Randomized Controlled Trial of a Novel Peer Concussion-Education Program for Collegiate Athletes

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Context: The National Collegiate Athletic Association and US Department of Defense have called for educational programs to change the culture of concussion reporting, increase reporting behavior, and enhance the safety of players and service members.

Objective: To evaluate the effects of a novel peer concussion-education program (PCEP) in changing knowledge, attitudes, and norms about concussion reporting among collegiate student-athletes and assess program implementation.

Design: Randomized controlled trial and qualitative analysis of interviews.

Setting: National Collegiate Athletic Association athletic teams from randomly selected colleges or universities.

Patients or Other Participants: A total of 1614 male and female student-athletes from 60 teams at 10 colleges and universities and 8 athletic trainers.

Intervention(s): The PCEP intervention trains 2 peer concussion educators to provide 2 education modules to their teammates. Knowledge, attitudes (oneself and teammates), and concussion occurrence or reporting were assessed at baseline, postintervention, and 1 month later. Eight athletic trainers were interviewed about program implementation.

Results: Compared with the control group, the intervention group showed greater increases occurred postintervention and at 1 month in concussion knowledge (F1,2648 = 51.3, P < .0001), intention to report (oneself, F2,2633 = 82.3, P < .0001; teammates, F2,2624 = 53.9, P < .0001), return-to-play protocol knowledge, (F2,2632 = 28.4, P < .0001), direct subjective norms (oneself, F2,2625 = 51.7, P < .0001; teammates, F2,2644 = 40.6, P < .0001), direct perceived behavioral control (oneself, F2,2628 = 53.7, P < .0001; teammates, F2,2615 = 68.2, P < .0001), and indirect attitudes (oneself, F2,2626 = 47.1, P < .001; teammates, F2,2623 = 40.9, P < .0001). Peer concussion-education program participants discussed concussion more often with a teammate (F1,1396 = 13.96, P < .0001) or athletic staff (F1,1396 = 6.62, P < .001). Qualitative program analysis revealed both positive aspects of the PCEP and areas for improvement.

Conclusions: The PCEP showed promise in increasing concussion knowledge, intention to report concussion, reporting a teammate’s concussion, and facilitating attitudinal changes that support reporting among student-athletes.

Key Words: mild traumatic brain injuries, randomized trial, concussion reporting, attitudes

Key Points
- Peer concussion education about pathophysiology and cognitive-behavioral change models show promise in increasing reporting intention and knowledge of symptoms and facilitating positive changes in attitudes toward concussion.
- Participation in a peer concussion-education program increased discussion of concussions with peers, coaches, and athletic trainers.
- Athletic trainers who implemented the peer concussion-education program reported positive experiences using well-organized and engaging materials and clear guidelines for peer selection.

More than 460,000 student-athletes compete in 24 National Collegiate Athletic Association (NCAA) sports every year, and estimates of concussions are 0.43 to 0.57 per 1000 athlete-exposures (game or practice) for these individuals, with rates varying by sport and sex. The data on concussion prevalence rely on student-athletes’ self-report, which is likely to be affected by factors such as the culture surrounding athletics. About 25% of collegiate student-athletes reported pressure from others to continue playing despite an impact to the head. Moreover, one-half to two-thirds of student-athletes stated that they would continue to play with possible symptoms of a concussion, which is alarming because continuing to play while symptomatic puts athletes at risk for significant neurologic consequences.

Current Approaches to Changing Concussion Reporting
Current concussion-education programs have focused on increasing knowledge about the physiology, symptoms, and health consequences of concussion in student-athletes. However, knowledge was a distal predictor of behavior, and increased concussion knowledge was only weakly associated with reporting behavior. Greater change is needed consistent with a culture of safety, including increasing concussion reporting and compliance with return-to-play (RTP) protocols.
The conceptual framework of the Theory of Reasoned Action (TRA) and Theory of Planned Behavior (TPB)\textsuperscript{12} has been applied to understanding the attitudes and norms influencing concussion reporting.\textsuperscript{13,14} This theory posits that the relationship of knowledge to behavioral change is mediated by changes in cognitions that are more proximal (ie, intention to report) and intermediate (ie, attitudes, subjective norms, perceived behavioral control) to behavior.\textsuperscript{12} Attitudes are the cognitive-affective beliefs about concussion reporting; subjective norms are expectations the reference group holds for concussion reporting; behavioral control is the perception of the ability to carry out the behavior. These indicators can be direct (ie, for oneself) or indirect (ie, perceived in others, such as coaches or peers) and combine to predict intention, which is the belief that one will perform the behavior when the situation arises. Cognitive-behavioral interventions are well suited to help individuals modify attitudes and beliefs that perpetuate problematic behaviors such as the failure to report a concussion.\textsuperscript{15} Health-related behavioral adherence has been increased using cognitive-behavioral methods, whereas changing knowledge alone was insufficient.\textsuperscript{12,15} Studies\textsuperscript{12–14} of cognitive-behavioral interventions using a TRA or TPB framework demonstrated that changes in attitudes, norms, beliefs, and intentions significantly influenced athletes’ reporting behavior.

An Approach to Changing Concussion Reporting

To attain normative and attitudinal change, it is necessary to consider the factors affecting concussion reporting in collegiate athletes.\textsuperscript{16} Typical concussion-education programs use a “top-down” approach in which authority figures (eg, athletic trainers, neuropsychologists) deliver the intervention.\textsuperscript{11} An alternative to this traditional top-down approach is the use of peer-mediated programs in which individuals from the target population lead the intervention. Because peers have the most contact with one another and are critical to the development and maintenance of attitudes, norms, and beliefs,\textsuperscript{14} peer interventions may be especially influential in not only challenging cognitions but changing norms for reporting and enhancing reporting.\textsuperscript{11,11} Models using peer-mediated programs have demonstrated a wide range of positive outcomes in diverse populations.\textsuperscript{17–19} In addition, the involvement of multiple stakeholders through an interdisciplinary model consistent with the socioecological framework,\textsuperscript{20} which includes the intrapersonal (ie, the athlete themselves), interpersonal (eg, coaches, athletic trainers), and environmental (eg, sports culture, access to prevention material) levels, further supports positive change at all levels. Thus, an interdisciplinary model that includes multiple stakeholders is likely to be more effective than a single top-down approach.

Using a peer-mediated, interdisciplinary, cognitive-behavioral approach, the Peer Concussion Education Program (PCEP) was developed in response to a call for novel interventions from the NCAA and US Department of Defense. The present study was a nationwide randomized controlled trial (RCT) designed to evaluate the effect of a novel PCEP among NCAA student-athletes competing in sports with a high risk of concussion. Our purpose was to compare the PCEP intervention and a control condition for changes in concussion knowledge, reporting behaviors, attitudes, intentions around reporting behaviors, discussion of concussion with others, and reporting behaviors after the intervention and 1 month later. Additionally, we solicited feedback from athletic trainers who implemented the PCEP to describe important themes encountered in carrying out the intervention.

METHODS

Participants

Schools. The Consolidated Standards of Reporting Trials (CONSORT) table in the Figure illustrates the enrollment of institutions and randomization of teams to conditions. First, colleges and universities were sampled randomly if they (a) were a member of the NCAA, (b) had a men’s football team, (c) had at least 2 of the following NCAA additional men’s sports: baseball, basketball, ice hockey, lacrosse, soccer, or wrestling, and (d) had at least 3 of the following women’s sports: basketball, field hockey, ice hockey, lacrosse, soccer, or softball. These sports were chosen because they have been identified as having the highest rates of concussion for each sex.\textsuperscript{4} From this pool, a multistage cluster-sampling technique was used to ensure representation of key variables in the final sample (including NCAA Division [I, II, III]; enrollment [<5000, \(\geq5000\)); geographic location [Northeast, Midwest, South, West]; and funding source [public, private]).

Second, we contacted the athletic director and head athletic trainer for 42 randomly selected schools. Eighteen schools did not respond within the 2-week timeframe after 3 attempts at contact. A total of 24 institutions responded, and 10 schools (Division I = 3, Division II = 4, Division III = 3) initiated an agreement with the research team, received local ethical board approval, and were enrolled in the study. Student-athletes and athletic trainers who provided data all supplied informed consent and were free to decline to participate in any aspect of the study without penalty. Finally, within each institution, 6 individual teams meeting the inclusion criteria (3 men’s, 3 women’s) were randomly assigned to receive either the experimental (PCEP) or control (routine concussion education mandated by the NCAA and implemented individually on each college campus) condition. Random assignment to condition was counterbalanced for sex within school and NCAA Division.

Student-Athletes. A total of 1614 student-athletes (773 in the experimental group, 841 in the control group) participated in the study: 389 competed in Division I, 794 in Division II, and 431 in Division III. Ethnicity was described by 364 individuals as African American, 18 as Asian, 1206 as European American, 50 as Latino or Latina, 10 as Native American, and 19 as mixed or another identity.\textsuperscript{a} The average age of participants was 19.8 years (SD = 1.33, range = 18–27 years). Table 1 presents participants by sport and sex. Men were overrepresented due to the inclusion of football at every school and the larger roster sizes of football. A total of 528 (32.9%) student-athletes were freshmen, 468 (29.2%) were sophomores, 426 (26.5%) were juniors, 150 (9.4%) were seniors, and 34 (2.1%) were fifth-year and above students. Student-athletes reported having played their sport for an average of

\textsuperscript{a} Participants were permitted to choose multiple ethnicities, so percentages are not available.
10.7 years (SD = 4.96, range = 0–21 years). Thirty-two percent (n = 515) of students reported participating in a previous concussion-education program, 54% (n = 847) never experienced previous concussion education, and 14% (n = 222) were uncertain whether they had. Concussion history was assessed through self-report at baseline in the demographic portion of data collection via the question, “Have you ever had a concussion?” Half of student-athletes reported no (n = 824; 51.2%), 40.3% (n = 648) reported yes, and 8.6% (n = 138) were not sure. The PCEP and control conditions did not differ with respect to concussion history ($\chi^2_{1610} = 1.68, P = .43$).

### Table 1. Frequencies of Women and Men Participating by Sport

<table>
<thead>
<tr>
<th>Sport</th>
<th>Women (n = 511)</th>
<th>Men (n = 1103)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseball</td>
<td>NA</td>
<td>117</td>
</tr>
<tr>
<td>Basketball</td>
<td>92</td>
<td>60</td>
</tr>
<tr>
<td>Field hockey</td>
<td>28</td>
<td>NA</td>
</tr>
<tr>
<td>Football</td>
<td>NA</td>
<td>666</td>
</tr>
<tr>
<td>Ice hockey</td>
<td>21</td>
<td>17</td>
</tr>
<tr>
<td>Lacrosse</td>
<td>72</td>
<td>53</td>
</tr>
<tr>
<td>Soccer</td>
<td>164</td>
<td>117</td>
</tr>
<tr>
<td>Softball</td>
<td>134</td>
<td>NA</td>
</tr>
<tr>
<td>Wrestling</td>
<td>NA</td>
<td>73</td>
</tr>
</tbody>
</table>

Abbreviation: NA, not applicable.

### Intervention

The development of the PCEP was influenced by the TRA or TRB and uses a peer-mediated, cognitive-behavioral, and interdisciplinary model to enhance concus-
Concussion and program assessment. Moreover, the assess-
studies' coprincipal investigators, who have expertise in

to report

Behavioral Control subscale relevant to the current study
circumstances. Two questions were added to the Perceived
report

notice symptoms

tions about context (ie,

intention-to-report subscale was altered to include ques-
consequences of reporting), and (e) indirect perceived
attitudes (individual's attitudes about reporting), (c) direct
perceived behavioral control (whether individuals feel they
in concussion research.

Concussion Occurrence and Reporting. Finally, at 1-
month follow up, all student-athletes described concussion
occurrence and reporting in the month since posttest.
Participants answered questions about whether they sus-
pected or knew of a concussion in self or teammate;
whether they spoke with teammates, peer educators or
knowledgeable peers, coaches, or athletic trainers about
concussions; and whether they reported a concussion that
they experienced or witnessed (Table 2).

Procedure

After being randomly selected and agreeing to participate
in the study, the site study coordinator from each college or
university was e-mailed an enrollment packet that consisted
of an overview of the study protocol, assessment measures,
and access to the PCEP online manual. Next, a phone
conference with each study site coordinator was conducted
by 1 of the coprincipal investigators to review the contents
of the enrollment packet and foster adherence to the study
protocol across all 10 participating colleges or universities.
The phone conference allowed us to ensure functionality
of the online manual for the potential participants and describe
the 4-step process for selecting and training peer educators
and having peer educators present to their teammates. It
also was done to familiarize participants with the study
materials and assessments and to answer any questions
about the study protocol.

After the enrollment meeting, the study site coordinators
followed the PCEP implementation process outlined in the
online manual with the individual teams within a school
randomly assigned to the experimental group, which
included (a) forming an interdisciplinary implementation
team, (b) selecting the PCEs, (c) training the PCEs, and (d)
having the PCEs present the 2 modules to their teammates.
The goal of the study was to evaluate the utility of the
PCEP as it would be used on college campuses. Thus, the
site coordinators implemented the program for teams in a
way that worked with those teams' schedules, usually
aligning it with team meetings. The PCEs were typically
trained 1 to 2 weeks before the implementation of the
PCEP, following the recommendations outlined in the
online manual. Assessments occurred immediately before
the PCEP was administered (baseline), immediately after
the PCE presentation to teammates (or after an equivalent
length of time for those teams in the control condition:
posttest), and after 1 month (follow up) for all treatment
conditions. Study site coordinators scheduled all treatment,
control, and assessment times. The data for each student-
athlete were linked over the 3 timepoints by a unique
identifier. All assessments used a paper-and-pencil format.
The control condition had similar assessment schedules.

The control groups did not receive any experimental
intervention. External site study personnel were instructed
to advise the PCEs and the teams participating in the PCEP
to avoid discussing the program with control-group
participants or any other students or student-athletes at
their school. During the time intervals, which mimicked
the time between baseline and the immediate posttest for
the PCEP groups, control teams engaged in standard athletic

Assessments

Knowledge Measures. Knowledge of concussion symp-
toms was assessed using a symptom checklist from the
Acute Concussion Evaluation22 and nonsymptoms from a
survey developed by Valovich McLeod et al.23 The
checklist consisted of 27 items, with 19 true symptoms
(eg, blurred vision, headache) and 8 false symptoms (eg,
black eye, chest pain). Scores reflect the number of actual
symptoms endorsed and the number of incorrect symptoms
not endorsed (Table 2). Knowledge of the RTP protocol
was assessed using a 5-item Likert scale questionnaire
(Table 2).

Attitude Measures Based on the TPB or TRA. An
adapted version of a TPB questionnaire24 for concussion
reporting by Register-Mihalik et al13 contained subscales to
measure (a) intention to report concussion and (b) direct
attitudes (individual’s attitudes about reporting), (c) direct
perceived behavioral control (whether individuals feel they
are able to report), (d) indirect attitude (the possible
consequences of reporting), and (e) indirect perceived
behavioral control (pressures about concussion reporting
from others such as coaches, fans, and parents). See Table 3
for an overview of the assessments, timelines, and
description of the measure and Table 2 for the specific
assessments used. The questionnaire was first modified to
include questions about reporting a suspected concussion in
oneself and one’s teammates for each subscale. The
intention-to-report subscale was altered to include ques-
tions about context (ie, under most circumstances, even if I
am not sure it is serious, to make an effort to report, when I
notice symptoms, in a playoff or championship game, in
practice) to account for the potential influence of
circumstances. Two questions were added to the Perceived
Behavioral Control subscale relevant to the current study
(ie, the encouragement of my teammates makes it easier to
report, having a peer concussion educator makes it easier
to report). The adapted versions were reviewed by the
studies’ coprincipal investigators, who have expertise in
concussion and program assessment. Moreover, the assess-

ment measures were reviewed by a researcher affiliated
with the NCAA Sports Science Institute who has expertise
in concussion research.
Table 2. Assessments Continued in Next Column

Concussion knowledge
- Amnesia (memory loss)
- Bleeding from the mouth
- Difficulty breathing
- Drowsiness
- Irritability
- Nausea
- Sensitivity to noise
- Blurred vision
- Bleeding from the nose
- Difficulty concentrating
- Fatigue
- Loss of consciousness
- Nervousness
- Sharp burning in the neck
- Black eye
- Chest pain
- Distractibility
- Feeling “fogy”
- Loss of neck range of motion
- Sadness
- Sleep disturbance
- Bleeding from the ear
- Confusion
- Dizziness
- Headache
- More emotional sensitivity to light

Return-to-play protocol knowledge (5-point Likert scale from never to always except where noted)
- How well do you understand the return-to-play protocol for concussion? (5-point Likert scale from not at all to very well)
- Light cardio exercise can be initiated while symptoms of a concussion are still occurring.
- A full-contact practice is required before returning to competition.
- Clearance by a health care professional is required before returning to full participation.
- The athlete could still have some symptoms but return to practice.

Intention to report (self; 7-point Likert scale from strongly disagree to strongly agree)
- When I myself experience possible concussion symptoms:
  - I intend to report under most circumstances.
  - I plan to report even if I am not sure it is serious.
  - I will make an effort to report.
  - I plan to report when I notice symptoms.
  - I will report if it happens in a playoff or championship game.
  - I intend to report in a practice.

Intention to report (teammate; 7-point Likert scale from strongly disagree to strongly agree)
- When my teammate experiences possible concussion symptoms:
  - I intend to report under most circumstances.
  - I plan to report even if I am not sure it is serious.
  - I will make an effort to report.
  - I plan to report when I notice symptoms.
  - I will report if it happens in a playoff or championship game.
  - I intend to report in a practice.

Direct subjective norms (teammate; 7-point Likert scale from strongly disagree to strongly agree)
- When my teammate experiences possible concussion symptoms:
  - My coach believes I should report.
  - My teammates believe I should report.
  - My trainer thinks I should report.
  - It is expected of me to report.

Direct perceived behavioral control (self; 7-point Likert scale from strongly disagree to strongly agree)
- When I myself experience possible concussion symptoms:
  - I am confident I could report.
  - I have control over reporting.
  - I am able to report.
  - The encouragement of my teammates makes it easier to report.
  - Having a peer concussion educator makes it easier to report.

Indirect perceived behavioral control (self; 7-point Likert scale from strongly disagree to strongly agree)
- When I myself experience possible concussion symptoms:
  - Reporting will improve my athletic performance.
  - Reporting will reduce the chances of my suffering another concussion.
  - Reporting will cause me to lose my position on the team (R).
  - Reporting will help me maintain my health.
  - Reporting will help me maintain my school performance.
  - Reporting will let my teammates down (R).

Indirect perceived behavioral control (teammate; 7-point Likert scale from strongly disagree to strongly agree)
- When my teammate experiences possible concussion symptoms:
  - Reporting will help my teammate maintain their health.
  - Reporting will cause my teammate to lose playing time (R).
  - Reporting will improve my teammate's athletic performance.
  - Reporting will reduce the chances of my teammate suffering another concussion.
  - Reporting will cause my teammate to lose their position on the team (R).
  - Reporting will help my teammate maintain their health.
  - Reporting will help maintain my teammate’s school performance.
  - Reporting will let my teammates down (R).

Concussion occurrence and reporting (yes or no response)
- Please indicate any of the following you have experienced in the last month. If you have answer yes to any question, please give a brief (2–3 sentence) description of what you experienced.
  In the past month:
    - I have seen someone in practice or competition sustain athletic contact, a collision, fall, or head injury.
    - I myself in practice or competition have sustained athletic contact, a collision, fall, or head injury.
    - I myself have experienced symptoms of a concussion.
    - I have seen a teammate experience symptoms of a concussion.
    - I have discussed concussions with my teammate(s).
    - I have discussed concussions with my coach(es).
    - I have discussed concussions with a trainer.
    - I have discussed concussions with a peer concussion educator or another student knowledgeable about concussion injuries.
    - I myself have sustained a concussion.
    - I suspected a concussion in my self.
    - I suspected a concussion in a teammate.
    - I suspected a concussion in a teammate.

If you answered yes to the previous question, did you report it?
- If you answered yes to the previous question, did you report it?

* Items are presented in their original format. (R) indicates the item was reverse scored.
activities including practice, strength training, and team meetings at the discretion of the site coordinator to accommodate challenging time demands and other logistics associated with student-athletes and athletic department staff.

All student-athletes gave informed consent for the research procedures. Because all recruits were also student-athletes, participation in the routine concussion-education programming provided by their school was required by the NCAA, whether the student-athletes were in the experimental or control condition. The NCAA-mandated routine concussion education occurred outside of the study and fell under the purview of each individual university or college, regardless of the student-athletes’ participation in the PCEP or control condition. The PCEP was designed to supplement and not replace the current NCAA-mandated training. The current NCAA training was not part of the control condition. Participation in the PCEP

Table 3. Assessments, Modifications, Timeline, and Theory of Reasoned Action or Theory of Planned Behaviora

<table>
<thead>
<tr>
<th>Outcome Measure or Theory of Reasoned Action or Planned Behavior Construct</th>
<th>Outcome Assessed or Description</th>
<th>Description or Modification</th>
<th>Assessment Point(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td>Demographic information</td>
<td>Demographic questions to determine age, sports played, history of concussions, sex, etc.</td>
<td>Baseline</td>
</tr>
<tr>
<td>Concussion knowledge</td>
<td>Concussion knowledge or ACE checklist modified from Gioia and Collins22 (2006) and McLeod et al23 (2007)</td>
<td>Total items = 27, 19 true symptoms of concussion from ACE checklist and nonsymptoms from McLeod et al.23 Participants received 1 point for each item that was correctly identified as a symptom or not a symptom of concussion.</td>
<td>Baseline Postintervention 1-mo Follow up</td>
</tr>
<tr>
<td>Knowledge of RTP protocol</td>
<td>Knowledge of RTP protocol</td>
<td>Five-item questionnaire based on Module 1 content. A 5-point Likert scale is used to assess knowledge of RTP protocol.</td>
<td>Baseline Postintervention 1-mo Follow up</td>
</tr>
<tr>
<td>Intention modified from the original 3-item questionnaire of Register-Mihalik et al13 (2013)</td>
<td>Intention to report</td>
<td>The 12-item questionnaire was modified from the original 3 questions and expanded to include intention under general and specific circumstances such as practice, playoff, even if I am not sure it is serious, etc. A 7-point Likert scale was used to assess intention to report in oneself (6 items) or one’s teammates (6 items).</td>
<td>Baseline Postintervention 1-mo Follow up 1-mo Follow up</td>
</tr>
<tr>
<td>Direct subjective norms scale modified from Register-Mihalik et al13 (2013)</td>
<td>What important others around the athlete believe about reporting</td>
<td>Eight items about what important others think were modified to be more specific (people I know changed to coach, teammates, trainer, it is expected of me) for oneself (4 items) or one’s teammate (4 items). Participants indicated their agreement with each statement on a 7-point Likert scale.</td>
<td>Baseline Postintervention 1-mo Follow up 1-mo Follow up</td>
</tr>
<tr>
<td>Direct perceived behavioral control questionnaire modified from Register-Mihalik et al13 (2013)</td>
<td>Ability to report or how able the athlete feels to actually carry out the reporting behavior</td>
<td>Ten items address one’s perceived ability to report a concussion in oneself (5 items) or one’s teammates (5 items). Participants indicated their agreement with each statement on a 7-point scale. Two items were changed from the original scale to Likert scale (I have control over reporting and I am able to report), and 2 items were added (the encouragement of my teammates makes it easier to report and having a peer concussion educator makes it easier to report).</td>
<td>Baseline Postintervention 1-mo Follow up 1-mo Follow up</td>
</tr>
<tr>
<td>Indirect attitude modified from Register-Mihalik et al13 (2013)</td>
<td>Consequences of reporting</td>
<td>Fourteen items address beliefs about reporting their own (7 items) or a teammate’s (7 items) concussion. Items taken directly from the original. Items from the original construct with extremely good or extremely bad Likert-scale formats were excluded. Participants indicated their agreement with each statement on a 7-point Likert scale.</td>
<td>Baseline Postintervention 1-mo Follow up 1-mo Follow up</td>
</tr>
<tr>
<td>Concussion occurrence and reporting</td>
<td>Suspected occurrences of concussions in the last month in oneself and one’s teammates, including if participants reported concussions</td>
<td>Thirteen items designed to address suspected concussions; discussions with trainers, teammates, and coaches about concussions; and self- and teammate-reported concussions over the study time period. Questions use a dichotomous yes or no format and include an open-ended format for additional information.</td>
<td>1-mo Follow up only</td>
</tr>
</tbody>
</table>

Abbreviations: ACE, acute concussion evaluation; RTP, return-to-play.

a Items are presented in their original format.
or any of the study assessments was voluntary as a condition of institutional review board approval.

Statistical Analysis

To account for the nesting in the student-athlete data (timepoint, within student-athlete, within school, within division), mixed-effects multilevel models (MLMs) were run for each measure separately with random intercepts for student-athlete, school, and division. Time (baseline, posttest, follow up), treatment condition, and the interaction of time and condition were treated as fixed effects. Because the main variable of interest was the effect of the PCEP, and sex and sport are known to potentially influence concussion reporting, these variables were included as covariates to account and control for the possible influences of these variables on the dependent variables. A conservative $\alpha$ level of .001 was adopted for all significance tests. A significant interaction suggests that the PCEP and control groups differed in their rate of change for that measure over time, and between-groups contrasts were then performed at each timepoint to determine differences in outcome. Mixed models were run for each measure separately with random intercepts for student-athlete, school, and division. For questions about experiences with concussion given only at the 1-month follow up (including questions about whether athletes reported their own or a teammate’s concussion), logistic MLMs were used to account for nesting by division and school. For questions about concussion occurrence and reporting given only at follow up, logistic MLMs were used to account for nesting by division and school.

Athletic Trainer Qualitative Program Evaluation

At the end of the study, 8 athletic trainers participated in a program evaluation. All provided informed consent and then answered the following questions: (1) “What were your overall impressions of the implementation of the program, including what worked well and what didn’t work?” (2) “How well did having peer educators providing the modules to their teammates work?” (3) “What suggestions do you have for improving the program?” The questions were based on the Moutakas recommendation to ask broad, general questions in qualitative research. Answers were then transcribed. We evaluated the entire set of answers blindly, without knowledge of the identity of the participant or school. Additionally, before analyzing the athletic trainer data, 2 researchers bracketed, or set aside preconceived ideas that might influence their interpretation of previous knowledge or experiences that might influence their interpretation of the debriefing data. We then reviewed the transcripts of the debriefing responses several times to understand the overall phenomena of interest, which is an important component of an inductive approach to qualitative analysis. Statements were coded to reflect the participants’ experiences. Next, we independently developed clusters of meaning (themes) that organized these codes. Discrepancies were resolved through discussion to establish intercoder agreement.

RESULTS

Student-Athlete Data

Analysis-of-variance (ANOVA) tables summarizing the main effects, interactions, and covariates for each measure are presented in Table 4. Importantly, for all 10 outcome measures, time $\times$ condition produced significant effects, indicating that the PCEP participants changed more over time than the control participants. Time $\times$ condition effects were found for concussion knowledge ($F_{2,2648} = 51.3, P < .0001$), RTP protocol knowledge ($F_{2,2632} = 28.4, P < .0001$), and intention to report a suspected concussion in both oneself ($F_{2,2633} = 82.3, P < .0001$) and a teammate ($F_{2,2632} = 53.9, P < .0001$). Direct behaviors were also different across time between the PCEP and control conditions, including direct subjective norms for oneself ($F_{2,2632} = 51.7, P < .0001$) and teammates ($F_{2,2644} = 40.6, P < .0001$) and direct perceived behavioral control for oneself ($F_{2,2628} = 53.7, P < .0001$) and teammates ($F_{2,2615} = 68.2, P < .0001$). In addition, indirect attitudes were different between groups across time when reported for oneself ($F_{2,2626} = 47.1, P < .0001$) and teammates ($F_{2,2623} = 40.9, P < .0001$). The means, standard deviations, and effect sizes across baseline, posttest, and 1-month follow up are presented for the knowledge measures (Table 5), intention to report (Table 6), direct measures (Table 7), and indirect perceived behavioral control (Table 8).

No differences occurred at baseline (ds $= -0.10$–$0.04$). On average, scores for student-athletes in either group were within 0.4% on any given measure. After the intervention, those who received the PCEP displayed an increase in each measure versus those who received the standard concussion training (ds $= 0.18$–$0.41$). Student-athletes who received the PCEP scored 10.5% higher on average for any given measure than student-athletes who did not receive the intervention. Gains in the experimental group relative to control persisted 1 month after the intervention (ds $= 0.19$–$0.33$). On any given measure, average scores for the student-athletes who received the PCEP remained 9.4% higher at the 1-month follow-up assessment compared with those of the average student-athlete who did not experience the intervention.

Effects of Sex and Sport. As sex and sport are known to influence concussion reporting, they were included as covariates in the analysis. Sex was a significant covariate in concussion knowledge, RTP protocol knowledge, direct subjective norms for self, and indirect attitudes in oneself and one’s teammates, with women consistently scoring higher at every timepoint than men on concussion knowledge and RTP protocol, direct perceived behavioral control (others’ beliefs about reporting), direct subjective norms (feelings of being able to report a concussion), and direct perceived behavioral control (consequences of reporting).

Sport was a significant covariate for some analyses. On average, basketball players had less knowledge of concus-
Concussion knowledge values measure, the time individual's history of concussion education. For each student-athletes who had never experienced concussion concussion-education programming did not influence student-athletes’ potential for learning from the PCEP. Interestingly, main effects for prior concussion education were significant for concussion knowledge ($F_{2,2370} = 8.36, P < .0002$) and RTP protocol ($F_{2,2354} = 4.30, P < .01$) but not for any other measure (all $P$ values > .50). At every timepoint, student-athletes with prior concussion education reported more concussion knowledge (22.09 ± 0.45) and RTP protocol knowledge (21.09 ± 0.33) than did those without prior education (for concussion knowledge: 21.37 ± 0.44; for RTP protocol knowledge: 20.78 ± 0.32) or those who did not know whether they experienced prior education (for concussion knowledge: 21.62 ± 0.47; for RTP protocol knowledge: 20.55 ± 0.35).

**Concussion Occurrence and Reporting at Follow Up.** Both PCEP and control student-athletes reported on their experiences with concussion and reporting behavior in the month after the posttest. The ANOVA tables for these questions appear in Table 9. Versus control participants,

| Measure | df_{den} | Covariate Sex (df_{num} = 1) | Covariate Sport (df_{num} = 8) | Repeated-Measures Time (df_{num} = 2) | Between-Subjects Effect Condition (df_{num} = 1) | Time × Condition (df_{num} = 2)
|---------|----------|-------------------------------|----------------------------------|----------------------------------------|---------------------------------------|----------------------------------------
| Concussion knowledge | 2648 | 91.7b | 5.0b | 157.6b | 54.8b | 51.3b |
| Return-to-play protocol | 2632 | 67.6b | 3.1 | 25.0b | 31.9b | 28.4b |
| Intention to report | | | | | | |
| Oneself | 2633 | 0.2 | 1.6 | 278.9b | 32.2b | 82.3b |
| Teammates | 2624 | 1.5 | 1.4 | 209.7b | 44.7b | 53.9b |
| Direct subjective norms | | | | | | |
| Oneself | 2625 | 24.5b | 2.1 | 12.9b | 19.2b | 51.7b |
| Teammates | 2644 | 1.7 | 1.6 | 20.2b | 7.5b | 40.6b |
| Direct perceived control | | | | | | |
| Oneself | 2628 | 11.0 | 1.5 | 100.8b | 35.8b | 53.7b |
| Teammates | 2615 | 4.06 | 1.7 | 113.1b | 46.9b | 68.2b |
| Indirect attitudes | | | | | | |
| Oneself | 2626 | 72.9b | 7.2b | 30.9b | 17.7b | 47.1b |
| Teammates | 2623 | 94.8b | 6.7b | 24.0b | 25.7b | 40.8b |

###Table 5. Descriptive Statistics for Knowledge Comparing Peer Concussion Education Program (PCEP) With Control Condition Across Time*

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Condition or Effect Size</th>
<th>Baseline</th>
<th>Postintervention</th>
<th>1-mo Follow Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concussion knowledge</td>
<td>PCEP</td>
<td>20.25 ± 3.5</td>
<td>22.64 ± 3.7</td>
<td>21.82 ± 3.5</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td>19.74 ± 4.2</td>
<td>20.44 ± 4.1</td>
<td>20.1 ± 3.9</td>
</tr>
<tr>
<td>Effect size</td>
<td></td>
<td>0.07</td>
<td>0.41b</td>
<td>0.26b</td>
</tr>
<tr>
<td>Return-to-play protocol knowledge</td>
<td>PCEP</td>
<td>20.40 ± 2.8</td>
<td>21.23 ± 3.3</td>
<td>21.41 ± 3.2</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td>20.30 ± 2.8</td>
<td>20.13 ± 3.1</td>
<td>20.26 ± 3.3</td>
</tr>
<tr>
<td>Effect size</td>
<td></td>
<td>0.04</td>
<td>0.28b</td>
<td>0.24b</td>
</tr>
</tbody>
</table>

*Table values indicate mean ± SD and Cohen d effect size for each measure at baseline, postintervention, and 1-mo follow up. Positive d values indicate that the experimental group showed numerically greater scores than the control group at that timepoint.

b $P < .001$ indicates significant time × treatment effect.
student-athletes in the PCEP group were more likely to discuss concussion with a teammate ($F_{1,1396} = 13.96, P < .0001$), peer educator or knowledgeable teammate ($F_{1,1396} = 76.35, P < .00001$), coach ($F_{1,1396} = 4.09, P < .05$), and athletic trainer ($F_{1,1396} = 6.62, P < .001$). Compared with control participants, those receiving PCEP were nearly two-thirds more likely to discuss concussion with teammates (49.1% versus 38.5%, odds ratio [OR] = 1.61), 3 times more likely with peer educators (55.4% versus 28.9%, OR = 3.13), and about one-third more likely with coaches (37.2% versus 23.4, OR = 1.31) and athletic trainers (57.1% versus 48.1, OR = 1.36). The number of suspected concussions between those in the PCEP or control condition did not differ. Student-athletes were no more likely to suspect concussion in themselves (13.2% versus 16.8%, OR = 1.24) or others (15.9% versus 16.2%, OR = 1.05) whether they participated in the PCEP or not. However, when a teammate was suspected of having a concussion, those in the PCEP condition tended toward being more likely to report their teammate than those in the control condition ($F_{1,141} = 3.29, P < .10$). The rates of suspected and reported concussions in oneself and teammates are presented in Table 10. When student-athletes suspected concussion in teammates, PCEP participants were nearly 2.5 times more likely to report than were control participants (65.2% versus 54.7%, OR = 2.45). Reporting a suspected concussion in oneself was not different between PCEP and control student-athletes and was relatively high (74.4% versus 63.9%, OR = 1.61).

### Athletic Trainer Debriefing Results

Responses from the 8 athletic trainers to the debriefing questionnaire yielded 56 significant statements that were organized into clusters of meaning resulting in 7 themes. The themes and exemplar statements are shown in Table 11.

**Theme 1: Materials (Online Manual and Slides) Were Well Organized.** Participants indicated that the online manual was helpful, clear, and well organized.

**Theme 2: Clear Guidelines for Selecting PCEs.** Participants stated that the online manual provided helpful information on the process and criteria for selecting the PCEs.

**Theme 3: Worksheet Activity Was Engaging.** Participants gave several statements indicating that Module 2 engaged the student-athletes. They also supported the rationale for not having staff present during this module.

**Theme 4: Educational Material Was Challenging.** The first education module presented by the PCEs to their teammates included information about the pathophysiology of concussion. Several participants indicated that it was difficult for some PCEs to understand and deliver this information, and some of their teammates appeared to “tune out” when it was being presented.

**Theme 5: Scheduling Problems and Timing.** Several participants indicated that scheduling the PCEP was difficult due to the demanding schedules of student-athletes.

**Theme 6: Peers Were Better Than Authorities.** Participants recognized the value of the peer-mediated aspect of the PCEP.
Theme 7: Variation in PCEs’ Abilities. Several participants commented on the presentation skills of the PCEs.

DISCUSSION

This multisite RCT evaluated the effectiveness of a peer-mediated, cognitive-behavioral PCEP to enhance concussion knowledge, attitudes, and behaviors supporting concussion reporting. Compared with standard concussion training, the PCEP had significant effects after implementation. Those teams receiving the PCEP showed increased knowledge of concussion symptoms and RTP protocols and more positive attitudes, subjective norms, and perceived control regarding concussion reporting. This is the first known study to show a peer intervention that influences changes in (1) concussion knowledge, (2) attitudes and intention to report for both oneself and teammates, and (3) discussions about concussions. Understanding factors such as reporting, perceived norms, and self-efficacy, in addition to knowledge, is important to increase program efficacy.13

Effect sizes were small but consistent across all measures and at 1-month follow up, which is not unusual for educational interventions with large sample sizes.28,29 We purposely incorporated many key factors in the study design, creating a large, heterogeneous sample (as opposed to a carefully selected sample of participants who had not received concussion education or athletes from only 1 sport). All indicators changed significantly; the positive changes in many of the measures indicated that the PCEP can improve reporting behavior in collegiate athletes.

Socioecological Changes

The overarching goal of the PCEP was to positively influence concussion reporting among the student-athletes who participated, specifically in altering the attitudes and norms regarding and the willingness to discuss and report concussions of athletes. Kerr et al20 suggested that the culture may change if behaviors and attitudes are addressed at multiple levels of the socioecological framework. The PCEP’s peer-mediated and interdisciplinary approach, involving student-athletes, coaches, and athletic trainers, addressed not only intrapersonal (symptom and RTP protocol knowledge and attitudes) but also interpersonal aspects (attitudes and norms regarding teammates). Environmental changes were likely, as when the full team interacted in an exercise to change cognitions together. Moreover, the involvement of coaches and athletic trainers further reinforced the program’s objectives at the environmental level.20 Collegiate athletes want more concussion education. Most (83.1%) indicated they would like more athletic community members involved and preferred lecture or video formats.30 Our program was a 2-part interactive presentation delivered by 2 PCEs from among the student-athletes’ teams. Meeting the needs of student-athletes for concussion education through a peer-centered model18,19 appeared to change both knowledge and norms, especially

Table 8. Descriptive Statistics for Indirect Behaviors Comparing Peer Concussion Education Program (PCEP) and Control Condition Across Timea

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Condition or Effect Size</th>
<th>Baseline</th>
<th>Postintervention</th>
<th>1-mo Follow Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indirect perceived behavioral control: oneself</td>
<td>PCEP</td>
<td>35.38 ± 6.7</td>
<td>37.83 ± 7.3</td>
<td>37.79 ± 7.4</td>
</tr>
<tr>
<td>Control</td>
<td>35.51 ± 6.4</td>
<td>35.62 ± 6.9</td>
<td>35.13 ± 6.9</td>
<td></td>
</tr>
<tr>
<td>Effect size</td>
<td>-0.01</td>
<td>0.31b</td>
<td>0.29b</td>
<td></td>
</tr>
<tr>
<td>Indirect perceived behavioral control: one’s teammates</td>
<td>PCEP</td>
<td>35.68 ± 6.7</td>
<td>37.74 ± 7.4</td>
<td>38.00 ± 7.3</td>
</tr>
<tr>
<td>Control</td>
<td>35.49 ± 6.7</td>
<td>37.74 ± 7.4</td>
<td>38.00 ± 7.3</td>
<td></td>
</tr>
<tr>
<td>Effect size</td>
<td>-0.01</td>
<td>0.35b</td>
<td>0.33b</td>
<td></td>
</tr>
</tbody>
</table>

a Table values indicate mean ± SD and Cohen d effect size for each measure at baseline, postintervention, and 1-mo follow up. Positive d values indicate that the experimental group showed numerically greater scores than the control group at that timepoint. b P < .001 indicates significant time × treatment effect.

Table 9. Concussion Occurrence and Reporting

<table>
<thead>
<tr>
<th>Reporting Behavior</th>
<th>df_den</th>
<th>Condition (df_num = 1)</th>
<th>Sex (df_num = 1)</th>
<th>Sport (df_num = 8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discussed with</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teammates</td>
<td>1396</td>
<td>13.96a</td>
<td>8.29b</td>
<td>1.15</td>
</tr>
<tr>
<td>Peer educators or knowledgeable teammate</td>
<td>1396</td>
<td>76.35a</td>
<td>0.71</td>
<td>1.33</td>
</tr>
<tr>
<td>Coaches</td>
<td>1396</td>
<td>4.09c</td>
<td>2.14</td>
<td>0.62</td>
</tr>
<tr>
<td>Athletic trainers</td>
<td>1396</td>
<td>6.62c</td>
<td>0.07</td>
<td>1.19</td>
</tr>
<tr>
<td>Suspected concussion in Self</td>
<td>813</td>
<td>1.20</td>
<td>0.06</td>
<td>1.04</td>
</tr>
<tr>
<td>Teammate</td>
<td>822</td>
<td>0.06</td>
<td>0.08</td>
<td>1.78a</td>
</tr>
<tr>
<td>Reported suspected concussion in Self</td>
<td>164</td>
<td>2.24</td>
<td>0.07</td>
<td>0.18</td>
</tr>
<tr>
<td>Teammate</td>
<td>141</td>
<td>3.29a</td>
<td>2.43</td>
<td>1.03</td>
</tr>
</tbody>
</table>

Abbreviations: den, denominator; num, numerator.

a P < .0001.

b P < .001.

P < .00001.

P < .01.

P < .10.
Concussions and their impact on student-athletes' care for each other. Peer-mediated education did not lead to differences between the PCEP and control conditions with respect to attitudes, norms, and the intention to report, indicating that the PCEP was novel in its effect on these important TRA or TPB constructs. Limitations

Our study did have several limitations. First, assessments occurred immediately after the intervention and 1 month later. A longer assessment timeframe consistent with the playing season would be desirable in future research. Second, not all sports were in season during the implementation of the intervention, possibly affecting responses on the outcome measures. Student-athletes may have found the intervention more salient when in season. Despite deliberate sampling procedures and recruitment attempts, no schools from the West regions agreed to participate, and no institutions with enrollment over 11 000 participated. The results may not generalize to institutions from the unrepresented geographic regions or to those with very large enrollments. Finally, athletic staff contacted through random sampling had to choose to participate. Staff from schools with a strong interest in concussion education may have been more likely to participate than those at schools with less commitment, which may have resulted in preexisting cultures supportive of or negative toward concussion reporting. The athletic trainers indicated that, although the information in the education modules was clear, some PCEs had difficulty presenting some of the more complex material, including information on the pathophysiology of concussion.

Changes in Concussion Knowledge

Most concussion-education programs aim to improve concussion knowledge. Interestingly, concussion knowledge among student-athletes in this study was relatively high at baseline. Those who indicated prior exposure to concussion education showed more knowledge of concussion symptoms and RTP at every timepoint versus those who had never received such education, suggesting that trainings are effective. However, previous concussion education did not lead to differences between the PCEP and control conditions with respect to attitudes, norms, and the intention to report, indicating that the PCEP was novel in its effect on these important TRA or TPB constructs. Knowledge alone does not predict concussion-reporting behavior, and additional educational programs such as the PCEP may be needed to influence attitudes and beliefs that are more directly related to behavior.

After the PCEP, student-athletes recognized an average of 2 additional symptoms of concussion compared with those in the control condition. Physical symptoms (eg, confusion, dizziness, headache) are more readily recognized than typically psychological and behavioral indicators (eg, irritability, emotionality, nervousness, sadness), as they are more easily observable. The PCEP likely increased knowledge of these previously unrecognized symptoms: in a pilot study, undergoing the PCEP resulted in the largest increases in knowledge of psychological symptoms, improving from less than 50% correct identification before the intervention to greater than 85% postintervention. In contrast, physical symptoms were well known to these pilot participants, identified at baseline by 90% or more.

Implementation Successes and Suggestions for Modification

Onsite athletic trainers implemented the program independent of the research team. Poststudy interviews with the athletic trainers revealed that the PCEP worked autonomously as designed. They found the online manual easy to navigate and felt they could use it without additional instruction. Athletic trainers liked the peer-education component, believing it promoted peer interaction regarding concussion and the cognitive-behavioral model of change and would likely be more effective than if an authority delivered the intervention. Helpful critiques were that time demands are always a concern for busy student-athletes and athletic staff, the scientific information needed to be more accessible to individuals at all levels, and selection of PCEs may need to be especially rigorous to ensure program quality.

Limitations

Our study did have several limitations. First, assessments occurred immediately after the intervention and 1 month later. A longer assessment timeframe consistent with the playing season would be desirable in future research. Second, not all sports were in season during the implementation of the intervention, possibly affecting responses on the outcome measures. Student-athletes may have found the intervention more salient when in season. Despite deliberate sampling procedures and recruitment attempts, no schools from the West regions agreed to participate, and no institutions with enrollment over 11 000 participated. The results may not generalize to institutions from the unrepresented geographic regions or to those with very large enrollments. Finally, athletic staff contacted through random sampling had to choose to participate. Staff from schools with a strong interest in concussion education may have been more likely to participate than those at schools with less commitment, which may have resulted in preexisting cultures supportive of or negative toward concussion reporting. The athletic trainers indicated that, although the information in the education modules was clear, some PCEs had difficulty presenting some of the more complex material, including information on the pathophysiology of concussion.
CONCLUSIONS

Participation in the novel PCEP increased concussion knowledge and understanding of key aspects of RTPs in collegiate student-athletes. In addition, participation in the PCEP increased the intention to report concussion and improved attitudes, subjective norms, and beliefs about behavioral control to report for both oneself and one’s teammates. These changes were observed for all study measures and remained at 1-month follow up, suggesting that the program holds promise for changing attitudes and norms that can potentially enhance concussion reporting. The use of a peer-mediated approach is further supported by our finding that the student-athletes appeared to be more receptive when information was provided by a peer as opposed to staff. In addition, feedback from the athletic trainers who implemented the program indicated that it was consistent with the original interdisciplinary, peer-mediated, cognitive-behavioral model. The athletic trainers also found the online manual to be clear and easy to use and the PCEP easy to implement, autonomously supporting its potential for widespread dissemination.

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REFERENCES


