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Ellen K. Payne
Radford University, ellen.payne@gmail.com

William S. Gear
New Mexico State University, wgear@nmsu.edu

Maureen Burke
Dunmore High School, burkem1120@gmail.com

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Cover Page Footnote
We would like to thank Innocorp, ltd. for their generous donation of the Concussion Goggles™ and educational program for this study. We would also like to thank Meredith Moore and Tristan Ragland for their help during the educational sessions. Finally, we would like to thank Marywood University, Scranton, PA, for the Research Initiation Grant used to fund this study.

Payne, Gear, and Burke
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Goggle™ Education Program: A Pilot Study
JSMAHS. 2017. 2(3) Article 1

Investigation of the Concussion Goggle™ Education Program with Secondary School Athletic Teams: A Pilot Study

Ellen K. Payne PhD, ATC, EMT [€], William S. Gear PhD, ATC[≠], Maureen Burke ATC[β].
Radford University[€], New Mexico State University[≠]. Dunmore High School[β]

Background: Researchers have investigated different types of concussion education programs within various populations with mixed results. To date, no research has been published using the Concussion Goggles™ educational program **Objective**: To compare secondary school student-athletes' knowledge about concussions before and after attending a concussion education program using the Concussion Goggles™. **Design**: Pre- posttest. **Setting**: Public secondary school. **Patients or Other Participants**: 41 secondary school students (14 girls soccer players, 14 boys basketball players, and 13 girls basketball players) with a mean age of 15.37 ± 1.22 years. **Intervention(s)**: Participants completed the Concussion Goggles™ concussion educational program consisting of PowerPoint slides with 3 activities and short video segments within the presentation. Participants completed a test developed by the manufacturers of the Concussion Goggles™ educational program prior to and following the intervention to measure change in concussion knowledge. **Main Outcome Measure(s)**: A 3-way mixed factorial analysis of variance (sport x grade level x gender) for repeated measures was utilized to determine statistical significance. **Results:** A statistically significant difference between the overall pretest (9.37 ± 1.20) and posttest (9.63 ± 1.04) scores was not found (p = 0.28). Repeated measures analysis did not indicate significant interaction effects for test score x grade (p = 0.18), test score x sport (p = 0.63), nor test score x grade x sport (p = 0.96). **Conclusion**: The Concussion Goggle™ education program did not affect participant knowledge of concussions in the posttest. In its current form, the Concussion Goggle™ program may not be an effective concussion education program. **Key Words**: *concussion knowledge, concussion education, secondary school athletes*

INTRODUCTION

The Centers for Disease Control (CDC) reports a 62% increase in nonfatal traumatic brain injuries between 2001 and 2009.[1] In that time period, traumatic brain injuries accounted for 6.5% of all emergency department visits for sport and recreational injuries sustained by children under 19 years of age.[1] It is estimated that over 62,000 high school aged student-athletes sustain concussions annually.[2] As part of the response to the increase in the number of concussions reported, and the potential catastrophic effects of poor management, a number of professional organizations and associations have issued position statements and other guidelines for clinical practice.[1-5] One common element of these statements is a call for concussion education programs to help increase concussion knowledge among various stakeholders. It has been stated that concussion education programs "have enormous value and must be pursued vigorously"[4] and that "education and recognition remain the most important components of improving the care of athletes with concussion."[5]

A variety of educational resources are readily available to different stakeholder groups, yet few are identified as evidenced based.[6] A recent review of available concussion education programs included the Heads Up program (CDC), ThinkFirst (National Injury Prevention Foundation), the Sports Legacy Institute Community Educators (SLICE) program (now the Concussion Legacy Foundation's Team Up Against Concussions Program), Brain 101 (ORCAS, Inc.), and Barrow Brainbook (Barrow Neurological Institute), but the review lacks empirical evidence to support these tools.[7] Researchers have investigated many different concussion education programs within various populations to examine changed attitudes, knowledge, and reporting behaviors and have discovered mixed results. For example, one

study found that among the students who reported participating in formal concussion education, there was not an increase in the ability to identify concussion symptoms and possible consequences from sustaining a concussion.[8] Another study found a negative effect on concussion reporting post intervention that warranted the researchers to warn against its use among the adolescent population.[9]

Conversely, the Heads Up program has been met with favorable reviews from coaches in regards to increasing their concussion knowledge as well as their ability to educate athletes regarding concussions.[2,6] A modified version of the SLICE education program was found to be an effective tool for reducing the number of concussion that went unreported.[10] The authors found that the number of reported concussions increased from 44 prior to the implementation of the modified SLICE program to 216 reported concussions after the program was implemented.[10] Another study found the interactive nature of the SLICE program "promotes effective learning among both male and female students in elementary school, middle school, and high school."[11] This study suggests the SLICE program benefits an additional stakeholder group, as the volunteers who teach the program are more likely to retain concussion knowledge in their practice as healthcare providers.[11]

Of interest to us are the multiple studies that provide insight regarding secondary school athletes and concussion education.[2,8,13-18] One such study determined that secondary school athletes with previous formal concussion education are more likely to notify their coaches of concussion symptoms.[15] Secondary school athletes with a previous history of concussion are also more likely to report concussion symptoms.[16] However, to contrast that it was found that only 62% of secondary school football players understood the term concussion and that 47% believe a diagnosis of concussion is made with imaging studies rather presence of symptoms.[14] Multiple studies show a majority of secondary school student-athletes would continue to play while experiencing concussion symptoms.[6,14,16,17] Another study found the most common reason for not reporting a concussion among secondary school football players was a belief the injury was not serious enough to warrant medical attention.[18] When further examining students-athletes who failed report an injury, it was found that one third did not associate their symptoms with a concussion.[18]

A novel educational program that incorporates a goggle system to replicate "symptoms of dizziness, visual disconnect, disorientation, hesitation, apprehension, confusion, and lack of confidence" that can occur with a concussion has been introduced by Innocorp, Ltd. called the Concussion Goggles™.[19] This program includes the use of educational materials using information from the CDC's Heads Up program. Innocorp, Ltd., also produces Fatal Vision® Goggles, which are designed to replicate the visual and motor impairments which result from consuming alcohol. Previous research has determined that the Fatal Vision® Goggles and the associated educational program are effective in reducing the intention to drink and drive among certain users.[20] To date, no studies have been published regarding the use of the Concussion Goggles™ program and its effect on concussion knowledge, concussion reporting, or rate of concussions by attendees. This concussion education program was selected for investigation due to the novel approach, especially the interactive components, and the use of information from the Heads Up program. The purpose of this study was to compare secondary school

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Payne, Gear, and Burke
Investigation of the Concussion
Goggle™ Education Program: A Pilot Study
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student-athletes' knowledge of concussions before and after attending a concussion education program using the Concussion Goggles™. We hypothesized that there would be a statistically significant improvement in the participants' test scores after attending the educational session.

METHODS

Participants

Participants included 41 secondary school student-athletes from one small, suburban secondary school. Descriptive statistics for study participants can be found in Table 1. Team selection was based on timing of the study (fall) and access to the teams by the coaches (for example, the boys soccer coach would not give up practice time for the team to attend a session). All student-athletes had completed the Pennsylvania Interscholastic Athletic Association's (PIAA) Comprehensive Initial Pre-Participation Physical Evaluation (CIPPE) form. The CIPPE includes a mandatory concussion education sheet that student-athletes and a parent/guardian must sign to acknowledge the nature and risk of concussion and traumatic brain injury as well as the risks associated with continuing to compete after a concussion or traumatic brain injury.[21] This Understanding of Risk of Concussion and Traumatic Brain Injury form defines concussion and includes a list of symptoms. In addition, reporting procedures for concussion symptoms as well as preventative measures are outlined. This part of the CIPPE form was designed to meet the concussion education requirement as mandated by Pennsylvania's Safety in Youth Sports Act.[22] This was the extent of the known previous formal concussion education the student-athletes received prior to the study. Football was excluded due to formal concussion education beyond the CIPPE form during pre-season conditioning. Student-athletes were excluded if they did not complete both the pre- and posttest. This included 1 student-athlete who left the session prior to completing the post-test.

Table 1. Descriptive Statistics for Study Participants.

Sport	Number of participants by grade level				Total number of participants	Avg. Age (years old ± SD)
	9	10	11	12		
Girls Basketball	4	1	5	3	13	15.83 ± 1.28
Girls Soccer	4	4	5	1	14	15.36 ± 0.84
Boys Basketball	10	1	1	2	14	14.93 ± 1.39
Total Participants	18	6	11	6	41	15.37 ± 1.22

Instruments

Demographic data was collected on participants' age, gender, grade level, and primary sport. The pre- and posttest was developed by Innocorp, Ltd., the manufacturers of the Concussion Goggles™ and the educational program.[19] There is currently no data regarding the validity of the instruments. The test included 13 true or false questions (Figure 1) about general concussion knowledge such as "People only get concussions in contact sports like football and boxing" and "Nausea, headaches, sensitivity to light or noise, and difficulty concentrating are all symptoms of a concussion". The pre- and posttests were identical.

Procedures

After approval by the Institutional Review Board, the principle investigator (PI - EKP) coordinated with the head athletic trainer (MB) to schedule educational sessions for the girls soccer, boys basketball, and girls basketball teams. Parental consent forms and

student assent forms were collected at the start of each team's session. Sessions were held after school in a classroom without any coaching staff present.

Student-athletes received a pre-numbered packet that included the demographic questionnaire, the pretest, and a sealed envelope containing the posttest to be completed after the educational session. Participants were then instructed to complete the demographic questionnaire and the pretest. The PI then presented the educational session provided by Innocorp, Ltd. the manufacturers of the Concussion Goggles™, which was based on the information provided on the Heads Up website.[19] The presentation included PowerPoint slides with three activities using the Concussion Goggles™ and short video segments within the presentation. The educational session addressed the definition of a concussion, signs and symptoms, consequences, and prevention. During each session, two student research assistants facilitated the Concussion Goggle™ activities in two separate groups to allow more hands-on time for participants with adequate supervision. The interactive activities were intended to allow participants to experience signs and symptoms that may be associated with a concussion such as altered vision and coordination through the Concussion Goggles™. At the end of the presentation and activities, time was allowed for participants to ask questions. The educational sessions took approximately 60 minutes each depending on the level of interaction by the participants and number of questions asked. Immediately following, participants were instructed to complete the posttest. After the collection of the posttest, the answers to the questions were reviewed using additional PowerPoint slides provided by the manufacturer. After each team's educational session, two members of the research team scored the pre- and posttests using the answer key provide by the manufacturer.

Data analysis

A 3-way mixed factorial analysis of variance [sport (girls basketball, girls soccer, boys basketball) x grade level (9, 10, 11, 12) x gender (male, female)] for repeated measures was utilized to determine statistical significance. All tests of significance were carried out at an alpha level of $p < 0.05$. Tukey's HSD was used to determine which findings were significant at the 0.05 level. Statistical procedures were performed using the SPSS statistical package (v 23.0).

RESULTS

Initial analysis showed that pre- and posttest scores were not affected by gender ($p = 0.76$, $p = 0.56$ respectively) allowing all participant data to be pooled for further analysis. Mean and standard deviations for pre- and posttest scores on the concussion awareness test by sport and all participants is presented in Table 2. Mean and standard deviations for pre- and posttest scores on the concussion awareness test by grade level is presented in Table 3. The repeated measures analysis did not indicate significant interaction effects for test score x sport ($F_{2,29} = 0.46$, $p = 0.63$), test score x grade ($F_{3,29} = 1.75$, $p = 0.18$), nor test score x grade x sport ($F_{6,29} = 0.24$, $p = 0.96$). A statistically significant main effect was not found for test score ($F_{1,29} = 1.21$, $p = 0.28$).

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Payne, Gear, and Burke
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Goggle™ Education Program: A Pilot Study
JSMAHS. 2017. 2(3) Article 1

Table2. Pre-posttest Test Scores (Mean (%)±SD) by Sport and all Participants. Scores are out of 13.

Sport	Pretest	Posttest
Girls Basketball	9.23 (71.00%) ± 1.42	9.46 (72.77%) ± 1.27
Girls Soccer	9.57 (73.62%) ± 1.02	9.93 (76.38%) ± 0.92
Boys Basketball	9.29 (71.46%) ± 1.20	9.50 (73.08%) ± 0.94
All Participants	9.37 (72.08%) ± 1.20	9.63 (74.08%) ± 1.04

Table2. Pre-posttest Test Scores (Mean (%)±SD) by grade level. Scores are out of 13.

Grade level	Pretest	Posttest
9	9.67 (74.38%) ± 1.14	9.72 (74.77%) ± 1.07
10	9.00 (69.23%) ± 0.63	9.67 (74.38%) ± 1.03
11	8.73 (67.15%) ± 1.35	9.55 (73.46%) ± 1.13
12	10.00 (76.92%) ± 1.10	9.50 (73.08%) ± 1.05

DISCUSSION

Concussions are a significant health issue in athletics at all levels. Effective concussion education may play a role in increasing concussion knowledge and decreasing the number of concussions that go unreported. The present study examined the effectiveness of the Concussion Goggles™ education program on secondary school student-athletes' knowledge of concussions. Our results showed that the Concussion Goggles™ education program did not significantly affect the participants' post-test scores on the concussion knowledge. These findings illustrate some fundamental issues with the Concussion Goggle™ education program and highlight inconsistencies in the evidence supporting available concussion education programs.

A previous study examining the SLICE program discussed the influence of prior concussion knowledge of the participants on the posttest results, as the researchers determined that the participants scored high (average of 70%) on the pretest.[12] Given that the average pretest score for all participants in the present study was 72.08%, we determined the pretest scores did not show a high level of prior concussion knowledge. Further, the average score for the posttest, 74.08%, did not show a significant improvement in the participants' knowledge of concussions after attending the educational program and participating in the activities using the Concussion Goggles™. These results did not show a significant difference between the grade levels on prior knowledge of concussions, nor a significant change in knowledge following the education program. While all participants in this study had access to a full-time athletic trainer as well as passive concussion education materials such as the PIAA's CIPPE, it is unclear if participants had reviewed these resources prior to participating in the current study. With the pretest scores ranging from 67-74%, we do not believe prior knowledge was the reason for lack of a significant improvement on the posttest.

One factor that may have contributed to the lack of change between pre- and posttest scores on certain items is a misalignment between portions of the educational program and the test that participants took. Participants did significantly worse on the posttest for question 7 ("Wearing a helmet will prevent a concussion from happening").

The manufacturer's correct answer was false, but there was a disconnect between what was presented during the educational session and the manufacturer's correct answer on the test. Many of the other questions, such as "If a person falls asleep with a concussion, they could die", were not specifically addressed within the educational program. This demonstrates the misalignment between the educational information presented to the student-athletes and the assessment material used. Answers to all test questions were reviewed in the large group setting after taking the posttest, but for many student-athletes this might have been the first time they were exposed to the material since it was not presented in the main educational program or the goggle activities. Only questions 1 ("A concussion is a brain injury") and 11 ("A normal brain scan means you are clear to play again") had significant improvements among participants after the educational session. These items were clearly defined and directly addressed in the educational session. Interestingly, there was no change on question 6 ("Heading a soccer ball can cause a concussion"). During the review of answers at the end of the session members of the girl's soccer team reported that they had been told by their coaches that heading the ball causes concussions. The manufacturer's correct answer was false, which could be debated as the incorrect answer to that test item.[23]

Concussion education programs, in general, should be valuable resources for raising awareness of the signs and symptoms of a concussion, but not all are created equal.[6,8-10,12,24] While there has been a call for concussion education in the literature, what topics that should be included in the educational programs have not be clearly defined. As stated in the literature, "the number of websites, applications, and social media sites clearly outnumbers evidence-based reviews of these sources of information, raising concerns that they may be continuing to propagate misconceptions and errant practices".[6] According to the National Athletic Trainers' Association position statement on concussion management, more than 50% of secondary school athletes and 70% of collegiate athletes demonstrate limited knowledge regarding concussion symptoms.[3] However, on a positive note, it was previously found that athletes with concussion education are more likely to notify coaches and athletic trainers of a possible concussion compared to those with no education.[15] Concerns as to whether knowledge of concussion translates into improved rates of concussion reporting have also been raised in previous studies.[6,16] The current study did not examine if participants of this program were more likely to report a possible concussion to a coach or athletic trainer.

Limitations

Participants' prior education and knowledge about concussion was not assessed. As stated above, members of the girls soccer team stated during their session that their coaches had told them heading the ball causes concussions. This confirms that the girl's soccer team had been provided with informal education about concussions from the coaching staff. All participants had previously signed an Understanding Risk of Concussion and Traumatic Brain Injury sheet as part of the PIAA's CIPPE prior to participation in any athletic practice or contest. These possible influences, and whether or not participants had received any other formal or informal concussion education, were not assessed. This study did not take into account the previous knowledge participants had about concussions and how that knowledge may have influenced test scores.

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Future Research

There is a need for additional research on concussion education programs. Programs need to be based on the most current research and thoroughly investigated for their validity and reliability. Future research should investigate the incidence of concussions and concussion reporting after athletes attend a concussion education program rather than just knowledge gains immediately after an educational session. Athletes' awareness of the signs and symptoms of concussions, along with their knowledge about the importance of reporting concussions need to be assessed. The effects of gaining new knowledge about concussions on athletes' reporting behaviors needs to be addressed.

CONCLUSION

There is a need for quality concussion education programs as frequently called for in the literature.[3,4,6,9,15,24,25] The need for concussion education does not stop at the athletes - it must extend to parents, coaches, and officials as well. Individual states have mandated concussion education for various constituent groups, yet the framework to accomplish this is not always clearly defined.[26] More work needs to be done on all fronts to help improve concussion education across the board.

In its current form, the Concussion Goggle™ program may not be an effective concussion education program. This is the first study to investigate the Concussion Goggle™ program as a tool to educate secondary school athletes about concussions. While the current study adds to the growing body of knowledge about concussion educations program, the study also demonstrates what this specific education program is lacking. The Concussion Goggle™ education program needs to be updated and based upon the best available evidence, the instrument needs to align with the educational information in the

presentation, and additional research using the educational program is recommended.

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