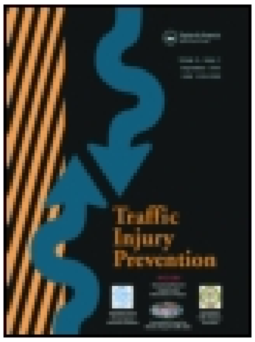

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The effectiveness of an on-bicycle curriculum on children

Bryan Pomares, Jonathan Hooshmand, Matthew Cushing, and Gillian Hotz

University of Miami, Miller School of Medicine, Miami, Florida

ABSTRACT

Objective: The objective of this study was to determine whether the BikeSafe on-bicycle curriculum affects children's bicycle safety knowledge and collect cross-sectional data on cycling beliefs and attitudes.

Methods: The University of Miami's BikeSafe program collected surveys from 286 participants, aged 7–15, in 10 Miami–Dade County Parks, Recreation, and Open Spaces summer camps from June to August 2015. Pre and post knowledge assessments were analyzed for 83 intervention group and 57 control group participants. Posttesting occurred immediately following program implementation and 2–4 weeks postimplementation.

Results: Intervention group participants demonstrated significant differences ($P < .05$) in knowledge gain between testing points, whereas control group participants did not. Participants ($n = 286$) were more likely to be encouraged to ride a bicycle by parents/guardians (61.2%) than by friends (38.1%) or schools (19.6%). Older respondents reported lower intentions of helmet use compared to the younger age group, $\chi^2(4) = 27.96$, $P < .0005$.

Conclusions: Children's bicycle safety knowledge increased following implementation of the BikeSafe on-bicycle curriculum. This study confirmed previous research on the decrease in helmet use as children get older and provided insight into how children view their parents' beliefs and attitudes relating to cycling. The findings of this study can be used to effectively target future educational and encouragement initiatives.

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Bicyclist; education; children; injury; safety; interventions; helmet

Introduction

Bicycling is a popular mode of recreation and transportation in the United States; in 2016, over 66 million people reported riding a bicycle (Nielsen Scarborough 2018). Children aged 5 to 15 account for 39% of all cyclists (Pucher et al. 2011), with 3 out of 4 children reporting riding a bicycle at least once a month (Dellinger and Kresnow 2010). However, though cyclist mortality rates in the United States have dramatically decreased over the last 40 years for children under 15 years of age (Vargo et al. 2015), unintentional bicyclist incidents were still the seventh highest cause of nonfatal injury for children aged 5 to 15 in 2015 (National Center for Injury Prevention and Control 2016).

In an effort to decrease these rates of injury, educational programs have been developed across the country to encourage and promote safe cycling to school through Safe Routes to School funding. Schools are likely one of the most effective venues for reaching children with educational campaigns, because there are few institutions with as direct an education focus or where children spend as much time. However, the majority of pediatric cycling injuries occur during the summer months (Mehan et al. 2009), when children are not typically in school. Summer recreation programs may serve as an additional venue for educational injury prevention efforts and may often allow for on-bicycle experiences that are more difficult to provide in a school setting. The on-bicycle curriculum examined in this study has been expanded and adapted from a classroom setting (Hooshmand et al. 2014) to an application in Miami–Dade County Parks, Recreation, and Open Spaces (M-DCPROS) summer camps. As a fundamental contrast with the classroom curriculum, BikeSafe provided children in the summer camps with bicycles and on-bicycle stations to practice and reinforce the essential safety concepts taught during the off-bicycle portion of the curriculum.

Although both off-bicycle and on-bicycle programs have been shown to increase participants' bicycle safety knowledge (Lachapelle et al. 2013; van Lierop et al. 2016), they do not necessarily cause changes in behaviors or attitudes (Richmond et al. 2014). Though education will be essential in long-term cycling safety initiatives, it is equally important to focus on internal and external factors that influence a child's beliefs and attitudes. Social and environmental factors, alongside attitudes about commuting behavior, have an effect on both the likelihood of cycling as transportation and the likelihood of using safe cycling practices (Azeredo and Stephens-Stidham 2003; Gielen et al. 1994; Panter et al. 2010; Thompson et al. 2002; Timperio et al. 2006).

CONTACT Bryan Pomares bpomares@med.miami.edu University of Miami, Miller School of Medicine, 1580 NW 10th Ave., Miami, FL 33136, USA.
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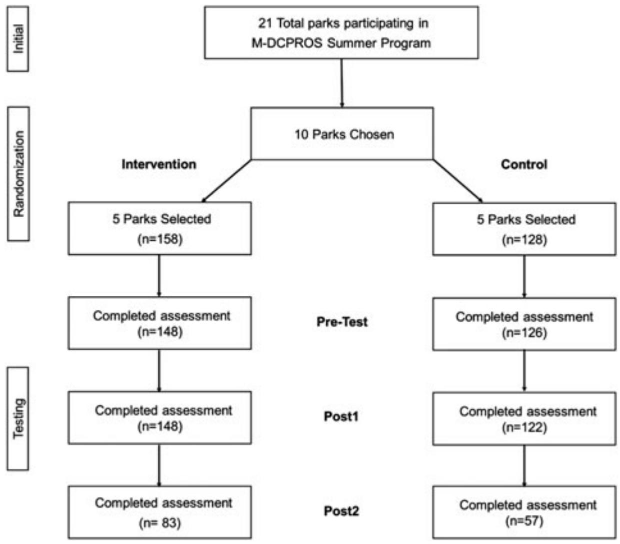

Figure 1. Flowchart of eligible parks, parks in each study branch, and number of participants in each testing point for the knowledge assessment. The differences between stages in the study process were due to participants not completing the instrument during the pretest or Post1 test or participants lost to follow-up between Post1 and Post2.

Children's attitudes toward helmet use and commuting to school are also impacted by parental perceptions (Christie et al. 2011; Panter et al. 2010), peer group interactions (Carver et al. 2005; Safe Kids Worldwide 2016), and perceptions of danger in the environment (Panter et al. 2010; Timperio et al. 2006).

This study evaluates short-term and long-term knowledge gain after implementation of the BikeSafe on-bicycle educational curriculum and reports cross-sectional data about the participants' beliefs and attitudes.

Methods

Summer parks

M-DCPROS offer summer camp programs for children aged 5 to 15 from the middle of June to the beginning of August. These summer camps engage children in activities that promote physical fitness and nutrition, with the goal of improving overall health. In the summer of 2015, 21 summer camp programs were eligible for sampling. The summer camps that were exclusively for children with disabilities were not included in the sampling. An M-DCPROS administrator scheduled the BikeSafe curriculum to be implemented at each of the 21 summer camp programs. However, only 10 camps were chosen to participate in the study (Figure 1), due to time constraints at the other camps. After completion of the study, the participants at the summer camps in the control group received the BikeSafe curriculum.

The summer camps were randomized prior to implementation, resulting in all participants at an individual camp being assigned to one of the 2 study branches. An M-DCPROS administrator conducted the randomization process, randomly assigning parks into 2 groups based on location and overall camp participants, aiming for a distribution of sites and even sample sizes. The researchers then assigned one group of parks as the intervention group and the other group as the control group.

Prior to data collection, park managers distributed consent forms to the parents of summer camp participants. Children aged 5 and 6 were excluded from participating in the study, because there were no bicycles that would properly fit them. Individuals who returned consent forms were verbally assented prior to dissemination of the instrument. Individuals who did not want to participate were excluded. The acceptance rate for the study was 94%. The University of Miami Institutional Review Board approved this study.

Instruments

The knowledge assessment used in this study was developed from a tool used in a previous study (Hooshmand et al. 2014), consisting of 16 knowledge-related assessment questions and 3 general bicycle-related questions.

Two factors were considered in the creation of the beliefs and attitudes survey: (1) The social–ecological model (Stokols 1996) and (2) a review of existing surveys in the field of cycling and pedestrian safety (Gielen et al. 1994; Panter et al. 2010). Intrapersonal factors were assessed by targeting the child's perceptions of cycling. Perception of parental and peer group's attitudes were assessed to measure interpersonal factors. In addition, questions about school encouragement of cycling and the availability of cycling infrastructure were included to measure community factors. Answers to all but one question were presented with yes/no or *always/sometimes/never* selections. Due to the age of the children, a Likert-type scale was not used. This instrument is provided in Appendix A (see online supplement).

Data analyses

Data were collected and imported into the Research Electronic Data Capture system (Harris et al. 2009) and analyzed with the R environment (Ver. 3.4.3). Outcomes were modeled by Poisson-distribution generalized linear mixed models. Intercepts by camp were used as a random variable to account for potential camp-specific effects, and each of the repeat measurements was accounted for by random intercepts for each participant. Models were selected from those that analyzed study branch and sequence of repeated measures along with potential covariates of age and gender. Models were compared by second-order Akaike information criterion (AICc). The lowest AICc was 2,033.1. Five models had AICc within 2.0 of this, making them effectively equivalent. Of these, the model with the fewest elements was chosen as most parsimonious. Analyses of the mean differences for the participants at each individual park were completed using a paired *t*-test. Pearson's chi-square test was used to determine the relationship between the knowledge assessment participants and answers to supplemental questions regarding bicycle and helmet ownership, as well as bicycle and helmet use.

For the belief and attitude questions, differences in frequencies were assessed for each of the 286 participants. Pearson's chi-square test was conducted to examine the relationship between gender and question responses and between 3 distinct age groups and question responses.

Results

Participants

Two hundred and eighty-six children in 10 M-DCPROS summer camps, ranging from aged 7 to 15 years old (mean =10.99), participated in the study, which occurred from June to August 2015. Testing occurred prior to the dissemination of the curriculum (pre-intervention), immediately after the 3-h curriculum was completed (Post1), and 2–4 weeks after the curriculum was completed (Post2). The beliefs and attitudes survey was given once, pre-intervention, to the 286 participants. Appendix B (see online supplement) shows the characteristics of the participants who completed this survey.

A total of 140 participants (Table 1) completed the knowledge assessment at all 3 testing points and were included in the data analysis for this part. Table 2 compares the characteristics of the 140 participants included in data analysis and the 134 participants lost to follow-up. Figure 1 presents a breakdown of the participants in each testing point of the knowledge assessment.

Twelve participants completed the beliefs and attitudes survey but returned a pre-intervention knowledge assessment that was less than 50% complete and were therefore not included in the data analysis for the knowledge assessment. These 12 participants originated from different summer camps and both study branches. Four participants in the control group did not complete the Post1 knowledge assessment.

The control group, which received a short NHTSA video on bicycle safety (U.S. Federal Highway Administration 2014), consisted of 57 participants. The intervention group, which received the BikeSafe curriculum, consisted of 83 participants. M-DCPROS provided county-level demographics for 2015 summer camp programs. Twenty-five percent identified themselves as white (non-Hispanic), 35% as African American black, and 40% as Hispanic.

Knowledge assessment

Participants in the control group ($n = 57$, mean age =10.63) and the intervention group ($n = 83$, mean age =11.60) demonstrated similar rates of bicycle ownership, frequency of riding, and helmet use. Overall, for the intervention group, there is a mean difference of 2.15 between the pre-intervention scores (mean score =7.77) and Post1 (mean score =9.92) and a 1.21 mean difference between pre-intervention and Post2 (mean score =8.98) scores. The control group had a mean difference of 0.28 from pre-intervention (mean score =7.61) to Post1 (mean score =7.89) and a mean difference of −0.24 from pre-intervention to Post2 (mean score =7.37). Table 3 shows the mean scores for each individual park.

Table 1. Characteristics of the participants used in data analysis for knowledge assessment, both study branches.

Study branch	Intervention ($n = 83$)	Control ($n = 57$)
Female	46 (55.4%)	24 (42.1%)
Male	37 (44.6%)	33 (57.9%)
Age	Mean =11.60	Mean =10.63

Table 2. Comparison between participants analyzed group and lost to follow-up group, both study branches.

Characteristic	Control, analyzed ($n = 57$)	Control, lost to follow-up ($n = 69$)
Age	Mean =10.63	Mean =10.01
Gender (female)	24 (42.1%)	21 (30.4%)
Ride a bicycle	51 (89.5%)	61 (88.4%)
Wear a helmet	34 (60.0%)	40 (57.6%)
Rode in past week	26 (45.5%)	38 (54.5%)
	Intervention, analyzed ($n = 83$)	Intervention, lost to follow-up ($n = 65$)
Age	Mean =11.60	Mean =11.52
Gender (female)	46 (55.4%)	38 (58.5%)
Ride a bicycle	74 (89.2%)	51 (78.5%)
Wear a helmet	42 (50.6%)	26 (39.3%)
Rode in past week	43 (51.9%)	29 (45.0%)

The changes in knowledge of intervention group participants were significantly different ($P < .05$) from the control group participants. Specifically, the final model selected was "Outcome ~ StudyBranch + Sequence + StudyBranch × Sequence" (Table 4), where "Sequence" is the order of tests/repeated tests (0, 1, 2). The model was not over dispersed. Neither StudyBranch nor Sequence were independently significant, but the interaction StudyBranch × Sequence was significant ($P = .049$). There were no knowledge differences by group at time 0. However, the distance between the 2 groups increased at each successive testing, and this increase was significant. The standard deviation of "Camp" was 0.089 and the standard deviation of individual participants was 0.127, indicating that they had (by comparison to magnitude of fixed effects coefficients) roughly proportionate contributions to Outcome as did fixed effects. Camp random intercepts were tested by parametric bootstrap, showing no significance for any single camp.

Five questions were shown to have statistically significant ($P < .05$) improvement from pretesting to Post1 (Table 5). None of the 5 questions showed a significant decrease from Post1 to Post2, suggesting that the participants retained their gains in knowledge throughout the testing periods.

Only one question showed a statistically significant increase from pre- to posttesting for the control group. Participants were able to identify the correct vocalization when they are approaching someone they need to pass. None of the other questions showed any change throughout the testing period.

Belief and attitude survey

Bicycle safety, helmet usage, and bicycle and helmet ownership

Of the 286 participants, 90.2% felt safe riding a bicycle (Appendix B). A larger amount (94.4%) knew that wearing a helmet protects their brain. However, only 61.5% of

Table 3. Results of the knowledge assessment, for each testing point and mean differences, both study branches, per park.

Study group	Park	Mean pretest ($t1$)	Mean Post1 ($t2$)	Mean Post2 ($t3$)	Mean difference $t1 \rightarrow t2$ (confidence interval)	Mean difference $t1 \rightarrow t3$ (confidence interval)
Intervention	1	8.43	10.17	9.33	1.74* (0.92, 2.55)	0.90* (0.06, 1.73)
	2	7.40	10.40	7.20	3.00* (1.76, 4.24)	−0.20 (−3.76, 3.36)
	3	7.57	10.29	9.93	2.72* (1.43, 4.00)	2.36* (0.80, 3.92)
	4	6.40	8.20	8.10	1.80 (−0.10, 3.70)	1.70 (−0.69, 4.09)
	5	6.25	9.63	7.50	3.38* (0.85, 5.90)	1.25 (−0.52, 3.02)
Control	6	6.00	7.00	6.33	1.00 (−1.48, 3.48)	0.33 (−3.46, 4.13)
	7	8.22	8.17	8.28	−0.05 (−1.29, 1.18)	0.06 (−1.00, 1.14)
	8	8.71	9.00	7.93	0.29 (−0.77, 1.33)	−0.78 (−2.09, 0.52)
	9	7.75	8.88	7.25	1.13* (0.43, 1.82)	−0.50 (−2.99, 1.99)
	10	6.00	6.07	5.93	0.07 (−0.95, 1.10)	−0.07 (−1.76, 1.62)

*$P < .005$.

participants would wear a helmet always or sometimes, with 38.5% responding that they would never wear a helmet while riding a bicycle. Further analysis shows that of the 94.4% of those who knew that wearing a helmet protects their brain, 36.4% would still not wear a helmet. Overall, only 50.5% of participants owned a helmet.

There were also differences in age groups when it came to helmet use and ownership. Participants in the older age groups felt safer riding a bicycle, χ^2 (2) = 9.702, $P = .008$, and were less likely to wear a helmet, χ^2 (4) = 27.961, $P < .0005$, than the younger age groups. Though there were no differences between genders when it came to wearing a helmet or owning a helmet, there were differences within genders by age groups. Female participants in the oldest female age group were less likely to wear a helmet than the younger female age groups, χ^2 (4) = 30.003, $P < .005$. Male participants in the oldest male age group were less likely to own a helmet, χ^2 (2) = 12.737, $P = .002$.

Cycling encouragement

The participants reported that their parents (61.4%) were more likely than friends (38.5%) to encourage them to ride a bicycle. Female participants were less likely to be encouraged by their parents to cycle as they increased in age, χ^2 (4) = 11.496, $P = .022$. Overall, there was no significant difference ($P > .05$) between genders when it came to parents/guardians allowing them to cycle by themselves.

Participants reported that they were less likely to be encouraged by their school (19.6%) than by either friends or parents, even though 61.9% of participants expressed interest in riding a bicycle to school. The 7–10 age group reported higher rates of encouragement by their school than the 11 and 12–15 age groups, χ^2 (4) = 10.144, $P = .038$.

Discussion

The BikeSafe on-bicycle curriculum was developed by following the core educational elements of the off-bicycle curriculum (Hooshmand et al. 2014) that, when tested, resulted in statistically significant knowledge increase. This study demonstrated that participants in the intervention group, who received the on-bicycle curriculum, had statistically significant knowledge improvements from pre- to Post1 and Post2, whereas those in the control group showed no improvement. The baseline results for both groups were similar, which suggests that participants had equal bicycle safety knowledge before the study began. The intervention group's improvement in score from pre- to posttesting and knowledge retention in follow-up testing suggest that the BikeSafe on-bicycle curriculum is effective at increasing cycling safety knowledge in children aged 7 to 15.

Table 4. Fixed effects of outcome sum model.

Variable	Estimate	SE	exp(est.)	Chi-square	*df*	*P*
Study branch	0.125	0.078	1.134	2.654	1	.103
Sequence	0.021	0.054	1.021	1.473	1	.225
Study branch × Sequence	−0.034	0.017	0.966	3.878	1	.049

The participants demonstrated similar improvements in this study and Hooshmand et al. (2014) regarding 2 questions on helmet fit. This demonstrates that the addition of the on-bicycle portion, where participants were required to wear a helmet, had a minimal effect on understanding proper helmet fit. However, the improvement in understanding the ABC Quick Check, the appropriate hand signal for STOP, and the correct side of the road to ride on may be attributed to the on-bicycle portion of the curriculum. This approach may benefit children who learn best kinesthetically, because it allows them to practice the material that they were taught. Nonetheless, the effect of the on-bicycle portion of the curriculum to overall improvement of these concepts needs to be further investigated.

By examining children's beliefs about helmet use and perceptions of the beliefs and attitudes of their parents, it is possible to assess where there may be room for targeted interventions to prompt significant behavioral change. For instance, interventions should weigh the need for helmet promotion initiatives versus helmet distribution initiatives for each target population. In this study, 49.5% of the participants reported not owning a helmet and 55.1% of those not owning a helmet reported that they would wear one when cycling. This may suggest that a significant population would wear a helmet if they had access to them. When the target population does not own helmets, providing helmets may have a higher impact than focusing exclusively on modeling helmet use.

Consistent with the literature (Dellinger and Kresnow 2010), older children reported wearing helmets less often than younger children. The influence of friend groups (DiGuiseppi et al. 1990; Gielen et al. 1994; Liller et al. 1998; Otis et al. 1992), social pressure from peers (Berg and Westerling 2001; Otis et al. 1992), and increased belief in the safety of cycling among older age groups (Berg and Westerling 2001; Christie et al. 2011; Dellinger and Kresnow

Table 5. Breakdown of knowledge assessment questions.

Question	Number of correct responses[a] Pretest	Post1	Post2
How should the helmet fit where (arrow #1) is pointing?	21	54	50
How loose should the chinstrap fit (arrow #2)?	38	67	60
What does "ABC Quick Check" stand for?	26	41	36
On what side of the road and in what direction of traffic should cyclists ride their bike?	42	57	47
This hand signal (STOP) tells drivers you are going to:	26	54	44

[a]83 responses in total.

2010) may be reasons for this difference. Though communitywide interventions educating children about helmet use are an effective way to increase rates of use (Liller et al. 1998), it is likely that these initiatives may have higher rates of success if they considered age and social groups. Questions that explore differences in the effect of friend groups at various ages and how this impacts helmet use should be included in future research.

The study reinforced the notion that parents play an important role in the beliefs and attitudes of their children. When targeting initiatives with significant parental involvement, it is essential to factor in the age of their children. Initiatives for parents with older children, who are allowed to ride by themselves more often, should aim to teach safety skills for riding alone. In addition, there is a need for schools to promote cycling and provide safe cycling initiatives for older children, given that participants aged 11–15 were less encouraged by their schools than the younger participants were. Initiatives for parents with children who are younger, and less likely to ride alone, may have a more significant effect by utilizing group rides, where children are given a chance to ride with supervision, such as event-oriented community rides, bicycle trains, and bicycle rodeos.

Limitations

There were differences between the intervention and control group participants for age, sex, and helmet use, both when comparing the participants in each study branch used in data analysis and analyzing between those lost in follow-up within each study branch. This may have resulted in differences in testing scores and understanding of the concepts presented in the curriculum. The knowledge assessment portion of the study would be improved with a greater sample size and less attrition. Due to the low retention from the initial date to follow-up, this study may be better suited for an environment where attendance is more consistent.

The reach of the study is another limitation. Testing locations were spread throughout Miami–Dade County and the number of participants varied per location. More uniform population sizes at each park and more detailed population data would have strengthened the analysis. Further, because this study only considered children enrolled in summer camps, the study population may not be representative of the overall population.

Given that the BikeSafe program is actively involved in education projects in both schools and other parks in the local community, children may have been exposed to cycling educational and encouragement initiatives previously, which may have influenced their attitudes and beliefs. Similarly, because the BikeSafe staff identified themselves as bicycle safety researchers, children may have been more inclined to answer the questions more positively.

Measuring parental attitudes would build upon this study, to allow a comparison between children's and related adults' perceptions. Further, given what is known about the influence of parental attitudes, it would be beneficial to identify which attitudes are shared between parent and child, rather than just assessing the child's perception of these attitudes. Future studies should include questions regarding parental helmet use and cycling behaviors, especially with an aim of comparing parental and child reports of parents' behavior.

This study had a similar limitation as Richmond et al. (2014), because it did not measure differences in injury rates before and after implementation of the BikeSafe curriculum. Therefore, though an increase in bicycle safety knowledge occurred, knowledge gains cannot be linked with changes in behavior resulting in decreased injury rates.

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