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The Effect of an Online Concussion Education Program on Knowledge Retention for High School Football Coaches

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**THE EFFECT OF AN ONLINE CONCUSSION EDUCATION PROGRAM ON
KNOWLEDGE RETENTION FOR HIGH SCHOOL
FOOTBALL COACHES**

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Abstract

A quasi-experimental repeated measure design was used to investigate the effect of an online concussion education program on the knowledge retention among 37 high school football coaches over a 15-week period and whether any variables can successfully predict knowledge retention. Data were collected immediately following an online concussion education program and post 15-weeks using a valid and reliable concussion assessment tool consisting of three distinct subsections: signs and symptoms recognition, common concussion misconceptions, and scenario-based question. A 2-tailed dependent samples t-test was conducted to test knowledge retention, while a multiple linear regression analysis was performed to assess which coaching characteristics and school attributes affect knowledge retention.

Results indicated that the high school football coaches had significantly lower overall 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. Coaches' age, experience, level of education, school size or access to a full-time certified athletic trainer did not significantly influence knowledge retention in this study. 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.

Key words: sports-related concussion, online education, knowledge, retention

THE EFFECT OF AN ONLINE CONCUSSION EDUCATION PROGRAM ON KNOWLEDGE RETENTION FOR HIGH SCHOOL FOOTBALL COACHES

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; Langlois, Rutland-Brown, & Wald, 2006; Mitchko et al., 2007). In a 2017 national survey, approximately 2.5 million 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 (McCroory et al., 2017). Since SRCs may be difficult to recognize, head trauma can be extremely harmful and detrimental to the career of any athlete (Institute of Medicine (IOM), & National Research Council (NRC), 2015). Due to the continued concern of concussive injuries during athletic participation, increased attention and research support proper recognition and management of SRC.

I. Introduction

Leaders within the field of sports medicine have attempted to address athlete safety through educational programs provided to athletic administrators, coaches, and staff at many levels of competition. 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). Current changes to United States (US) laws fall into three main categories, including expanding coverage, clarifying existing requirements, and implementing

primary prevention techniques (Lowrey, 2015). Despite these enacted laws, legislation efforts alone have been insufficient in changing the sports culture of concussion management (Lowrey, 2015; Rivara et al., 2014).

Detection and management of concussion injuries may be improved through enrichment of educational modules and improvement of communication among athletes, coaches, and medical professionals. Rivara et al. (2014) stated that 69% of the athletes continued to participate with concussion symptoms even after state law implementation. The initial recognition of SRC by coaches, which requires immediate removal from activity, is vital because of the failure for athletes to always self-report concussion symptoms (O'Donoghue, Onate, Van Lunen, and Peterson, 2009). Coaches are integral in recognizing signs and symptoms of concussions to assist healthcare providers in removing the athlete from participation to further reduce the risks associated with continued participation after suffering a concussion (Glang, Koester, Beaver, Clay and McLaughlin, 2010). Athlete safety may be enhanced allowing for fewer risks of long-term health effects if knowledge is retained by coaches after concussion education programs (Bagley et al., 2012; White et al., 2014).

Lawsuits concerning concussion related injuries in sports targeting large scale organizations, including the National Collegiate Athletic Association (NCAA), Pop Warner, and state athletic associations, remain on the rise (Pachman & Lamba, 2017). Everyone involved in the care of a young athlete who has sustained a concussion may be held legally responsible for a detrimental outcome if the appropriate standard of care is not followed (Tomei et al., 2012). Because of these developing litigation battles, organizations, such as the NCAA, have placed the responsibility of protecting the athlete on the membership schools and employees (Pachman & Lamba, 2017). Organizations can influence prevention of harm from sport-related concussions at

multiple levels through effective concussion education for coaches (Register-Mihalik et al., 2017).

The purpose of this study was 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 secondary purpose was to determine whether any variables indicate the ability to predict knowledge retention. Based on the need to examine the effectiveness of current online concussion education programs and inform athletic coaches of proper concussion management, the following research questions were addressed in this study:

- 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?
- Do any coaching characteristics or school attributes significantly influence knowledge retention in high school football coaches after completion of an online concussion education program as measured by differences in post-course and 15-week follow-up assessment scores?

II. Barriers to Effective Concussion Education

The increasing epidemic of concussion injuries in sports continues to attract significant attention throughout society. The potential to improve management of SRCs at multiple participation levels through appropriately delivered educational programs remains a significant benefit to individuals across all societal levels (Register-Mihalik et al., 2017). Although education for athletic coaches is required by all states, varying educational initiatives, lack of appropriate healthcare providers at athletic events, and the difficulty recognizing the “invisible

injury” by a diverse group of individuals are just a few complications that could inhibit the educational process required by legislation in all states.

The effectiveness of coaches’ education to enhance appropriate behaviors and attitudes toward concussion injuries is paramount (Provvidenza & Johnston, 2009). 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 when it came to 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. In addition, 90% of youth hockey coaches rated knowledge about concussions as being highly important in their role as a coach (Mrazik, Bawani and Krol, 2011). Although research indicates that most high school and youth coaches accept their role with concussion recognition, a disparity remains between educational programs and concussion awareness.

Certified athletic trainers are the most appropriate medical professional to provide care to high school athletes during participation (Wallace, Covassin, Nogle, Gould, & Kovan, 2017). In a study by Pryor et al. (2015), the researcher notes only 37% of student-athletes have access to a full-time certified athletic trainer. The inaccessibility of appropriate healthcare providers during sport activities further indicates the need for coaches to appropriately recognize concussion injuries to remain compliant with recent implementation of state laws. The lack of availability of a certified athletic trainer during practices and competitions continues to inhibit progress with appropriate concussion management while placing the burden of responsibility on the coach.

Since many student-athletes do not always have access to appropriate medical services, coaches may find themselves in a critical decision-making capacity to recognize a suspected concussion and promptly remove an athlete from play (McCrory et al., 2017).

No standardized method for training and educating coaches on concussion management currently exists (Harvey, 2013; IOM & NRC, 2015; Mrazik et al., 2015; Tomei et al., 2012). Education can range from an information sheet to formal training that may occur in a classroom or online setting. As of 2012, nearly half of the states required formal training (Tomei et al., 2012). In contrast, only 20% of states required optional education with no specific recommendations, while the remaining 32% of state laws required information sheets or an unspecified way to deliver the educational materials (Tomei et al., 2012). As these inconsistencies indicate, there is a significant lack of cohesion among state laws from an educational perspective that may lead to improper management of these serious injuries.

Even though online concussion education programs have been developed, schools and youth leagues still have options to develop their own educational materials without any medical supervision. In addition, it is currently difficult to create standardized concussion educational programs that comply with Louisiana law since the law covers a large age range of youth athletes along with the large variances recognized with coaches' experience, league rules, and physical attributes of the athlete. Provvidenza and Johnston (2009) noted that it is critical to establish a consistent educational process for coaches who require education on concussion management.

III. Knowledge Retention

Knowledge retention is an integral variable to evaluate during online concussion education programs. Knowledge retention is defined as cognitively organizing, rehearsing, coding, and transforming information for storage in memory, through images, verbal form, or

both (Schunk, 2012). The inability for high school coaches to retain knowledge from annual concussion education programs would significantly inhibit proper management of SRCs.

O'Donoghue et al. (2009) recommended that researchers should investigate the retention of knowledge from educational programs on SRCs. Caron, Bloom, Falcao and Sweet (2015) stated in an extensive literature review that additional research is needed to reveal specific factors, such as knowledge retention, that would improve participants' long-term knowledge, attitudes, and behaviors after concussion educational program exposure.

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 et al., 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; Stewart, 2006). As concussion educational program creators use various delivery methods, individual learning styles and preferences should always be considered when developing concussion educational programs (Provvidenza & Johnston, 2009). Caron et al. (2015) identified some 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. 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.

Coaches embrace the significant role that they play throughout the concussion management process, as they inherently want to learn more about concussions to protect the athletes under their watch. Faure and Pemberton (2011) found that many Idaho high school head

football coaches recognized their duty to determine when it was safe to allow a concussed athlete to return to activity. Because of this responsibility, concussion educational programs for coaches must be designed to allow for early recognition and proper management of concussion injuries. Validation of concussion education programs is essential to enhance efficiency and effectiveness of these programs, while allowing for the safe participation and efficient care of all injured athletes (Williamson et al., 2014). As legislative requirements continue to mandate concussion educational initiatives, effective concussion educational programs for high school coaches should be identified to improve care of an injured athlete while reducing current preconceived misconceptions that still exist from prior mismanagement (Faure & Pemberton, 2011; Kroshus, Garnett, et al., 2015). Online education continues to become an attractive option compared to traditional face-to-face courses because of the advantage of flexible scheduling for learners (Girard, Yerby, and Floyd, 2016).

IV. State Law Challenges Impacting Concussion Legislation

In May 2014, President Barack Obama held a summit on youth sport concussions at the White House where experts discussed the future of concussive injury and recovery, further validating the significant growth in injury awareness and its potential impact on public health (Caron et al., 2015). Although being recognized as a public health priority is an essential first step for proper concussion management, many states face substantial challenges to the current legislation since there is no current federal sport-related concussion law.

State concussion laws are initially increasing the awareness surrounding the concussion epidemic (Lowrey, 2015). In a survey of 59 head football coaches and athletic trainers in the state of Washington, the results showed that one-half of respondents did not change their concussion management practices after law implementation although awareness of injury may

have increased (Murphy et al., 2012). According to Lowrey (2015), the emphasis of all current laws is on secondary prevention efforts after an injury has been sustained rather than focusing on primary prevention of these injuries, such as equipment advancement, practice modifications, or technological advancements. Even though education may be utilized as a primary prevention technique, no framework has been developed to support this mandated aspect of the laws. These findings further show that legislation efforts alone will not suffice in changing the culture of concussion injury management in sports (Rivara et al., 2014).

Moreover, lack of standardization of educational programming along with minimal enforcement of these state laws can lead to problems with effectiveness (Harvey, 2013; Kerr et al., 2014; Lowrey & Morain, 2014; Register-Mihalik et al., 2017). The content of concussion education programs differed greatly among several studies (Caron et al., 2015). According to Lowrey and Morain (2014), some states experienced uncertainty in the law due to ambiguous language and unclear delegation of authority. Many of the concussion laws include the discrepancy between uniformity “on the books” as compared to implementation procedures (Lowrey, 2015). For example, many essential terms, including “youth,” “qualified medical professional,” and “education” within the laws go undefined leading to inconsistencies with implementation throughout various states and organizations. Variations exist among states in the specific educational requirements since each state can mandate a specific program or establish minimum standards for concussion education programs for key stakeholders, including coaches (Williamson et al., 2014). Due to the lack of specificity with content in the educational mandates with these state laws, significant differences may be noticed during the delivery of SRC education (Harvey, 2013; Register-Mihalik, et al., 2017).

V. Concussion Education Programs

The most commonly used concussion educational programs have been largely ineffective regarding injury reporting and participant safety, even though identification of symptoms by athletes are included these programs (Kroshus, Garnett, et al., 2015). Researchers have failed to validate teaching approaches directed at student-athletes because increased concussion knowledge by athletes does not always translate into the desired reporting behaviors (Bagley et al., 2012; Register-Mihalik et al., 2017). Some barriers to concussion reporting are intertwined with the culture promoted through sports participation including excessive competitiveness, viewing injuries as a weakness, and underestimating the potential risks of concussions (Sarmiento, Mitchko, Klein, & Wong, 2010). Due to these inadequacies within athlete education modules, effective coaches' educational programs have become more critical.

The CDC has developed fact sheets, handouts, and teaching guides that have become the model for sport-related concussion information and teaching tools (Williamson et al., 2014). This free toolkit includes an online video encompassing information on preventing, recognizing, and responding to concussions as well as concussion basics and return to play guidelines (Simons, 2013; Williamson et al., 2014). Coaches, parents, and health educators are targeted by this educational program, but the target audience does not include student-athletes because the developers rely on the previous mentioned groups to disseminate the information to the athletes (Williamson et al., 2014). The CDC has recently partnered with NFHS to produce a similar program for High School Sports entitled *Concussion in Sports*. The most recent version of this intervention takes approximately 45 minutes to complete all five modules and is commonly used by multiple states including Illinois, Iowa, Louisiana, Maryland, Massachusetts, Minnesota, Pennsylvania, Rhode Island, and Washington (Simons, 2013). The researcher uses this course as

the intervention in this study to assess knowledge retention due to the ease of accessibility and frequent use in many states.

Education and training may positively impact a coach's comprehension of sports concussion prevention and management since coaches have demonstrated significantly more concussion knowledge than the public after educational encounters (Glang et al., 2010; Guilmette, Malia, & McQuiggan, 2007). Although the Institute of Medicine (IOM) and National Research Council (NRC) stated that concussion education programs may be effective for improving concussion knowledge and awareness, these same educational programs have had minimal effect in reducing the common behavior by athletes of continued participation while being symptomatic (Kroshus, Garnett, et al., 2015). Faure and Pemberton (2011) stated that 76.7% of high school coaches in Idaho did not feel adequately trained in concussion management, and 94.2% of coaches said the risk of concussion in football concerned them. Finally, in a cross-sectional study of 126 high school coaches, O'Donoghue et al. (2009) found coaches in public and private high schools in southeastern Virginia were eager and willing to learn more about concussions if the materials were accessible. These studies indicated the need and expressed motivation of high school coaches to undergo additional effective concussion education courses.

In an extensive literature review, Caron et al. (2015) identified a few weaknesses in concussion education programs including limited use of interactive tools, one-time delivery methods, and lack of long-term assessment. Unfortunately, popular online resources, such as *Concussion in Sports*, often exhibit some of these weaknesses in the educational programming. Educational programs must not only improve concussion knowledge but also influence long-term behavioral and attitude modifications toward these injuries (Caron et al., 2015).

Identification of the inability to retain knowledge is critical because this gap in knowledge retention may lead to the inability to apply the necessary skills during an emergency (Popp & Berry, 2016). Independent education programs should be a significant component of a comprehensive solution to eliminating the public health crisis on concussion management (Kroshus, Baugh, Hawrilenko, & Daneshvar, 2015). There is an integral need for medical education research developers to assess long-term outcomes to assure knowledge retention, so that coaches can make appropriate decisions after completing the most effective concussion education program or seminar (Emke et al., 2016; Mrazik et al., 2011).

Mode of delivery is one critical component that can enhance knowledge retention (Provvidenza & Johnston, 2009; Reardon, Lavis and Gibson, 2006). In a cohort study of high school coaches in Washington state, Rivara et al. (2014) identified in-person concussion training as having the most proficient score on coach awareness for presence of concussion symptoms in athletes; whereas a video and quiz may have been less effective than other modes of delivery. Provvidenza and Johnston (2009) found coaches use reflective processes more effectively throughout learning endeavors. Concussion education programs should be easily accessible, currently updated, and administrative friendly to enhance knowledge retention of participants (Caron et al., 2015; Stewart, 2006).

Availability of resources may be different among coaching levels, types of leagues, and sports, although coaches share many of the same attributes. High school coaches had more resources available to them through associations, conferences, or workshops, while youth sports coaches received education from a lay population (O'Donoghue et al., 2009). Researchers have uncovered some significant differences on the effectiveness of concussion education for coaches among different sports. Approximately one-third (37%) of the hockey coaches indicated they had

limited knowledge about concussions, while only 1 in 5 of these coaches rated themselves as having a high knowledge base of concussion symptoms (Mrazik et al., 2011). Faure and Pemberton (2011) found high school coaches were likely to make a return to play decision at smaller schools. Finally, Esquivel et al. (2013) also found a difference in concussion education among high school sports in Michigan, as education was well promoted in high school football, but education expansion was recommended specifically for soccer and hockey. Although mandatory education has been implemented across various levels, leagues, and sports, inequities have continued to be elucidated throughout multiple studies.

Many studies have shown the need to further evaluate specific educational techniques used to educate coaches because of the seriousness of concussion injuries, the growing responsibilities of high school coaches, and the various delivery methods of educational programming. DePadilla et al. (2018) identified the importance to create a culture of safety when managing concussions; to expand educational efforts for students, parents, and coaches; and to identify programs and policies that prevent concussions. The IOM and NRC (2015) recommended that groups develop, implement, and evaluate the effectiveness of specific educational techniques to increase knowledge about concussions in various groups of individuals. Many authors recommended additional research to investigate the retention of knowledge obtained from educational programs on SRCs (Glang et al., 2010; Kerr et al., 2014; O'Donoghue et al., 2009). It is critical to identify whether changes in knowledge, attitude, self-efficacy and intention after educational concussion programs are maintained over time.. Researchers and investigators must study the effectiveness of the current programs to make recognizable progress within this public health priority.

VI. METHODOLOGY

A quasi-experimental repeated measure design was used to investigate the effect that an online concussion education program has on the knowledge retention among high school football coaches. Superintendents, along with administrative individuals at local school boards and individual schools, were contacted through a sample of convenience to obtain letter of support from project sites as required by the ULM Institutional Review Board (IRB). After IRB approval, a designated community contact was identified to assist with participation and organization throughout this study.

A convenience sample of high school football coaches from two communities in south Louisiana were recruited to participate within this study through collaboration with the local school board and individual schools. The researcher contacted a total population of 143 participants between these two communities. Inclusion criteria of the participants required individuals to be a high school football coach within the selected area. Exclusion criteria within this study included individuals who did not coach football. In addition, individuals who did not coach at the high school level or were not employed within the communities were also excluded. A power analysis following Cohen's procedure was conducted to assure an appropriate number of individuals would agree to participate and complete the study. With a significance level of $\alpha = .05$, β of .20, and effect size (d) of .50, a sample size of 34 participants from the population would assure an acceptable power level.

The coaching characteristic and school attribute questions assessed additional variables including type of school (public/private), size of school, age, gender, level of education, total years of full-time coaching experience, faculty/non-faculty coach, sports coached, coaching role

(head/assistant), presence of a full-time AT, personal history of concussions, CPR/first aid certification, and most commonly used concussion resource.

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 which has been deemed valid and reliable (Glang et al., 2010; Saunders, Burdette, Metzler, Joyner, & Buckley, 2013; Valovich McLeod, Schwartz, & Bay, 2007). The checklist consists of 16 yes/no questions, with eight correct and eight incorrect symptoms each, 9 true/false questions to assess common misconceptions and six scenario-based questions to evaluate appropriate decision making during concussive injuries.

Content validity of the instruments used in this study as it relates to the online concussion education course was assured using subject-matter experts (SME). The assessment of content validity included nine certified athletic trainers and one sports medicine physician who have greater than 8 years of experience in a high school or educational setting. Experts expressed agreement throughout both validation procedures leading to enhanced validity of the instrument used to assess knowledge retention throughout this study.

Two dates were set within each community to present the online concussion education course to maximize participation from individual coaches. The participants consented to complete the online concussion course sponsored by the NFHS entitled *Concussion in Sports*, during the scheduled meeting with the researcher. Each attendee received an initial introductory email immediately after the online concussion education course requesting completion of the post-course assessment. The participants had 3 calendar days to complete the post-course

assessment. The post-course assessment took approximately 10-15 minutes to complete.

Individuals could complete the post-course assessment via Survey Monkey at their convenience within the 3-day window following the educational course on any personal electronic device.

All participants resumed normal coaching and occupational 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 a 7-day window to complete this 15-week follow-up assessment.

Data within this study were transferred and collected anonymously through Survey Monkey. The researcher requested each participant to 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 so that post-course assessment scores and 15-week follow-up assessment scores could be compared.

Demographic data and assessment scores were transferred directly to an Excel spreadsheet for coding into SPSS statistical software. Raw scores from the post-course assessment were reviewed to obtain scores for each subsection: signs and symptoms recognition, common concussion misconceptions, and scenario-based questions. Each correct response to each sign and symptom recognition, misconception, and scenario-based 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.

Descriptive statistics (frequency, mean, and standard deviations) were calculated for all demographic coaching categories, independent variables, and dependent variables. A priori alpha

level of significance was set at 0.05 for all analyses. A 2-tailed paired samples t-test was conducted to test the hypothesis relative to the knowledge retention among high school coaches after an online concussion education program. The paired-samples t-test compares scores across time for overall scores as well as subsection scores (signs and symptoms recognition, common concussion misconceptions, and scenario-based questions). A series of multiple linear regression analyses were performed to assess hypotheses relative to how coaching characteristics and school attributes affect knowledge retention over time of high school coaches.

VII. RESULTS

A total of 50 football coaches completed the post-course assessment. Of these 50 coaches, a total of 37 coaches completed the follow-up assessment that occurred 15 weeks after the educational course. The demographic characteristics of the subjects who completed the post course and follow up assessments in this study are noted in appendix A.

A. Comparison of Assessment Scores

A 2-tailed paired samples t-test was used to assess and compare the overall and three subsection post-course and 15-week follow-up mean scores. Data analysis revealed that football coaches had significantly lower overall scores on the 15-week follow-up assessments than post-course assessments $t(36) = 5.50, p = .000, d = .90$. Additionally, paired samples t-tests were performed on the three subsection scores.

Table 1

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

Post-Course and Follow-Up Assessment Pairs	Paired Differences					t	Sig. (2- tailed)
	Mean	SD	SEM	95% CI of the Difference			
				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

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 $t(36) = 5.50$, $p = .000$, $d = .90$. 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 $t(36) = 1.36$, $p = .181$, $d = .22$. 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 $t(36) = .75$, $p = .457$, $d = .12$.

B. Coaching Characteristics and School Attributes

The researcher conducted two separate multiple regression to investigate which coaching characteristics and school attributes best predicted overall knowledge retention among football coaches. The means, standard deviations, and intercorrelations can be found in Table 2 for coaching characteristics and Table 3 for school attributes.

Table 2

Means, Standard Deviations, and Intercorrelations for Overall Knowledge Retention and Coaching Characteristic Predictor Variables (n=37)

Variables	Mean	Std. Deviation	Age	Exp	Edu	Role	Previous Concussion
Knowledge Retention	-2.08	2.302	.023	.046	.106	-.270	.352*
Age	35.97	8.742	--	.903**	.461**	-.309*	.218
Experience	12.32	8.320		--	.365*	-.246	.166
Education	2.19	.518			--	-.160	.091
Role	1.76	.435				--	.113
Previous Concussion	.189	.397					--

*p<.05; **p<.01

Table 3

Means, Standard Deviations, and Intercorrelations for Overall Knowledge Retention and School Attribute Predictor Variables (n=37)

Variables	Mean	Std. Deviation	AT Access	School Size
Knowledge Retention	-2.08	2.302	.021	.164
AT Access	.86	.347	--	.577**
School Size	3.86	1.294		--

*p<.05; **p<.01

The combination of variables to predict knowledge retention from age, experience, education, coaching role, and prior personal concussion history was not statistically significant, $F(5,31) = 2.40$, $p = .059$, although it neared significance. Examination of the data revealed that the coaching role and prior personal concussion history significantly predict overall knowledge retention when all five variables are included. The adjusted R^2 value was .163. This indicates that 16.3% of the variance in knowledge retention was explained through the predictor variables of age, experience, education, coaching role, and concussion history. The beta coefficients for coaching characteristics are presented in Table 4.

Table 4

Simultaneous Multiple Regression Analysis Summary for Coaching Characteristics Predicting Knowledge Retention (n=37)

Predictor Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	3.770	3.316		1.137	.264
Age	-.143	.103	-.545	-1.395	.173
Experience	.088	.100	.318	.881	.385
Education	.614	.770	.138	.798	.431
Coaching Role	-2.056	.869	-.388	-2.366	.024*
Previous Concussion	2.601	.927	.449	2.806	.009**

Note. $R^2=.163$; $F(5,31) = 2.40$, $p = .059$, * $p<.05$; ** $p<.01$

The combination of variables to predict knowledge retention from access to a full-time certified athletic trainer and school size was not statistically significant, $F(2,34) = 0.62$, $p = .545$.

The beta coefficients for school attributes are presented in Table 5.

Table 5

Simultaneous Multiple Regression Analysis Summary for School Attributes Predicting Knowledge Retention (n=37)

Predictor Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-3.011	1.273		-2.365	.024
Access to AT	-.737	1.370	-.111	-.538	.594
School Size	.406	.367	.228	1.106	.277

$R^2=-.022$; $F(2,34) = 0.62$, $p = .545$, * $p<.05$

The only variables that were found to influence knowledge retention were coaching role and personal concussion history. Coaches' age, experience, or level of education did not significantly influence knowledge retention in this study. Furthermore, school size or access to a full-time certified athletic trainer did not influence knowledge retention in this study.

Table 6

Coefficients for Coaching Role (n=37)

Section	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Overall	-2.056	.869	-.388	-2.366	.024*
Signs and Symptoms	-1.811	.865	-.364	-2.094	.045*
Misconceptions	-.227	.349	-.117	-.651	.520
Scenarios	-.017	.379	-.008	-.045	.964

*p<.05

Coefficients and significance values for the variable of coaching role can be found in Table 6. Examination of the data revealed that coaches' role did significantly influence knowledge retention for overall scores as well as signs and symptoms subsection scores. The following statistics supported the significance for differences in overall as well as signs and symptoms subsection assessment scores: overall scores: $t = -2.366$, $p = .024$; signs and symptoms subsection scores: $t = -2.094$, $p = .045$. These statistics support that football only coaches retained significantly more knowledge on the overall scores as well as the signs and symptoms subsection over the 15-week intermission compared to multi-sport coaches. In contrast, the statistics did not reveal a significant difference in misconception and scenario subsection assessment scores. In summary, coaching role did significantly influence knowledge retention on overall as well as signs and symptoms subsection scores but failed to influence knowledge retention on the other two subsections.

Table 7

Coefficients for Previous Concussion (n=37)

Section	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Overall	2.601	.927	.449	2.806	.009**
Signs and Symptoms	1.691	.923	.311	1.832	.077
Misconceptions	.444	.372	.209	1.192	.242
Scenarios	.466	.405	.212	1.153	.258

*p<.05; **p<.01

Coefficients and significance values for the variable of personal concussion history can be found in Table 7. Data analysis revealed that coaches' personal concussion history did significantly influence overall knowledge retention but failed to provide significance in any subsection scores. When considering the variable of coaches' personal concussion history, coaches with previous history of concussions retained a significantly greater amount of overall knowledge as compared to those coaches who have never been diagnosed with a concussion. The results did not reveal a significant difference in any subsection assessment scores.

VIII. Discussion

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 sport-related concussions for youth athletes. Although Saunders et al. (2013) and Valovich McLeod et al. (2007) used similar assessments to demonstrate a knowledge base in youth coaches and coaching education students respectively, this study's 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 (Popp & Berry, 2016).

A. Knowledge Retention

High school football coaches in this study had significantly lower signs and symptoms subsection scores on the 15-week follow-up assessments. 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. Even though these signs and symptoms were incorrectly identified 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. Coaches most often incorrectly

identified negative concussion symptoms as positive on this subsection during the 15-week follow-up assessment. 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. Although overall signs and symptoms knowledge was not retained in this study, these participants did a better job as compared to previous studies on maintaining knowledge on positive concussion symptoms. The researcher agrees with the recommendation by Saunders et al. (2013) in supporting the need for continued education to review commonly missed symptoms.

Football coaches did not have significantly lower misconception subsection scores on the 15-week follow-up assessments compared to post-course assessments. The most common misconceptions missed on both post-course and the 15-week follow-up assessments centered around the use of proper terminology. On the 15-week follow-up assessment, Misconception 4 (“There are different return-to-play criteria for suffering a “ding” and experiencing a concussion.”) was correctly answered by 67.6% of the participants; whereas Misconception 9 (“Getting your “bell rung” or sustaining a “ding” is the same as experiencing a concussion.”) was correctly answered by 73% of the participants. Both questions 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. Like Faure and Pemberton (2011), “bell ringers” were often not identified as concussions. Elimination of improper terminology was explicitly addressed throughout the online concussion education program. Coaches may be less likely to make the appropriate removal from play decision if they continue to refer to concussion injuries with antiquated terminology.

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 most commonly missed scenario question involved return to play criteria after loss of consciousness (Scenario 4). Approximately 81% of the post course participants and 75.7% of the follow-up participants correctly answered this question. In this question, the researcher inquires if a coach would ensure that a player consult with a healthcare professional prior to returning to play “if a player loses consciousness for less than one minute yet shows no symptoms after 15 minutes.” On the other hand, the researcher asks a very similar scenario question about return to play prior to a healthcare professional evaluation “if a player was to exhibit disorientation and dizziness but his or her symptoms clear within 15 minutes.” Knowledge was not only retained but also enhanced during the time between assessments, as 86.5% answered correctly on post-course assessment, whereas 97.3% answered correctly on the 15-week follow-up assessment. Both questions refer to an outdated standard of care that allowed return to play on the same day of injury. It is perplexing how coaches correctly chose not to allow a player to return to play after dizziness and disorientation but would allow the athlete to return after loss of consciousness. Although these results are puzzling, they do correlate with the signs and symptoms section as 100% of coaches identified dizziness and confusion as positive symptoms of a concussion, whereas only 86.5% identified loss of consciousness as a sign or symptom. This cohort of coaches did very similar to coaching students in the Saunders et al. (2013) study and active coaches in the Guilmette et al. (2007) study, despite the latter study using a Likert scale for answering scenarios.

B. Coaching Characteristics

The combination of coaching characteristic variables to predict knowledge retention from age, experience, education, coaching role, and concussion history was not statistically significant, although it neared significance. After performing a multiple linear regression, coaching role and prior personal concussion history predicted 16.3% of the variance in knowledge retention when all five variables are included in the model.

These results may be attributed to the ever-evolving standards of care in concussion management. Age and experience should have little influence on knowledge retention since concussion management has changed significantly over recent years. Implementation of the Louisiana Youth Concussion Act in 2011 changed many of the management practices often used by experienced coaches. Some examples of outdated management practices that were commonplace prior to the law included same day return to play and requiring loss of consciousness for a concussion diagnosis. Furthermore, experienced coaches are occasionally reluctant to accept these new management changes due to their past experiences with concussion injuries. The recognition that the variables of age and experience would not influence knowledge retention after concussion education is rational since management techniques constantly change as more is learned about this injury.

Coaches' level of education did not significantly influence knowledge retention for overall or any subsection scores. These findings agreed with Rivara et al. (2014) that level of education did not significantly enhance the ability for high school football and soccer coaches to recognize concussions. These results also make empirical sense, as education curriculums for high school coaches lack standardization relating to concussion management. The designers of these educational curriculums often focus on preparing coaches to be effective within a

classroom setting. Educational curriculums often do not dedicate the time to injury management skills for coaches because coaching is considering a secondary responsibility to teaching in a high school setting. These coaches often learn sport specific techniques and injury management through past experiences and internships. Much of the information regarding concussion management is learned on the job by high school coaches.

Coaching role (single or multi-sport involvement) did predict overall assessment as well as signs and symptoms subsection scores. Coaches who only coached football did retain significantly more knowledge on overall as well as signs and symptoms subsection than coaches who coached multiple sports. Coaching role failed to influence knowledge retention on misconception and scenario subsections. These results support the findings of Mrazik et al. (2011) who found a significant relationship between head coaching experience and concussion knowledge in hockey coaches. In our study, six of the nine football-only coaches were currently head coaches. Organizations should find avenues to educate multi-sport coaches on recognition of non-football related concussion injuries, supporting Esquivel et al. (2013) recommendation to expand concussion education for other sports besides football.

Personal concussion history did influence overall assessment scores but did not significantly influence any subsection scores. These findings support that participants with a previous history of concussions did retain significantly more overall knowledge compared to participants that have never had a reported concussion. On the other hand, personal history of concussions did not significantly assist in influencing any subsection knowledge retention scores. The results on the overall score contradicted the Saunders et al. (2013) results that concussion history did not predict current knowledge of coaching education students.

C. Barriers to Effective Education

Many perceived barriers have been identified within the literature to possibly inhibit knowledge retention after online concussion education for high school football coaches. Some of these barriers that were addressed within this study include recent changes in concussion management recommendations and the inaccessibility of full-time certified ATs. First, continual changes in concussion management techniques did appear as a possible barrier to knowledge retention within this study. The misconception subsection revealed a deficit for coaches to recognize improper terminology that many healthcare professionals have attempted to eradicate from the concussion discussion. As covered in the *Concussion in Sports* online educational program, colloquial terms such as “ding” and “bell ringers” should no longer be used when referring to a concussion injury. On the 15-week follow-up assessment, approximately one in four coaches (27%) failed to identify a “ding” or “bell ringer” as a concussion. In addition, 32% of coaches incorrectly responded that different return to play criteria were possible for a “ding” and a concussion. Both misconception questions referring to improper terminology indicated the greatest decline between assessments, even though neither of these declines were statistically significant. Furthermore, the scenario subsection indicates that some coaches may be continuing to subscribe to outdated management practices. Nearly a quarter of the coaches stated that they would not ensure a player see a healthcare professional prior to returning to play after losing consciousness for less than one minute if symptoms resolved within 15 minutes. These results indicated that some coaches within this study may not adhere to the current management techniques of SRCs that require immediate removal from play, no same-day return to play, and mandatory healthcare professional evaluation prior to return to play after any signs and symptoms occur.

Next, the inaccessibility of full-time certified athletic trainers remains another possible barrier to appropriate management of SRC by high school coaches. Nine of the 37 participants (24%) within this study incorrectly identified if access to a full-time certified athletic trainer was available at their school. This is a significant finding as seven of the nine coaches did not believe they had access to a full-time certified athletic trainer when they did have daily access according to the healthcare provider. Although the coach should always be prepared to recognize a SRC and remove an athlete from activity, the coach's responsibility significantly changes in the presence of a certified athletic trainer. While the presence of a full-time certified athletic trainer did not appear to be a barrier to knowledge retention in this study, an unidentified barrier relating to athletic trainer access was uncovered.

IX. Recommendations

This study indicated significant findings for knowledge retention for high school football coaches after online concussion education. State representatives, school districts, athletic organizations and coaches should be encouraged by this study to take a closer look at the effectiveness of the current concussion educational programming used in their region.

Based on the significance of these findings, the following recommendations are indicated.

- School districts and state associations should strive to increase access to certified athletic trainers at the secondary school level
- States may consider modifying current legislation to increase effectiveness by inserting punitive measures, such as fines, for not complying with safety legislation.
- The United States should consider drafting federal legislation regarding concussion education programs to decrease the inconsistencies between current state laws.

- Louisiana would 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 and sponsoring organizations for youth leagues could increase the frequency of educational courses beyond the minimal standard of the law
- Concussion education program developers should integrate appropriate and effective knowledge transfer techniques for coaches, including interactive delivery methods, proper terminology and reflection opportunities.
- School boards and sponsoring organizations for youth leagues should consider in-person training to augment learning that occurs during online courses
- Educators should implement reminder messages for all individuals throughout the year to act as cues to action, especially for the individuals who coach multiple sports.
- School districts and sponsoring organizations for youth leagues should also formally educate parents and athletes through regular interactions to reduce the societal barriers
- School boards and sponsoring organizations for youth leagues should identify role models within the coaching profession and include these individuals as part of the educational programming

X. 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 as well

as signs and symptoms subsection scores on the 15-week follow-up assessments compared to post-course assessments.

The findings of this study indicate several implications for the field of concussion education, the athletic training profession, and current state legislation. 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. It is imperative that states continue to strengthen the current law by establishing an authoritative agency to track compliance and issue punishments, identifying a standardized education program for each audience type, and implementing evaluative procedures to assure effective educational techniques. Further research using a larger sample size in various regions including various high school sports to assess whether similar results are obtained would be beneficial. 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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Demographics of Study's Participants

Demographic Variables	Participants ^a
Type of School	
Public	35
Private	2
Size of School (based on student enrollment)	
5A	20
4A	0
3A	9
2A	8
1A	0
Gender	
Male	37
Female	0
Age Range	20-54
Under 30	10
30-39	15
40-49	10
50-59	2
Level of Education	
High School Diploma	2
Bachelor's Degree	26
Master's Degree	9
Years of Full-Time Coaching Experience	1-31
0-5 years	9
5-15 years	16
15-25 years	10
25+ years	2
Non-Faculty CECP coach	
Yes	2
No	35
Gender of Athletes Coached	
Male Only	18
Male and Female	19
Coaching Role (Single/Multi Sport)	
Multi-Sport	28
Football Only	9
Access to Full-Time AT	
Yes	27
No	10
Previously diagnosed with a Concussion	
Yes	7
No	30
CPR Certification	
Yes	33
No	4
First Aid Certification	
Yes	21

No	16
Primary Source of Concussion Information	
Coaches' Association	7
Conferences	2
Magazines/Newspaper/TV	1
Health care professionals (Doctor/AT)	24
Other coaches	1
Internet	1
Heads Up Concussion kit	1
Other (please specify)	0

^a n=37