
OUTSTANDING GRADUATE STUDENT RESEARCH PAPER AWARD

Assessment of High School Coaches' Knowledge Retention of Sport-Related Concussions

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Abstract

Sport-related concussions continue to be a serious epidemic for youth participants. A pathway to improper management, created by improper reporting by athletes, lack of recognition by coaches, and lack of access to athletic training services, must be mitigated through effective concussion educational initiatives. The purpose of this study is to investigate the effect of an online concussion education program, *Concussion in Sports*, on the knowledge retention among high school football coaches over a 15-week follow-up period.

A quasi-experimental repeated measure design was used to measure knowledge retention over time for high school football coaches from two parishes in south Louisiana. The main outcome measure in this study included coaches' knowledge retention in the follow-up period. The assessments consisted of 31 questions divided into three distinct subsections: signs and symptoms recognition, common concussion misconceptions, and scenario-based questions. A 2-tailed paired samples t-test was conducted to test knowledge retention.

High school football coaches had significantly lower overall knowledge scores as well as signs and symptoms subsection scores on 15-week follow-up assessments compared to post-course assessments, but the participants did not have significantly lower misconception or scenario subsection scores. This study provides some foundational support that knowledge was not retained in high school football coaches in south Louisiana. This study confirms the need to continue to assess long-term outcomes to assure knowledge retention in high school football coaches after online concussion education.

Keywords: sport-related concussion (SRC), education, knowledge transfer

Introduction

Concussions continue to be a serious epidemic in youth and competitive sports. The incidence of sport-related concussions continues to rise, as approximately 1.6 million to 3.8 million sport-related concussions occur each year (Bagley et al., 2012). In a 2017 national survey, 15.1%, or approximately 2.5 million, of high school students reported having at least one concussion during the 12 months before the survey, and 6.0% reported two or more concussions (DePadilla, Miller, Jones, Peterson, & Breiding, 2018). Sport-related concussion (SRC) is defined as "a traumatic brain injury induced by biomechanical forces" that may occur with a direct blow or indirect force to the head, face, or neck (McCrory et al., 2017). Since SRCs may be difficult to recognize, improper

management of head trauma can be extremely harmful and detrimental to the career of any athlete. Due to the continued concern of concussive injuries during athletic participation, investigators must provide increased attention and research to enhance proper recognition and management of SRC.

Leaders within the field of sports medicine have addressed athlete safety through educational programs. Concussion legislation, adopted throughout the United States between 2009 and 2014, contains a preseason education provision targeting various groups including coaches, athletes, and parents (Lowrey, 2015; Register-Mihalik, Baugh, Kroshus, Kerr, & Valovich McLeod, 2017). The Louisiana Youth Concussion Act (2011) includes a provision for coaches' education, removal from play requirements, and return to play guidelines. The educational provision requires that all coaches complete an annual concussion recognition course. Any training material made available by the National Federation of State High School Associations (NFHS), including *Concussion in Sports*, satisfies the annual education requirement for coaches. Despite these enacted laws, legislation efforts alone may be insufficient in changing the sports culture of concussion management (Rivara et al., 2014).

The inaccessibility of appropriate healthcare providers during sport activities further indicates the need for coaches to appropriately recognize concussion injuries. Pryor et al. (2015) stated that 70% of public high schools within the United States have access to a certified athletic trainer (AT), while only 37% of schools have access to a full-time certified athletic trainer. ATs are often absent from practices and competitions at the youth level causing even greater responsibility for the coach to properly recognize concussive injuries (Hainline & Ellenbogen, 2017). Since many student-athletes do not always have access to appropriate medical services, coaches may find themselves in a critical decision-making capacity to correctly recognize a suspected concussion and promptly remove an athlete from play.

The health and safety of high school athletes is at risk due to the inaccessibility of certified athletic trainers. Louisiana currently ranks 35th out of 51 within the United States in managing the sudden death and catastrophic injuries in high school athletes (Adams, Scarneo, & Casa, 2017). Adams et al. (2017) created a health and safety policy grading rubric for evidence-based practices for preventing death and catastrophic injuries in sport, including sections for sudden cardiac arrest, head injuries, exertional heat stroke, appropriate medical coverage, and emergency preparedness. Louisiana scored at 41% overall on the health and safety policy grading rubric, well below the median score of 47.1% established in this analysis (Adams et al., 2017). Louisiana only obtained 10 of the 20 points on the "Traumatic Head Injury" section, with all the deductions coming from training of coaches. Louisiana has an opportunity to improve the healthcare of athletes and ascend the rankings as compared to other states by evaluating the effectiveness of current educational programs used within the state.

The effectiveness of coaches' education to enhance appropriate behaviors and attitudes toward concussion injuries is paramount (Provvidenza & Johnston, 2009). McCrory et al. (2017) noted that "identifying the needs,

learning styles and preferred learning strategies of target audiences, coupled with evaluation, should be a piece of the overall SRC education puzzle to have an impact on enhancing knowledge and awareness” (p. 8). According to Rivara et al. (2014), 40% of coaches were not aware of athletes exhibiting concussion symptoms even after completing concussion education mandated by state laws. Most coaches recognized a need for additional educational training for managing concussions in their football programs. A study by Faure and Pemberton (2011) of 128 Idaho high school football coaches demonstrated that 94.2% of participants confirmed the risk of concussion in football did concern them, while 86.3% of these high school football coaches identified the responsibility to be able to recognize the signs and symptoms of concussions and to safely return an athlete to play. Although research indicates that most high school and youth coaches accept their role with concussion recognition, there remains a disparity between educational programs and concussion awareness.

Knowledge retention after concussion educational programs is an integral component to consider. Coaches may need to apply knowledge and skills at various time intervals throughout the season, which may be distant from the educational encounter. The inability for high school coaches to retain knowledge from annual concussion education programs significantly inhibits proper management of SRCs.

Countless considerations are critical when evaluating the effectiveness of any concussion education program for coaches, since many current programs, such as *Concussion in Sports*, show information through the convenience of the Internet (Caron, Bloom, Falcao, & Sweet, 2015; Provvidenza & Johnston, 2009). Educational efforts are successful when concussion education programs are user-friendly, interactive, and implement more than one technique to present the information (Mrazik et al., 2015;). Caron et al. (2015) identified common weaknesses within all concussion education programs including the limited use of interactive tools, delivery of education at one-time point only, and lack of long-term assessment. Furthermore, Caron et al. (2015) stated that additional research is needed to consider these factors that would improve participants’ long-term knowledge, attitudes, and behaviors after concussion educational program exposure. It is necessary to assess the knowledge retention after online concussion education programs for high school coaches since many of these weaknesses are apparent through an online delivery method.

The increasing epidemic of concussion injuries in sports continues to attract significant attention throughout society, due to recent law implementation, significant injury incidence, and the lack of access to appropriate healthcare providers during sport participation. A pathway to improper management created by lack of recognition by coaches in addition to the lack of access to athletic training services must be mitigated through effective concussion educational initiatives. It is essential to evaluate current online concussion educational programs for coaches to assure appropriate knowledge retention to enhance proper management, reduce the risks of damaging long-term health consequences of participants, and mitigate potential litigation. There is a significant need to evaluate the effectiveness of current online concussion education programs and develop more effective

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population-specific educational modules (Kroshus, Garnett, Baugh, & Calzo, 2015; Tator, 2012). Currently, limited research has been performed to evaluate the effectiveness of online concussion education programs and knowledge retention (Mrazik et al., 2015; Williamson et al., 2014).

The purpose of this study is to investigate the effect of an online concussion education program on the knowledge retention among high school football coaches over a 15-week follow-up period (approximate length of one competitive season). The following research question and hypothesis were addressed.

- Research Question: Does an online concussion education program significantly improve knowledge retention in high school football coaches as measured by differences in post-course and 15-week follow-up assessment scores?
- Research Hypothesis: Knowledge retention in high school football coaches will significantly increase following 15 weeks as measured by follow-up assessment scores being greater than or equal to post-course assessment scores.

Method

This author investigated the effect that an online concussion education program has on the knowledge retention among high school football coaches. The researcher measured knowledge retention over time for high school football coaches through a quasi-experimental repeated measure design. Following Institutional Review Board (IRB) approval from the University of Louisiana Monroe (ULM), administrators at local school boards and individual schools were contacted to obtain a letter of support from project sites as required by the ULM IRB. The school boards were contacted by phone and email to inform the organizations of the study's purpose and to request participation during the semester. The researcher received permission to contact the individual coaches employed within each parish by email.

Subjects

A convenience sample of high school football coaches from two parishes in south Louisiana were recruited to participate within this study. The researcher contacted a total population of 143 participants between these two parishes. Parish A had 12 schools participating in high school football that included 116 football coaches; whereas, Parish B was composed of four football schools and 27 football coaches. Fifty of the 57 football coaches who attended the concussion education course completed the post-course assessment. Thirteen of the 50 football coaches were removed from the initial sample since they did not complete the 15-week follow-up assessment. The final sample size was comprised of a total of 37 high school football coaches who watched the online concussion education course and completed both the post-course and 15-week follow-up assessments. This sample was comprised of 35 public school coaches and two private school coaches. When considering school sizes based on student enrollment, the final sample included 20 coaches from 5A-schools (54%); nine coaches from 3A-schools (24%); and eight coaches from 2A-schools (22%). All 37 coaches were male with an age range

of 20-54 years of age. From an educational degree perspective, two coaches had a high school diploma, 26 had a Bachelor's Degree, and nine had a Master's degree. In this sample, coaching experience ranged from 1-31 years of experience with 5-15 years of experience being the largest cohort (16 coaches). In addition, 28 of the participating coaches reported coaching at least one additional sport besides football. Among the 37 coaches, 27 reported having access to a full-time certified athletic trainer at their school daily. Seven of the participants reported being previously diagnosed with a concussion. Finally, these participants reported the primary source of concussion information being obtained from health care professionals (doctor/AT). Benefits to participate in this study included completion of a mandated annual concussion recognition course as required by Act 314 (Louisiana Youth Concussion Act, 2011).

Inclusion criteria of the participants required individuals to be a high school football coach within the selected parishes. Exclusion criteria within this study included individuals who did not coach football, did not coach at the high school level, and were not employed within the two parishes. A power analysis following Cohen's procedure (1969,1992) was conducted to assure an appropriate number of individuals would agree to participate and complete the study. An a priori power analysis requires an alpha value, power level, and an effect size to calculate an appropriate sample size to assure validity. A typical alpha size in the social sciences is 0.05; whereas, an acceptable power is 0.80. Cohen (1969,1992) has identified 0.2 as a small effect size, 0.5 as a medium effect, and 0.8 as a large effect. With a significance level of $\alpha = 0.05$, β of .20, and effect size (d) of 0.50, a sample size of 34 participants from the population would assure an acceptable power level.

Table 1

Participation in Concussion Education Course, Post-Course, and Follow-Up Assessment by Coaches

	Parish A	Parish B	Total
Total Coaches	116	27	143
Total Completed Education Course	41 (35.3%)	16 (59.3%)	57 (39.9%)
Post-Course Assessment Completed	37	13	50
Follow-Up Assessment Completed	30	7	37

Table 1 shows the number of coaches from each parish who completed the concussion education course, post-course and follow-up assessment. Fifty of the 57 football coaches who attended the concussion education course completed the post-course assessment. Following the 15-week intermission between assessments, 37 football coaches out of 50 completed the 15-week follow-up assessment. The final sample size for this study included these 37 football coaches.

Research Procedures

Two dates were set within each parish to present the online concussion education course to maximize participation. The entire population of participants was contacted multiple times to inform them of meeting times

to enhance attendance at these meetings. An introductory script briefly describing the study was read orally by the researcher to each group of participants. The researcher obtained written consent for participation from individual participants through in-person dissemination of the informed consent form. The participants completed the online concussion course sponsored by the National Federation of State High School Associations (NFHS) entitled *Concussion in Sports* during the scheduled meeting with the researcher. The researcher was present to assure attendance and obtain formal consent for participation within IRB guidelines, but the researcher did not interact with the participants or interrupt the online course at any time to reinforce content. Objectives of this 30-minute online concussion education course included acknowledging the impact of SRC on athletes, teaching how to recognize a suspected concussion, and providing protocols to manage a suspected concussion with steps to help players return to play safely after a concussion. The researcher's personal computer and projector were used to display the online concussion education course onto a large surface within the meeting rooms. Each attendee received an initial introductory email immediately after the online concussion education course requesting completion of the post-course assessment. The participants had three calendar days to complete the post-course assessment via Survey Monkey, so that the researchers could gather individual coaching characteristics while also measuring immediate knowledge gained. Reminder emails were sent prior to the expiration of the survey to enhance response rate.

All participants resumed normal duties after completion of the online concussion education program. An email was sent to each participant to request completion of an identical follow-up assessment once 15 weeks elapsed from the completion of the online concussion education course. The participants had seven days to complete this 15-week follow-up assessment. Reminder emails were sent throughout this time window prior to the expiration of the assessment to enhance cooperation and participation.

Data Collection

Data within this study were transferred and collected through electronic methods. All forms were submitted by the participants through Survey Monkey. The researcher assured anonymity of the respondent by choosing to exclude all respondent information on the survey platform. The researcher requested each participant create a unique, individualized code consisting of alpha and numeric characters by answering a series of five questions prior to beginning the post-course and 15-week follow-up assessment. These codes were used to match the post-course assessment and 15-week follow-up assessment scores.

Demographic data and assessment scores were transferred directly to an Excel spreadsheet for coding into Statistical Package for the Social Sciences (SPSS) (version 25.0; IBM Corp, Armonk, NY) statistical software. Raw scores from the post-course assessment were reviewed to obtain overall as well as subsection scores. Each correct response to each question was scored with a value of 1, and all incorrect responses were scored with a

value of 0, thus allowing for a total score to be calculated along with scores for each subsection. The 15-week follow-up assessment followed the same scoring procedures as the post-course assessment.

The post-course and 15-week follow-up assessments consisted of 31 questions divided into three distinct subsections: signs and symptoms recognition, common concussion misconceptions, and scenario-based questions. The *16-Item Concussion Symptom Recognition Checklist* was used to assess signs and symptoms recognition (Saunders, Burdette, Metzler, Joyner, & Buckley, 2013). This section consisted of 16 yes/no questions, with eight correct and eight incorrect symptoms each. Many previous researchers have used the symptom recognition aspect of this assessment, which has been deemed valid and reliable (Glang, Koester, Beaver, Clay, & McLaughlin, 2010; Saunders et al., (2013); Valovich McLeod, Schwartz, & Bay, 2007).

The next subsection of the assessment was composed of nine true/false questions to assess common misconceptions. Saunders et al. (2013) assured appropriate validity for this section by having 10 ATs who were knowledgeable on the topic of SRC review the tool for face validity. Finally, the last subsection included six scenario-based questions to evaluate appropriate decision making during concussive injuries. Both the scenario-based and misconception questions were based on questions previously used in studies on the knowledge of SRCs (Faure & Pemberton, 2011; Guilmette, Malia, & McQuiggan, 2007; Sullivan et al., 2009; Valovich McLeod, Bay, Heil, & McVeigh, 2008; Valovich McLeod et al., 2007).

Content Validity of Instrument

Content validity of the instruments used in this study as it relates to the online concussion education course was assured by using subject-matter experts (SME). The assessment of content validity involved nine certified athletic trainers and one sports medicine physician. Experts were asked to provide feedback related to the questions generated by the researchers after reviewing the online course, *Concussion in Sports*. The SMEs were initially asked to rate whether the knowledge or skills measured by each question on the assessment was “essential”, “useful, but not essential”, or “not necessary” to the proper performance of managing a concussion by a high school coach. The content validity of the individual questions is considered higher as more SMEs agree that items on the assessments are essential. The SMEs had 80% agreement on “essential” knowledge for coaches on 12 out of the 16 questions on the instrument tool. Two of the remaining four questions achieved 80% agreement when combining “essential” and “useful” responses together. Next, the subject-matter experts were asked if the material on the assessments were presented within the online concussion education course. Agreement among 90% of SMEs were achieved on five of the six questions presented on the content validity form. In summary, experts expressed agreement throughout both validation procedures leading to enhanced validity of the instrument used to assess knowledge retention throughout this study.

Statistical Procedures

Descriptive statistics (frequency, mean, and standard deviations) were calculated for all demographic coaching categories, independent variables, and dependent variables. All statistical analyses were performed in SPSS statistical software. A 2-tailed paired samples t-test was conducted to assess knowledge retention among high school coaches after an online concussion education program. The paired-samples t-test compared scores across time for overall scores as well as subsection scores. A priori alpha level of significance was set at 0.05 for all analyses.

Results

Knowledge retention was measured through the difference between post-course assessment and 15-week follow-up assessment scores. Raw scores were reviewed to obtain scores for each subsection: signs and symptoms recognition, common concussion misconceptions, and scenario-based questions.

Table 2

Post-Course Assessment Correct Responses^a

Section	Minimum	Maximum	Mean	Std. Deviation
Overall	22	31	28.43	2.328
Signs and Symptoms	8	16	14.32	2.148
Misconceptions	6	9	8.46	.900
Scenarios	5	6	5.65	.484

^an=37

Table 2 shows all descriptive statistics from the post-course assessment regarding overall and subsection scores. The overall average of scores on the entire post-course assessment was 28.43. The range of scores was 22-31, with six out of 37 individuals achieving a perfect score. The average score for all participants in the signs and symptoms subsection, was 14.32 out of 16 questions with 11 individuals correctly answering all 16 questions in this subsection. In the misconception subsection, the average score for all participants was 8.46 out of nine questions with 26 individuals correctly answering all questions on this subsection. The average score for all participants in the scenario subsection was 5.65 out of six questions with 24 individuals correctly answering all questions on this subsection.

Table 3

15-week Follow-Up Assessment Correct Responses^a

Section	Minimum	Maximum	Mean	Std. Deviation
Overall	21	31	26.35	2.658
Signs and Symptoms	8	16	12.54	2.468
Misconceptions	6	9	8.27	.932
Scenarios	4	6	5.54	.691

^an= 37

Table 3 shows all descriptive statistics of correct responses from the 15-week follow-up assessment. Results relevant to the hypothesis indicate a decrease in mean scores for overall knowledge scores as well as every subsection score on the follow-up assessment as compared to the post-course assessment. The overall average of scores on the entire 15-week follow-up assessment was 26.35, with two out of 37 individuals achieving a perfect score. In the signs and symptoms subsection, the average score for all participants was 12.54. The lowest identified signs and symptoms on the 15-week follow-up assessment were abnormal sense of smell and weakness in neck range of motion. In the misconception subsection, the average score for all participants was 8.27. In the scenario subsection, the average score for all participants was 5.54.

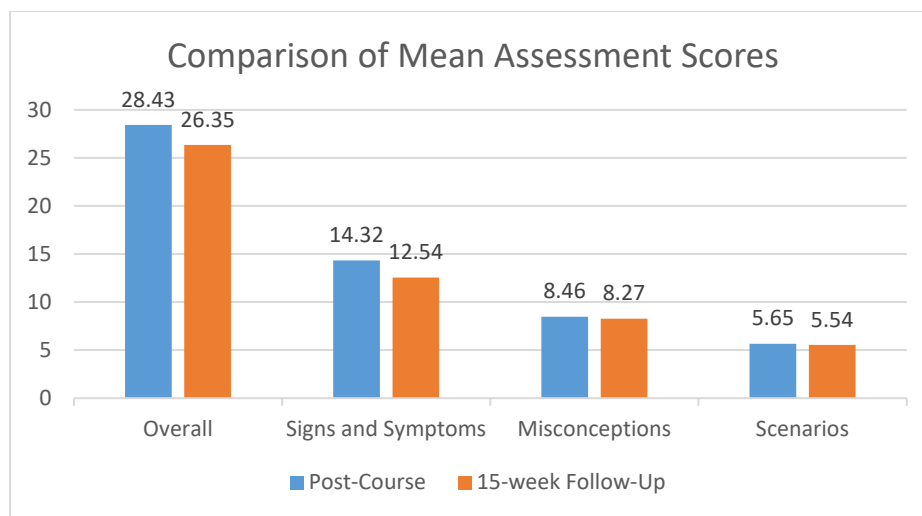


Figure 1. Comparison of Mean Assessment Scores

Figure 1 shows a graphical representation comparing mean assessment scores. A 2-tailed paired samples t-test was used to assess the hypothesis through comparison of the overall and three subsection post-course and 15-week follow-up mean scores.

Table 4

Paired Differences between Post-Course and 15-week Follow-Up Scores^a

Post-Course and Follow-Up Assessment Pairs	Paired Differences						Sig. (2-tailed)
	Mean	SD	SEM	95% CI of the Difference		t	
				Lower	Upper		
Overall	2.081	2.302	.378	1.314	2.849	5.499	.000*
Signs and Symptoms	1.784	2.162	.355	1.063	2.505	5.019	.000*
Misconceptions	.189	.845	.139	-.092	.471	1.363	.181
Scenarios	.108	.875	.144	-.184	.400	.751	.457

^an=37; *p < .05

The hypothesis stated that knowledge retention in high school football coaches would significantly increase following 15 weeks as measured by follow-up assessment scores being greater than or equal to post-course assessment scores. Results pertinent to the hypothesis are shown in Table 4 include the t values and corresponding p values for changes in the post-course and 15-week follow up scores. Data analysis revealed that football coaches had significantly lower overall scores on the 15-week follow-up assessments than post-course assessments $t(36) = 5.50, p = .000, d = 0.90$. Additionally, paired samples t -tests were performed on the three subsection scores. On the signs and symptoms subsection, the analysis indicated that football coaches had on average significantly lower subsection scores on the 15-week follow-up assessments than post-course assessments $t(36) = 5.50, p = .000, d = 0.90$. The difference is not only statistically significant, but has a large effect using Cohen's guidelines. On the misconception subsection, the statistical test indicated that football coaches did not have significantly lower subsection scores on the 15-week follow-up assessments than post-course assessments $t(36) = 1.36, p = .181, d = 0.22$. Similarly, the statistical analysis indicated that football coaches again did not have significantly lower scenario subsection scores on the 15-week follow-up assessments than post-course assessments $t(36) = 0.75, p = .457, d = 0.12$.

Discussion

Football coaches had significantly lower overall scores on the 15-week follow-up assessments compared to post-course assessments. The paired samples t -test supported statistical significance at the 0.05 level (p values $< .001$). Although Valovich McLeod et al. (2007) and Saunders et al. (2013) used similar assessments to demonstrate a knowledge base in youth coaches and coaching education students respectively, these overall results begin to lay the groundwork that immediate knowledge assessment may not be the most appropriate method to assess whether coaches retain knowledge after an online concussion education program. Furthermore, the inability to retain knowledge is critical because the gap in knowledge retention may lead to the inability to apply the necessary skills during an emergency (Popp & Berry, 2016). Organizations should implement techniques that cue appropriate actions, such as reminder messages or dispersed delivery, to mitigate this lack of knowledge retention.

Signs and Symptoms Knowledge Retention

The high school football coaches in this study had significantly lower signs and symptoms subsection scores on the 15-week follow-up assessments. The paired samples t -test support statistical significance at the 0.05 level ($p < .001$). This subsection indicates the entire significant difference noted in the overall score difference.

These participants were able to retain higher rates on the signs and symptoms of amnesia, blurred vision, confusion, dizziness, headache, nausea, and sleep disturbances compared to previous studies (Saunders et al., 2013; Valovich McLeod et al., 2007). All seven of these signs and symptoms are positive for concussion injuries

requiring removal from play. Even though participants incorrectly identified distractors of abnormal sense of smell and weakness in neck range of motion as positive concussion symptoms, it is encouraging that these coaches would err on the side of caution and remove the athletes from play with these symptoms. This information provides some additional support that Louisiana high school football coaches may be beginning to address the societal cultural norm of playing through injury during sports participation. The researcher agrees with the recommendation by Saunders et al. (2013) in supporting the need for continued education to review commonly missed symptoms. This study strengthens recommendations from previous studies that organizations and certified athletic trainers should consistently review signs and symptoms of concussions with coaches throughout the year to enhance knowledge retention and symptom recognition to improve proper management of sport-related concussions (Saunders et al., 2013; Valovich McLeod et al., 2007).

Misconceptions Knowledge Retention

Football coaches did not have significantly lower misconception subsection scores on the 15-week follow-up assessments compared to post-course assessments. The paired samples t-test did not support statistical significance at the 0.05 level ($p = .181$). The most common misconceptions missed on both post-course and the 15-week follow-up assessments centered on the use of proper terminology. Misconception questions 4 and 9 involved use of colloquial terms such as “ding” and “bell ringer”. The researcher corroborates the findings of Saunders et al. (2013) that the use of improper terminology remains an issue among coaches. Elimination of improper terminology was explicitly addressed throughout the online concussion education program. Developers of educational programming must continue to address the importance of using proper terminology when dealing with concussion injuries.

Scenarios Knowledge Retention

Comparable to the misconception results, these football coaches did not have significantly lower scenario subsection scores on the 15-week follow-up assessments compared to post-course assessments. The paired samples t-test did not support statistical significance at the 0.05 level ($p = .457$). The most commonly missed scenario question involved return to play criteria after loss of consciousness (Scenario 4). This question refers to an outdated standard of care that allowed return to play on the same day of injury. This subsection supports the need to continue to address scenarios regarding the sign of loss of consciousness. Although loss of consciousness is not required to be diagnosed with a concussion, programs must inform coaches to never allow return to play on the same day with any loss of consciousness while also requiring evaluation by a healthcare professional before returning to play. Athletic trainers should consistently review the return to play policy with all coaches throughout the year to assure proper compliance. This study indicates the need to continue to assess long-term outcomes to

assure knowledge retention in high school football coaches after online concussion education, akin to the recommendation of Emke, Butler, and Larsen (2016) regarding medical education research.

Observations, Conclusions, and Speculation of Results

The first observation by the researcher is the lack of motivation of the coaches in attendance. Some coaches appeared very disinterested throughout the educational interaction, as they were often seen dividing their attention among cell phone usage, showing signs of tiredness, and holding peer conversations despite being instructed by the researcher to exclusively watch the video. Furthermore, some coaches verbalized their displeasure with the educational program to the researcher stating that they had previously seen this video in prior years. The difficulty in confirming an opportunity to meet with the participants in this study was another observation noted by the researcher. This observation indicates the significant fact that coaches have other duties besides the coaching responsibilities of their sport. Finally, coaches had difficulty correctly answering if they had daily access to a full-time certified athletic trainer at their school. Availability of an athletic trainer may not only assist the coach in recognizing a SRC and removing the athlete from play but also mitigates the conflict of interest the coach may face when making this critical decision.

Implications for Further Research

This study indicates some foundational support that knowledge was not retained in high school football coaches in south Louisiana. Despite these initial findings, many other areas of further research investigating the effectiveness of concussion education programs have been identified. First, it may be beneficial to repeat this study with a larger sample size while also expanding into other parishes to assess whether similar results are obtained. Furthermore, it would be of additional benefit to extend the time between assessments to ascertain whether knowledge degradation occurs in the latter part of the year.

It would be extremely beneficial to expand future research to include additional high school sports, since football is not the only sport where participants are at risks for concussion injuries. Whereas Esquivel, Haque, Keating, Marsh, and Lemos (2013) identified a difference in concussion education among high school sports in Michigan, these researchers recommended education expansion beyond football, specifically into soccer and hockey. For example, soccer, hockey, and cheerleading are examples of other sports where participants are at high risk for head injuries.

Next, because the Louisiana Youth Concussion Act (2011) covers an age range between 7-18 years of age, future research should be directed toward youth sport coaches as well. In addition to youth coaches, it would be beneficial to assess other cohorts of individuals that are present during sports participation, including athletes, parents, and officials.

The lack of standardization of educational programming by legislative bodies allows developers to educate coaches through a variety of programs. Although the researcher looked at one common online educational resource (*Concussion in Sports*), it would be beneficial to assess varying programs to identify the most effective program for specific audience groups. In addition, it would be beneficial to assess the effectiveness of in-person compared to online education programs to recognize any difference in knowledge retention between delivery methods of programs. Finally, the researcher specifically assessed knowledge of high school football coaches. It may be beneficial to look at other variables beyond knowledge, such as intention to report and societal barriers that may inhibit proper management of these injuries.

Limitations of Study

Several limitations must be considered when interpreting this study's findings. First, the population of this study included a convenience sample of high school football coaches from parishes within south Louisiana. Secondly, the time frame of this study approximates one competitive sports season; whereas, state laws require education on an annual basis. Next, there was an inability to control access to other concussion information resources during the 15-week intermission. Finally, the assessment tool being used to measure knowledge retention has been validated and used previously in many other studies (Faure & Pemberton, 2011; Glang et al., 2010; Guilmette et al., 2007; Saunders et al., 2013; Sullivan et al., 2009; Valovich McLeod et al., 2007). Despite these validation studies, the researcher's ability to measure knowledge retention may be limited by the categories addressed within this instrument.

Recommendations and Best Practices

This study indicated significant outcomes for knowledge retention for high school football coaches after online concussion education. Overall knowledge scores along with signs and symptoms knowledge subsection scores were not retained by participants. Based on the significance of these findings, the following recommendations and best practices are indicated to improve knowledge retention of coaches.

- School districts and organizations should be encouraged to take a closer look at the effectiveness of the current concussion educational programming.
- School districts and state associations should strive to increase access to certified athletic trainers at the secondary school level to augment the coach's responsibility of concussion recognition while decreasing the conflict of interest a coach may face in making a return to play decision after concussion injury.
- School boards should increase the frequency of educational courses beyond the minimal standard to enhance knowledge retention.
- Concussion education program developers should integrate appropriate and effective knowledge transfer techniques for coaches, including interactive delivery method and reflection opportunities.

- Developers of educational programming should continue to address the importance of using proper terminology when dealing with concussion injuries.
- The state of Louisiana should benefit from forming a committee to approve concussion education courses that meet the standard set forth by Act 314 (Louisiana Youth Concussion Act).
- School boards should consider in-person training to augment learning that occurs during online courses and provide an opportunity to dispel any misconceptions.
- Educators should implement reminder messages for all individuals throughout the year to act as cues to action.
- Educational programs should be updated on a regular basis to address significant changes in management of SRCs.

Conclusion

Sport-related concussions continue to be a serious epidemic for youth participants. Assuring knowledge retention after online concussion education for high school coaches is challenging but also paramount to address the epidemic with SRCs for youth athletes. This study indicated some foundational support that knowledge was not retained in high school football coaches in south Louisiana. High school football coaches had significantly lower overall knowledge scores as well as signs and symptoms subsection scores on the 15-week follow-up assessments compared to post-course assessments. Although overall signs and symptoms knowledge was not retained in this study, these participants did a better job as compared to the participants in the Saunders et al. (2013) and Valovich McLeod et al. (2007) studies on maintaining knowledge on positive concussion symptoms. The coaches were able to retain knowledge on the misconception and scenario subsections. This study indicates the need to continue to assess long-term outcomes to assure knowledge retention in high school football coaches after online concussion education.

Schools would benefit from formally evaluating their current educational structure while also addressing the dearth of sports medicine professionals at this level. Knowledge transfer principles must be considered when developing and evaluating evidence-based concussion education programs for high school coaches. The important and imminent need for effective concussion education to enhance knowledge retention in high school football coaches has clearly been established throughout this study. Time is of the essence when implementing these recommendations for concussion education programs, as the improper management of concussions by coaches puts the health and welfare of each athlete at risk during sports participation.

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