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BikeSafe: Evaluating a bicycle safety program for middle school aged children

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ABSTRACT

Purpose: The purpose of this study is to measure the effectiveness of a bicycle safety education curriculum for middle school age children in order to reduce the number of injuries and fatalities of bicyclists hit by cars in Miami-Dade County.
Methods: The University of Miami BikeSafe® program includes a four day off-bike middle school curriculum that follows a train-the-trainer model, where a small number of staff trains a larger group of grades 6th–8th physical education teachers from various schools to teach the bike safety curriculum to their students. Subjects in this study included 193 students from 18 classes (3 per school) at 6 selected middle schools. Measures included a knowledge assessment of the curriculum that was administered to students pre- and post-curriculum implementation. Data were collected and analyzed with school and class period examined as predictors of post-score.
Results: A significant difference ($p < .001$) was found between pre- and post-test conditions across all subjects. In addition, there was no significant difference between testing from class periods ($p > .05$), suggesting that a standard intervention was applied.
Conclusion: The BikeSafe educational curriculum was found to improve the bike safety knowledge of middle school aged children. Future efforts will focus on sustaining and expanding this program throughout Miami-Dade County and other high risk communities.

Introduction

Background

Bicycling is one of the most popular recreational outdoor activities in the United States (U.S.) with an estimated 43% of the population riding a bicycle at least once a year (Lustenberger et al., 2010). The bicycling trend in the U.S. is on the rise with bicycle sales increasing each decade along with an increase in bike share programs spreading across cities nationwide (Kennedy, 2008). With a potential shift in active transportation and a national focus to increase physical activity, it is important to address the safety issues that surround bicycling especially in children learning how to ride.

According to the National Highway Traffic Safety Administration (NHTSA), in 2009 there were 630 bicycling-related deaths in the U.S., the greatest number (107 or 17%) of these occurring in Florida (NHTSA, 2009). In 2011, Florida continued to be ranked the highest with an increase to 125 pedalcyclists fatalities (18.5%) of 677 fatalities nationwide (NHTSA, 2013). NHTSA Traffic Safety Facts from 2010 and 2011 reported that 72% and 69% of pedalcyclist fatalities, respectively, occurred in urban areas (NHTSA, 2012; NHTSA, 2013).

Nationally, one-fifth of bicycle-related injuries occur in children 15 years and younger (McLaughlin and Glang, 2010) with peak incidence of bicycling-related injuries and deaths within the age group of 9–15 years old (Kennedy, 2008). According to the National Safe Kids Campaign (NSKC), more than seventy percent (70%) of children ages 5–14 ride bicycles at a frequency of fifty percent (50%) more than the average adult bicyclist (NSKC, 2004). Given the ability for outdoor activities year round in Florida and the fatality and injury rates; there is a critical need for an effective and evaluated bicycle safety curriculum aimed at this age group. According to Lachapelle et al. (2013) there are a limited number of bicycle safety educational programs that have been evaluated and shown to be effective even though this could be a cost effective approach to increasing safety. While improvements to bicycle infrastructure are important, bicycle safety education is necessary to promote bicycle safety behaviors and prevent injuries. This is particularly important in middle school aged children, since this age group comprises a large percentage of a new bicyclist population

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reported to have one of the highest incidences of bicycle related injuries.

Proper helmet use, which includes correct fit and positioning, is a key principle to include in bicycle safety education. Correct fit and positioning has been found to reduce the risk of a head injury by 85% in falls (Lustenberger et al., 2010; NSKC, 2004; Kiss et al., 2010). Many times children and adults can be observed not wearing a helmet properly by having it positioned too far back on their head, exposing their forehead, and or having a loose chinstrap. A study by Grimard et al. (1995) examined bicycle-related head injuries in children that wore helmets and found that upon impact the helmet was lost 15% of the time, indicating that the helmet was not the right fit or positioned incorrectly. Poor helmet fit can put a child at twice the risk of head injury if they are involved in a bicycle-related crash as compared to a child whose helmet is properly fitted (NSKC, 2004; McLaughlin and Glang, 2010).

Program content

Currently grant funded by the Florida Department of Transportation (FDOT)/Safe Routes to School (SRTS) program, the BikeSafe program continues to be implemented in the MDC Department of Parks and Recreation children's programs and select grant funded schools. The BikeSafe program follows the "5E" model of education, engineering, encouragement, enforcement, and evaluation that is endorsed by the National SRTS Center. The BikeSafe curriculum knowledge assessment was conducted in the spring of 2013, the second year of implementation of the BikeSafe curriculum in MDC public middle schools.

The BikeSafe curriculum is an off-bike educational curriculum that is designed to be implemented in four (4) consecutive days over the course of fifty (50) minute class periods. The curriculum covers fundamentals of bike safety, including helmet use and fit, parts of the bike, rules of the road, behaving/riding predictably, and visibility. Each lesson is segmented into three components: an instructional component, where the P.E. teacher instructs on the key principles of the lesson; a modeling component, which involves the students being shown visual cues that model appropriate safety; and a creative component, which incorporates a physical activity or group discussion about the lesson. The curriculum format is standardized to allow for familiarity and ease with each lesson containing an overview, description of activities, and guiding questions for teachers.

Purpose

The purpose of this study was to evaluate whether the University of Miami's BikeSafe® educational curriculum is effective in increasing bicycle safety knowledge in middle school aged children. The BikeSafe curriculum utilizes a train-the-trainer model where physical education (P.E.) teachers from public middle schools across Miami-Dade County (MDC) are trained by BikeSafe staff how to implement and teach the curriculum to their students. This model allows the program to reach the largest number of children in the county, regardless of limited program resources and personnel. Because of the manner in which the curriculum is disseminated (via train-the-trainer model), this evaluation aims to examine the knowledge assessment (pre-/post-test) outcomes, hypothesizing that there will be a significant improvement from pre- to post-test scores. This educational curriculum includes teaching students many bicycle safety principles, one of the most important being proper helmet use and fit.

Methods

Participants

The study occurred from January 2013 through May 2013 and included 193 students in grades 6–8 (ages 11–14) from 18 classes (3 per school) taught by 6 different P.E. teachers at 6 MDC public schools. During post-testing, five student participants were lost due to school absences. Students were not separated by grade level as there were instances where P.E. class periods contained 6th, 7th, and 8th grade students combined; therefore grade-level effects were not analyzed in this study. All P.E. teachers participating in this study received the BikeSafe curriculum training and volunteered to allow students in three of their class periods to take the pre and post BikeSafe curriculum knowledge assessment tests. The 6 schools that participated in this study were part of a larger group of 15 schools selected by BikeSafe staff to receive the BikeSafe training and curriculum. School selection was based upon the school's proximity to locations of high bicyclist-hit-by-car (BHBC) incidents as well as recent or future planned infrastructure improvements aimed at facilitating safe and active transportation around these schools.

The P.E. teachers involved in the study assisted the BikeSafe staff by sending home consent forms for parents to sign and return, which indicated agreement of their child's participation in the study. Students who returned signed consent forms completed a pre- and post-BikeSafe curriculum knowledge assessment conducted by BikeSafe staff.

Participants were not surveyed for socioeconomic status (SES) or ethnicity; however, information from the Florida Department of Education was used to identify the percentage of minority students and students eligible for free/reduced lunch at each school. Out of the six participating schools, four qualified as Title I Schools, which receive subsidized meals before, during, and after-school. The remaining two schools did not qualify for Title I as only 71% and 10% of the students, respectively, qualified for free/reduced lunch. Title I schools are defined by the percentage of student enrollment that qualifies as being low income; the number of students on free or reduced lunch is used to quantify the percentage of low income students. The percentage of low income students at a Title I school must be at least 35% or match percentage of the district. It's mandated under Title I that schools with 75% free and reduced lunch receive funding. All six schools had a predominant minority student population, with only one school having a student population consisting of less than 90% minority students. These measures serve as a proxy for SES at the six participating schools, demonstrating that the student populations are diverse. The study was approved by University of Miami's Institutional Review Board prior to implementation.

BikeSafe program implementation

This BikeSafe curriculum has a similar structure and uses the same model as the WalkSafe program and is implemented using a train-the-trainer model; with the requirement of all participating P.E. teachers to attend a training session prior to implementation (Hotz et al., 2004). This model consists of single training session administered by the BikeSafe program manager using a PowerPoint presentation over the course of approximately 30–45 min. and provides demonstrations on the central subjects of the curriculum.

Concepts included in the BikeSafe curriculum were originally adopted from the League of American Bicyclists (LAB) certified instructor manuals and bicycle safety materials developed by NHTSA. BikeSafe staff adapted on-bike activities from the LAB manuals into off-bike activities that emphasized the principles of each lesson. The "2-finger" helmet rule was sourced from NHSTA safety documents and incorporated into the curriculum to ensure that helmet fit would be properly taught to students. Bike rodeo stations, specifically the scanning and signaling station, were adapted from the LAB manuals into a physical activity by asking students to dribble a basketball along a course and signal as if they were on a bike. These are two of the key concepts that were adapted and incorporated into the BikeSafe curriculum.

Prior to implementation in MDC public middle schools, the BikeSafe curriculum went through a one year pilot phase in which a knowledge assessment test was conducted and data was collected on student performance in middle schools and parks. P.E. teachers who piloted the BikeSafe curriculum were also asked to provide feedback. Upon evaluation, revisions were made to the curriculum and the knowledge assessment test. The knowledge assessment test included twenty-six (26) multiple choice questions, allowing for a maximum of 26 possible points, and students were asked to select the best answer (see online supplementary appendix A). Of the twenty-six (26), three of the questions were related to the "2-finger" helmet rule and asked if the helmet was seated properly on the forehead (Q1), whether the chin strap was adjusted appropriately (Q2), and whether the straps around the ears were in the appropriate position (Q3).

Data analysis

Prior to data collection, a power analysis indicated that a sample size of 198 would be sufficient to achieve 80% power to detect a 20% increase in knowledge post-intervention at a significance level of 0.05. Eleven participating students per class period, with three class periods from each of the six schools, were randomly selected for a total sample size (n) of 198. As previously stated, five students were lost during post-testing due to school absence, resulting in a total sample size (n) of 193. Prior to testing, teachers provided the BikeSafe staff with a list of student identification numbers in order to create test codes for each respective student in order to declassify participants. Each student that returned a consent form was given a BikeSafe test code that enabled matching of pre- and post-curriculum knowledge assessment tests. Pre-testing was administered between 2–7 days prior to curriculum implementation and post-testing occurred within 2–14 days after receiving the complete curriculum. All participants were provided the same instructions each time prior to testing. During each testing session, students were given an explanation of the procedure and understood that the test was not going to count for an academic grade.

Test responses were filed according to class period and school prior to being entered into Microsoft Excel. Upon completion of data collection, test code numbers and corresponding data were compiled and eleven participant codes were randomly selected from each class period to be used for data analysis. The Excel data were imported into IBM's SPSS Inc., for statistical analysis. A paired samples t-test was used to examine whether or not there was a significant difference between test scores of the total sample (all six schools) and for each individual school. Three questions regarding helmet fit were examined using McNemar's test in order to understand if there was significant change between tests. A univariate analysis of covariance (ANCOVA) was used to examine whether the main effects, interactions between the main effects, and the covariant had a significant effect on post-test scores. School and class period were the main effects that were analyzed using ANCOVA. Grade level (6th, 7th, and 8th) was not analyzed.

Results

Using a paired samples t-test, a statistically significant difference was found between pre- and post-test scores indicating there was a significant overall increase in bicycle safety knowledge (MD = 1.91, SE = 0.22), ($t(192) = 8.76$, $p < 0.01$). Table 1 below shows the results from paired t-tests conducted with the individual schools. School 3 was the only school that did not show a significant improvement (MD = 0.66, SE = 0.57), ($t(29) = 1.14$, $p = 0.26$), all other schools showed significant improvement.

Table 1
School-level comparison using individual paired t-tests[a].

School	Mean	Mean	Mean	95% Confidence interval	
	Pre-test	Post-test	Difference	Lower	Upper
1	17.72	19.09	1.38	0.41	2.34
2	17.42	19.46	2.03	1.03	3.03
3	18.00	18.66	0.66	−0.52	1.83
4	16.73	20.21	3.48	2.28	4.69
5	18.73	23.36	1.64	0.85	2.42
6	17.42	19.52	2.09	0.92	3.26

[a] Out of 26 possible points.

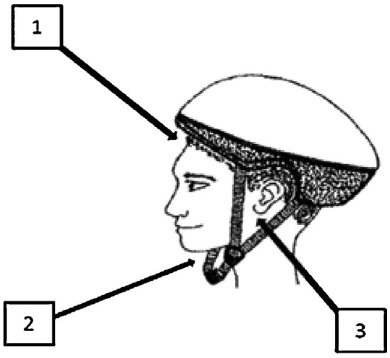
McNemar's test was performed on three knowledge assessment questions regarding helmet fit (shown in Table 2) because there was evidence showing that students improved upon completion of the BikeSafe curriculum intervention. In regards to question 1, 86 of 149 students who answered incorrectly in the pre-test, showed improvement on the post-test. Question 1 demonstrated a significant difference with a p-value < 0.001. This question asked students how far the helmet should be placed above the eye brows for adequate fit. Question 2,103 of the 147 students who answered incorrectly in the pre-test; improved on the post-test and demonstrated a p-value < 0.001 indicating there was a significant difference. This question asked students how tight the chinstrap should be and students were supposed to correctly identify the two finger rule. Question 3 asked where the "V" straps of the helmet should line up relative to the individual's ear. This question demonstrated no significant difference (p-value > 0.05) with only 35 of 72 students improving their score on the post-test and 85 students answering correctly on both the pre- and post-test.

Table 3 provides a summary of ANCOVA results. The variable "class period" was evaluated as a main effect and as a component of interactions (school × class period × pre-test score, class period × school, or class period × pre-test score). Class period demonstrated no statistically significant effect in post-test scores (F (2,157) = 1.60, $p = 0.21$). The variable "school" was found to have a statistically significant main effect ($F(5,157) = 3.02$, $p = 0.01$, $\eta p^2 = 0.09$) (independent variable). However, because there was a statistically significant interaction, post-hoc analysis were run to compare the differences between the groups. When school mean is evaluated at pre-test score of 17.66, post-test score was dependent upon which school administered the intervention.

Discussion

With mean difference between pre- and post-tests indicating a significant difference between overall test scores that confirms that the knowledge gain was a result of the curriculum. Although the schools showed varying mean differences, they all showed significant improvement with the exception to school 3. School 3 had the highest free and reduced lunch rate (96%) of the six schools and it was the only school with 100% minority rate. Socioeconomic status may have contributed to the difference between the schools, however, all the schools with the exception of school 5 had free or reduced lunch rates of 71% and higher. School 5 reported a free and reduced lunch rate of 10% but it was not one of the schools to score significantly different in the ANCOVA analysis. With that said, there

Table 2
Breakdown of helmet fit questions.



Question	Number of correct responses[a]	
	Pre-test	Post-test
How should the helmet fit where (arrow #1) is pointing?	44	124
How loose should the chin strap fit (arrow #2)?	46	142
How should the strap (arrow #3) fit when you are wearing your helmet?	121	120

[a] Responses are out of a total of 193.

is not enough information to presume that socioeconomic status was a factor for test scores.

Proper helmet use, a crucial component of bicycle safety and a major component of the BikeSafe curriculum, was surveyed in the knowledge assessment. Based on analysis using McNemar's test, it was found that there was a significant knowledge gain in two out of three test questions regarding helmet fit (questions #1–3) with students were more likely to answer questions 1 and 2 correctly after implementation. The corresponding curriculum lesson which emphasizes the two finger rule as a method for ensuring proper helmet fit demonstrated success in generating student improvement.

Although the paired *t*-test showed a significant difference between pre- and post-intervention test total scores, it was important to examine the knowledge assessment results between schools and class periods and account for these main effects and interactions.

Results showed that class period was not significant and did not impact post-test score as a main effect or as part of an interaction. This is meaningful to establish an understanding of whether or not the BikeSafe curriculum implementation is consistent. This suggests that the information taught from the curriculum did not vary drastically across class periods and student performance was not dependent on their class period.

The interaction between school and pre-test score was found to be significant. Closer examination demonstrated that even when adjusting for a pre-test score of 17.66, there remained a significant difference between schools' post-test scores. This effect could originate from various factors, including variations in teaching style and pre-existing student knowledge of bike safety.

Limitations of the study

Limitations of this study included lack of a hands-on evaluation component in which a student demonstrates bike safety skills acquired, such as proper helmet fit. This type of hands-on demonstration would verify knowledge gain and would enhance the quality of the evaluation. In addition, pre- and post-testing were not scheduled at consistent time frames and varied between schools due to scheduling conflicts out of the study team's control. Also, the curriculum implementation was not controlled by the study team and was dependent upon the teacher's lesson planning, school holidays, or standardized testing. The study team attempted to mediate this issue by collaborating with teachers to execute implementation during a time frame where there was the least amount of scheduling conflicts and by reducing the length of time between testing and curriculum implementation. While a standardized time frame for each school was not obtained, the study team was successful in limiting extensive gaps between testing and elimination. School 3 also had four participants who did not participate in the post-test, which may have affected the *t*-test scores. In the future, conducting the study in the early spring, far in advance of any national or state testing, would allow for more flexibility in scheduling and administering the curriculum and knowledge assessment across various schools simultaneously. This would also allow for a second, long-term post-test prior to the end of the school year.

Due to time constraints of the spring semester and limited staff it was not feasible to conduct testing with an entire control group. However, it is recommended that a future study involve a control group that receives a time-matched collection of traffic safety or health promotion videos to compare the outcomes between the

Table 3
Summary of ANCOVA Results.

Source	Sum of squares	Difference	Mean square	*F*	*p*-value	Partial eta squared
School × period × pre-test score	112.07	10	11.21	1.59	0.113	.09
Period × pre-test score	18.78	2	9.39	1.33	2.66	.02
School × pre-test score	88.38	5	17.68	2.51	0.03	.07
School × period	106.14	10	10.61	1.51	0.14	.09
School	106.44	5	21.29	3.02	0.01	.09
Period	22.44	2	11.22	1.59	0.21	.02
Pre-test score	300.01	1	300.01	42.62	0.00	.21

groups. To enhance the evaluation, it would also serve to include an observational component as part of the evaluation to examine for bicycle safety behavior modification. This study did not contain an observational behavior component due to limitation of staff resources. Another possible limitation to this study was that the knowledge assessment was only conducted in English. This could have had an impact in the participating children's ability to fully understand the questions and answers, especially since the schools involved in this study were composed mostly of minorities with the possibility of English being a second language.

Conclusion

The University of Miami BikeSafe program was developed to decrease the number of children injured as cyclists, improve pediatric bicycle safety, increase physical activity levels through encouraging children to bike to and from school, and improve the bikeability in and around middle schools. To date, the BikeSafe curriculum has reached over 5,000 MDC middle school students. Overall, the knowledge assessment conducted at 6 MDC public middle schools demonstrated that the BikeSafe curriculum was effective in increasing bicycle safety knowledge in participating students. It remains to be seen whether the BikeSafe curriculum will help reduce the number of pediatric BHBC incidents in MDC. Future studies will include the evaluation of whether the curriculum affects behavioral change and a longitudinal study to evaluate any decrease in pediatric BHBC incidents in the county. The BikeSafe program plans to expand its reach to all middle schools in MDC by providing training at MDC Public Schools teacher professional development workshops and encouraging teachers to implement the curriculum made available via the BikeSafe website (www.ibikesafe.us). The BikeSafe curriculum has been demonstrated as effective in improving bicycle safety knowledge in middle school aged children. It is recommended that middle school P.E. teachers in other high risk counties implement the BikeSafe curriculum to provide bicycle safety education to their students.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at http://dx.doi.org/10.1016/j.aap.2014.01.011.

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