .065.

Concussion logs. For each Fall athlete who sustained a concussion, ATs collected information about the injury, number of days until return to full activity, and concussion symptoms experienced (Appendix B). Concussion logs also included three key outcomes about concussion management for data analysis: (1) whether the student saw a health care professional (medical doctor, doctor of osteopathic medicine, nurse practitioner, physician assistant, or neuropsychologist) for injury evaluation/treatment (ICC = .573); (2) whether the athlete returned to full activity (ICC = .179) and if not, why; and (3) whether the athlete received classroom accommodations (ICC = .362), and if so, what type. ATs submitted concussion logs to research staff at the conclusion of the study.

Exit interview with school administrators. At the conclusion of the Fall sports season in November, we interviewed each school's principal or athletic director in both treatment and control groups about concussion management policies and procedures. We began each interview with an open-ended question: Tell me about the concussion management program at your school. We then asked, Did you create a concussion management team? If so, is there a coordinator for the team? Administrators were not aware that the interview was part of the study until it was scheduled, 1–2 weeks before it occurred.

Procedures

Brain 101: The Concussion Playbook is a Web-based stand-alone guide on effective policies and practices in concussion management. Because knowledge alone does not always translate into behavior change [24], the program considers social and attitudinal aspects of concussion management. Developed with input from athletics personnel, educators, health care providers, parents, and student athletes and using the Health Belief Model [25,26] as its conceptual framework, *Brain 101* offers interactive modules on recognizing and managing sports concussion. It includes educational material for each target audience [27]: educators, athletics staff, students, and parents. Consistent with the literature on effective school-based change efforts [28,29], the Web site offers a comprehensive approach to preventing and managing sports concussion, including guidelines for creating a concussion management team (CMT) that meets regularly to support students as they return to academics, extracurricular activities, and athletics. It also includes strategies to support students in the classroom after concussion (e.g., designing reduced school schedules and monitoring school performance [30]).

Experimental procedures. The evaluation was conducted between August and November, 2011, over a secure server on the Internet. Following determination of eligibility, the project coordinator randomly assigned schools within blocks of two with a random digit table to treatment or control groups and either (1) granted access to the *Brain 101* Web site (treatment group) or (2) directed participants to CDC material on safety (control group). At treatment schools, the principal and athletic director were given access to the *Brain 101* Web site and asked to implement the recommended best practices described therein (e.g., develop policy, create CMT) and have athletes and parents complete their respective online trainings. At control schools, the principal and athletic director asked parents to view CDC materials on safe teen drivers [31]. Athletes viewed Web-based materials about teens staying safe on the job [32]. Thus, parents and athletes in the control group were exposed to an active intervention unrelated to the target topic of concussion safety.

At each school, athletes completed the pretest, accessed either the *Brain 101* or CDC site, and completed the posttest in one sitting (approximately 1 hour total time). School staff sent parents of Fall athletes a link to the pretest, program, and posttest. All parents completed the training within 4 weeks. With the exception of concussion logs, all data were collected electronically. School staff administering the interventions and research assistants responsible for data collection were not blind to study condition.

Data analysis

We tested our first two research hypotheses with mixed-effects analysis of covariance (ANCOVA) and our third research hypothesis with random intercepts regression, both within the framework of hierarchical linear models [14,33] to account for the dependence of individuals nested within schools assigned to conditions. Rates of missing survey data for students were 3%–5% at T1 and 17%–19% at T2. Rates of missing survey data for parents were 9%–16% at T1 and 43%–47% at T2. Missing data were not significantly related (at $p < .05$) to study condition or any baseline measure for either students or parents. For this intent-to-treat analysis, sequential regression multiple imputation was used to impute 10 data sets separately for students and parents. Data were not imputed for concussion logs. Given the relatively large rates of missing data, especially for parents at the follow-up assessment, the mixed-effects ANCOVA models were run for both the imputed data sets and the available data; they yielded similar results.

Results

Before testing for group differences, intervention and control schools were compared on all demographic characteristics and baseline measures. No statistically significant differences were found ($p > .05$), suggesting randomization produced initially equivalent groups.

Pretest–posttest survey measures

Descriptive statistics are summarized in Table 2, and results of the mixed-effects ANCOVA models are in Table 3. Posttest results show that student athletes and parents from intervention schools outperformed their counterparts at control schools, after adjusting for any pretest differences, on sports concussion knowledge, knowledge application, and behavioral intention. Differences between intervention and control schools were all medium to large with an average effect size of Hedges $g = .52$ for Fall athletes and $g = .61$ for parents. Differences between intervention and control schools for the available data models were medium-to-large effects with an average effect size of $g = .75$ for Fall athletes and $g = 1.32$ for parents.

Concussion log data

Among 24 schools (one intervention school did not provide concussion log data), 354 concussions were documented: 201 from intervention schools and 153 from control schools (2–31 per school). Most concussions were reported by male athletes (74% overall; 73% intervention, 75% control), and most occurred during game play (61% overall; 65% intervention, 57% control), followed by practice (36% overall; 33% intervention, 40% control), and other (3% overall; 3% intervention, 3% control). Reports of concussions were most prevalent while participating in football (67% overall; 70% intervention, 63% control), followed by soccer (25% overall; 21% intervention, 32% control), cheer/spirit (3% overall; 4% intervention, 2% control), and volleyball (3% overall; 4% intervention, 3% control). The remainder (2% overall; 2% intervention, 1% control) occurred during water polo, basketball, wrestling, and color guard. The average concussion incidence rate, concussions per 1,000 Fall athletes, across all schools was 47.4 (standard deviation [SD] = 29.0), slightly higher at intervention schools (mean = 51.5, SD = 29.5, range = 13.2–90.2) than at control schools (mean = 43.2, SD = 29.2, range = 8.9–97.5), but the rates did not differ significantly ($t[22] = .71$, $p = .49$, Cohen $d = .28$).

Of the 354 concussions logged, 297 (84% overall; 87% intervention, 84% control) students returned to full activity within the 90-day study period. Of the 57 who did not return to full activity, 24 (42% overall; 48% intervention, 38% control) cases remained unresolved, 11 (19% overall; 19% intervention, 20% control) had the sport season end, 2 (4% overall; 4% intervention, 4% control) dropped out of the sport, and 19 (35% overall; 30% intervention, 38% control) were unknown or another reason.

We found no statistically significant differences in mean time to return to full activity, whether a concussed student saw a health care professional, average number of school days missed (Table 4), or whether academic accommodations were provided. The average number of accommodations for students receiving them was 2.3 (SD = 1.4) for intervention schools and 1.7 (SD = .7) for control schools, a marginal statistical difference ($t[15] = 1.98$, $p = .067$, $g = .56$) associated with a medium effect size. Differences in the various types of accommodations reported in Table 4 were examined between the groups. Two marginally significant differences with medium-to-large effects were found: more student athletes from the intervention

Table 2
Descriptive statistics for pretest and posttest survey measures

	Pretest					Posttest				
	Available data[a]		Imputed data[b]			Available data[a]		Imputed data[b]		
	Mean	SD	Mean	95% CI		Mean	SD	Mean	95% CI	
				LB	UB				LB	UB
Fall student athletes										
Knowledge of sports concussions										
Control	.63	.15	.62	.62	.63	.65	.16	.66	.65	.66
Intervention	.63	.15	.63	.62	.64	.81	.15	.80	.78	.80
Knowledge application										
Control	3.55	.54	3.55	3.53	3.58	3.61	.60	3.64	3.61	3.67
Intervention	3.59	.53	3.59	3.57	3.61	4.05	.66	4.01	3.98	4.03
Behavioral intention										
Control	3.14	.81	3.13	3.10	3.17	3.24	.82	3.27	3.24	3.31
Intervention	3.12	.79	3.13	3.09	3.16	3.66	.85	3.61	3.58	3.65
Parents of Fall student athletes										
Knowledge of sports concussions										
Control	.68	.15	.68	.67	.70	.75	.16	.76	.74	.77
Intervention	.69	.10	.69	.67	.70	.92	.10	.86	.84	.87
Knowledge application										
Control	3.46	.50	3.45	3.41	3.50	3.62	.59	3.73	3.66	3.80
Intervention	3.45	.52	3.45	3.40	3.50	4.32	.46	4.09	4.03	4.17
Behavioral intention										
Control	3.33	.54	3.32	3.28	3.37	3.52	.57	3.61	3.53	3.70
Intervention	3.34	.53	3.33	3.28	3.39	4.20	.49	3.98	3.90	4.05

CI = confidence interval; LB = lower bound; SD = standard deviation; UB = upper bound.
[a] Descriptive statistics based on participants who provided data.
[b] Descriptive statistics based on 10 fully imputed data sets.

Table 3
Pretest–posttest change in study outcomes for athletes and parents

	Estimate	SE	*t* value	*p* value	Hedges *g*
Fall student athletes					
Knowledge of sports concussions	.116	.010	12.15	<.0001	.73
Knowledge application	.288	.042	6.85	<.0001	.45
Behavioral intention	.318	.033	9.68	<.0001	.38
Parents of Fall student athletes					
Knowledge of sports concussions	.090	.016	5.86	<.0001	.65
Knowledge application	.360	.052	6.95	<.0001	.61
Behavioral intention	.351	.060	5.85	<.0001	.58

Estimates based on 10 imputed data sets. Hedges *g* statistic [26] provided as measure of effect size with convention of .20 small, .50 medium, and .80 large. SE = standard error.

schools than from control schools received extended time to complete assignments (85.3 vs. 64.1; t [15] = 2.10, p = .053, g = .68) and a reduced workload (39.5 vs. 7.5; t [15] = 1.82, p = .089, g = .69). No other statistically significant differences or differences with meaningful effect sizes were found in the delivery of academic accommodations.

Exit interview with school administrators

Results from the interviews suggest that more *Brain 101* schools implemented the best-practice guidelines at the school level than control schools. Most *Brain 101* schools (77%) created a CMT that met regularly, and 54% had an assigned coordinator. Only 20% (2 of 10) of the control schools established a CMT, and neither of those teams had a coordinator. These differences were both statistically significant, $\chi^2(1,23) = 7.34$, $p = .007$ and $\chi^2(1,23) = 7.74$, $p = .005$, respectively.

Table 4
School-level summary of concussion log data

	Intervention			Control		
	n	%	Mean	n	%	Mean
Did student see a health care professional?						
Yes	124	61.7	70.2	136	88.9	88.4
No	75	37.3	29.0	13	8.5	9.2
Did not respond	2	1.0	.8	4	2.6	2.4
Did athlete return to full activity?						
Yes	174	86.8	83.1	123	80.4	75.3
No	27	13.4	16.9	30	19.6	24.2
If did not return to full activity, reason why						
Dropped sport	1	3.7	3.0	1	3.5	3.7
Unresolved, still out	13	48.2	43.3	11	37.9	36.1
Sport season ended	5	18.5	40.0	6	20.7	31.2
Unknown, not reported	4	2.0	12.2	2	6.9	4.2
Other	4	2.0	4.4	9	31.0	24.8
Did athlete receive classroom accommodations?						
Yes	113	56.2	51.2	59	38.6	24.8
No	43	21.4	22.0	47	30.7	29.5
Did not respond	45	22.4	26.8	47	30.7	45.6
Athlete received following accommodations (% of those receiving accommodations)						
Extended time to complete tasks	89	78.7	85.3	28	47.5	64.1
Reduced workload	53	46.9	39.5	3	5.1	7.2
Provided with written notes or instructions	20	17.7	20.9	2	3.4	19.4
Quiet room for tests	29	25.7	20.0	2	3.4	17.7
No physical education or weightlifting	32	28.3	20.9	31	52.5	33.3
Postponed examinations	33	29.2	29.0	22	37.3	28.4
504 plan	1	.9	.9	2	3.4	2.1
Time to visit school nurse	11	9.7	9.1	0	.0	.0

The number and percentage show responses across all concussion logs, and mean shows average percentage for each category when aggregated at the school level.

Discussion

Approximately 5% of the student athletes in our study experienced concussion during the Fall sports season. Thus, even a small high school can expect at least a few concussed student athletes every Fall with an impaired ability to learn. Although consensus statements provide guidelines for concussion management and return to play [5], no intervention studies on effective approaches to support youth as they return to school activities after concussion have been published. An initial statement detailing the best-practice guidelines has been developed for management of concussed student athletes in the classroom [34]. Educators clearly need further direction, guidelines, and resources to address concussion.

This study documented the effect of a freely available Web-based sports concussion management guide. *Brain 101* was developed specifically for use in high schools. It differs from other available concussion education in that it offers specific teen-friendly content. In addition, consistent with the Health Belief Model [26], *Brain 101* addresses attitudes and beliefs of student athletes, parents, educators, and coaches [35]. Research suggests that focusing on attitudinal barriers is important in implementing concussion management initiatives [36,37].

Our results indicate significant differences between the intervention and control groups in athlete and parent knowledge of effective concussion management practices. Also, both parents and athletes in the *Brain 101* group reported greater intention to use those practices than those in the control group. The importance of parent involvement in ensuring student athlete compliance with any prescribed cognitive restrictions or academic accommodations cannot be overstated.

Most (77%) *Brain 101* schools created a CMT, considered a best practice [34], to oversee return to activity. *Brain 101* users can create a CMT without needing to purchase materials, complete formal training, or bring in expert consultants. We believe the high level of CMT creation resulted directly in students in *Brain 101* schools receiving more varied academic accommodations than students in control schools. Implementation of other best-practice concussion management practices was also higher in *Brain 101* schools than in controls. The CMTs met regularly and had an assigned coordinator who provided linkage among the CMT, teachers, and parents.

In control schools, concussion education was provided only to coaches, as per Oregon State law and that education included only on the field management of concussion. In the absence of a formal CMT, the AT coordinated all concussion management practices. Although ATs are valuable in all phases of concussion management, their primary duty is managing athletic injuries; they typically do not have the time or expertise to manage the academic side of concussion.

Providing extra time on tests, a reduced workload (at home and in class), and structured mental rest breaks are believed to promote recovery after concussion [30,38]. Importantly, more students in *Brain 101* schools than in control schools received a variety of tailored accommodations currently considered best practice [30], although the results were not statistically significant. It is possible that we did not have enough schools in the study to detect a significant difference.

Limitations

Although the results of this study are promising, there are several limitations. It did not include an assessment of teachers', school administrators', or athletics staffs' knowledge and behavioral intention, which could improve understanding of how an entire school community's knowledge and intention affects schoolwide concussion management. Also, there is no information about the long-term maintenance of knowledge and behavioral intention or school practices. Future evaluation efforts could include a follow-up assessment with all school community members.

Our outcome measure was "days to return to full activity." We do not know how well athletes at control or *Brain 101* schools performed academically when they returned to activity or in the subsequent weeks and months. Further studies should address those outcomes. It is possible that without the close scrutiny of a CMT, some students at control schools had academic difficulties that went undetected as they returned to the classroom.

A measurement limitation involves the lack of connection between injury characteristics and outcomes. Although symptoms were tracked for each student athlete who experienced concussion, those data were not linked to specific outcomes (e.g., number of accommodations provided). The complexity of concussion profiles could play a role in a school's management. For example, a student with especially complex challenges might receive a range of accommodations and supports even in a school with overall ineffective management practices because staff perceive a stronger need. In addition, because of the significant percentage of schools in both groups, which did not provide information about the provision of academic accommodations (22% in *Brain 101* schools and 31% of control schools), the results must be interpreted with caution.

Another measurement limitation is the lack of a baseline fidelity measure. It is unknown whether some of the practices in place at *Brain 101* schools after intervention were present before the study. The study's inclusion criteria limit generalization of results to the 42% of high schools in the United States with ATs [39]. It is unknown whether schools without ATs would implement *Brain 101* in a similar manner or if outcomes would be equivalent. Future investigations should include smaller schools without ATs.

The scope of this study was limited to examining the effect of *Brain 101* on student athlete and parent knowledge and intention to implement effective concussion management practices and on schools' specific responses to concussion. This precluded a more in-depth examination of the range of variables that might affect concussion management practices. For example, we did not collect specific information about AT knowledge, experience, or employment (e.g., hired by district or contracted), each of which could affect concussion management [40].

Given the increased awareness of educators about sports concussion and the sensitivity created through survey questions, some parents and school administrators could have sought out concussion management information independently, calling into question whether differences between pretest and posttest in both groups are due to the *Brain 101* materials. We also acknowledge a significant lack of ethnic diversity in the study population. Differences in study outcomes by minority status are important, but with a sample size of 25 (13 intervention schools and 12 control schools), we lack the statistical power to adequately address differential effects as a function of minority status.

Given that all 50 states now have concussion laws [41] and school liability for child safety in the area of concussion is increasing, it is important to develop evidence-based cost-effective approaches to knowledge transfer and exchange in concussion management [34]. *Brain 101* is one such approach. Results from this randomized controlled trial demonstrate that when schools implemented the *Brain 101* intervention, rates of knowledge and behavioral intention to implement effective concussion management practices among parents and students increased and concussion management practices improved.

Acknowledgments

The authors thank David Schwebel, Ph.D., for his invaluable comments on revisions of this article. We would also like to thank the many parents, athletics staff, educators, and students who informed the content of the program. Special thanks to the athletic trainers for data collection and reporting.

Funding Sources

This project was completed with funding from the National Institute of Child Health and Human Development (grant number HD056610).

Supplementary Data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.jadohealth.2014.08.011.

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