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Changes in Self-Efficacy and Outcome Expectations from Child Participation in Bicycle Trains for Commuting to and from School

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Abstract

Background: Active commuting to school (ACS) is associated with increased physical activity and lowered risk of obesity. In observational studies, ACS was associated with child self-efficacy, parent self-efficacy, and parent outcome expectations, although few experiments have assessed changes in these behavioral constructs.

Aim: This study examined the effects of a bicycle train intervention (BTI) on child self-efficacy, parent self-efficacy, and parent outcome expectations in a diverse, low socioeconomic status population.

Methods: Data was from a 2014 BTI pilot randomized controlled trial (RCT) on 4–5th graders ages 9–12, n=54, from four schools serving low-income populations in Seattle, WA. The BTI was a group of children and study staff who cycled together to/from school daily, while controls received no intervention. Responses to validated child self-efficacy, parent self-efficacy, and parent outcome expectations questionnaires ranged from 1–3. Adjusted linear mixed effects models estimated standardized coefficients for child self-efficacy, parent self-efficacy, and parent outcome expectations comparing intervention and controls from Time 1 (pre-intervention) to Time 2 (final 4–6 weeks of intervention).

Results: The intervention group had increases in child self-efficacy of 0.84 standard deviations (95% CI [0.37, 1.31]), parent self-efficacy of 0.46 standard deviations (95% CI [0.05, 0.86]), and

Conflicts of Interest:
None.

parent outcome expectations of 0.47 standard deviations (95% CI [0.17, 0.76]) compared to controls from Times 1 to 2 (all $p<0.5$).

Conclusion: A BTI improved child self-efficacy, parent self-efficacy, and parent outcome expectations, which warrants a larger RCT to examine long term changes to these behavioral constructs and ACS.

Keywords

Behavioral Theories – Social Cognitive Theory; Health Behavior; Physical Activity/Exercise; Child Health; Health Promotion – School-based; Bicycle Train; Active Transportation

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Increasing children's physical activity (PA) is a national objective in the US (Office of Disease Prevention and Health Promotion, 2010; Physical Activity Guidelines Advisory Committee, 2008). Both self-efficacy and outcome expectations have been repeatedly shown to have a strong correlation to PA in youth (Mendoza, Cowan, & Liu, 2014; Sallis, Prochaska, & Taylor, 2000; Van Der Horst, Paw, Twisk, & Van Mechelen, 2007). Since inadequate PA is strongly tied to overweight and obesity in children, and greater PA is linked to numerous health benefits (Hills, Andersen, & Byrne, 2011; Sahoo et al., 2015), it is important to understand the relationship between PA and these behavioral constructs. Self-efficacy can be defined as one's confidence in one's ability to complete an action, and outcome expectations can be defined as one's anticipated positive and negative outcomes from performing this action (Bandura, 1977). According to Bandura's social cognitive theory, perceived self-efficacy and outcome expectations directly influence whether or not a person decides to initiate a behavior and the sustainability of that behavior in the face of adversity (Bandura, 1977).

Active commuting to school (ACS) through walking or cycling is associated with higher moderate-to-vigorous PA in children and lower body mass index (BMI) z-score, waist circumference, and skinfolds (Mendoza & Liu, 2014; Mendoza et al., 2011; van Sluijs et al., 2009). Implementation of the Safe Routes to School (SRTS) program is associated with greater active transportation when compared to schools without the SRTS program (McDonald et al., 2014). Hence, bicycle trains ("Bicycle Trains," 2006), an encouragement component of the SRTS program, is a promising way to increase children's PA, but the limited research that exists has focused on the walking school bus intervention, the sister program to the bicycle train intervention (BTI). A BTI is an adult-chaperoned group of children that cycles together to and from school and picks up or drops off children along designated stops. A child's participation in ACS is associated with greater child self-efficacy (Lubans, Foster, & Biddle, 2008), parent outcome expectations (Mendoza et al., 2014), parent self-efficacy (Lu et al., 2015) and support (Haerens et al., 2008; Lubans et al., 2008), but there has been limited research on a bicycle train's effect on these behavioral constructs.

We sought to determine the effects of a BTI on child self-efficacy (the child's confidence in their own ability to cycle to and from school), parent self-efficacy (the parent's confidence in their ability to allow their child to cycle to and from school), and parent outcome expectations (the parent's anticipated positive and negative outcomes of their child cycling to and from school) in a diverse, low socioeconomic status (SES) population. The original pilot randomized controlled trial (RCT) of the BTI (Mendoza et al., 2017) reported that mean % of daily commutes by cycling increased by 44.9% (95% CI [26.8, 63.0]) and mean minutes of PA increased by 21.6 minutes/day (95% CI [8.7, 34.6]) in the intervention group compared to the control group, showing the significant impact of the BTI. We focused the present study on the behavioral constructs of self-efficacy and outcome expectations to provide preliminary results and inform a larger and longer future RCT. We hypothesized that participation in a BTI would lead to improved self-efficacy and outcome expectations, which can in turn lead to more PA among the children.

Methods

Participants

We conducted a secondary analysis of the original pilot BTI cluster RCT which took place in two waves of two schools each, i.e., May-June 2014 and October-November 2014, and full details are provided elsewhere (Mendoza et al., 2017). This trial and the present analyses were approved by the Institutional Review Board (IRB) of Seattle Children's Hospital and by the Research, Evaluation, and Assessment Office of Seattle Public Schools. These analyses focus on self-efficacy and outcome expectations as outcomes. For the BTI RCT, we recruited four Seattle Public Schools designated as federal Title 1 to participate and applied the following school-level inclusion criteria: >60% of students qualified for federal free or reduced lunches, <50% of the student body were non-Latino white students, and none had existing bicycle train or walking school bus programs. Within these schools, participants were recruited based on the following participant-level inclusion criteria: currently enrolled in the 4^{th} or 5^{th} grade (ages 9–12), ability to ride or learn to ride a bicycle, and lived within a 2-mile radius of the school or had parents who agreed to drop off the participant and bicycle within the 2-mile zone. Enrollment at each school was capped at n=15, i.e. n=60 total students for all four schools, to fit the size and staffing allowed by the grant funding mechanism. Child participants provided written informed assent and parents provided written informed consent prior to any study procedures.

Design

Prior to randomization, all participants received bicycles (provided in part by Bike Works, bikeworks.org), equipment (helmets, locks, and front/rear lights), and a 2–3 hour professional riding safety course designed for children and provided by our community partner, Cascade Bicycle Club (www.cascade.org). After participant baseline assessments were completed, schools were randomly assigned to either intervention (2 schools) or control (2 schools) conditions. Only the intervention group received the voluntary BTI where there was a designated cycling route to and from school with stops assigned based on proximity to the participants' home addresses. The schools were in low-income neighborhoods that lacked bike lanes, so the routes were generally designed to avoid busy arterial streets as much as possible. Study staff rode the route and chaperoned participants in the intervention group to and from school Monday through Friday for the 4–6 week trial, except on days with severe weather, early dismissal, or no school. These components of the BTI targeted one or more of the three constructs of interest (Table 1).

Covariates

Parents reported their children's age, sex, race/ethnicity and home address (Table 2). Their reported address was entered into the Google maps website (http://maps.google.com) to obtain the network distance from home to school using the pedestrian option. For children who lived beyond the 2-mile radius from their respective school, distance from home to school was measured from their designated starting bicycle train stop to their school. Parents also reported their perceived neighborhood disorder using the 8-item neighborhood disorder scale that measures neighborhood safety, violence, drug traffic, and child victimization with scores from 0–24 (Burdette & Whitaker, 2005; Coulton, Korbin, & Su, 1996). A Bike Score ranging from 0–100 (with 100 being best for cycling) was obtained for each participant by entering their home address into the WalkScore website (http://walkscore.com). Bike Score assesses how bike-friendly an area is based on four factors: 1) bike lanes, 2) hills, 3) destinations and road connectivity, and 4) the amount of bike commuters ("Bike Score," 2012). The developers of Bike Score based this methodology on environmental factors consistently found in their literature review and have shown an association between Bike Score and cycling behavior among adolescents and adults (Winters, Teschke, Brauer, & Fuller, 2016). Each participant's height and weight were measured at school twice by trained research staff using the Seca 214 stadiometer and the Tanita BWB-800S digital scale. If the two measurements were more than 0.2cm or 0.2kg apart, a third measurement was taken and the average of the two closest measurements were used to calculate their BMI z-score based on United States growth charts (Kuczmarski et al., 2002). BMI z-score was intended as a covariate in the original pilot study, rather than as an outcome variable, due to the brief duration of the intervention.

Survey

All child participants and parents completed a survey in the 1–2 weeks prior to randomization (Time 1) and during the final 4–6 weeks of the intervention period (Time 2). These surveys were adapted from questionnaires that assessed child and parent self-efficacy and parent outcome expectations for children's walking to school (Lubans et al., 2008; Mendoza et al., 2011; Mendoza et al., 2010), which had acceptable internal constancy with Cronbach's alpha ≥0.75 (Mendoza et al., 2010) and validity with children's active commuting to school in bivariate ($r=0.165$ to 0.182) and adjusted ($\beta=1.60$, $p<0.05$) analyses (Mendoza et al., 2011). A 3-point Likert scale was used, following the approach of previous health behavior research among diverse samples (<40% non-Latino white) with substantial numbers of low-income participants (Baranowski, Beltran, et al., 2013; Baranowski et al., 2015; Baranowski, Chen, et al., 2013). Children responded to 16 questions and parents responded to 15 questions indicating self-efficacy on a scale of 1 to 3, 1 being "Not Sure," 2 being "A Little Sure," and 3 being "Very Sure" that the child can ride a bicycle to and from school. Parents also answered an additional 14 questions on a scale of 1–3, 1 being "Do Not Agree," 2 being "Agree a little," and 3 being "Agree a lot" to positive outcome expectations (better health, being on time) and negative outcome expectations (getting lost, being unsafe) for their child riding a bicycle to and from school (see surveys in supplementary materials). Negative outcome expectations were reverse coded for analyses.

Statistical Analysis

We conducted statistical analyses using STATA 12.0 (StataCorp LP, College Station, TX) in 2016. Using the same methods as the original BTI RCT (Mendoza et al., 2017), we conducted our primary analysis using three independent linear mixed effects models (Cnaan, Laird, & Slasor, 1997; Gueorguieva & Krystal, 2004), the xtmixed command, to measure the association between the BTI and each of the outcomes of child self-efficacy, parent self-efficacy or parent outcome expectations from Time 1 to Time 2. We used a mixed effects approach due to several advantages over linear regression and ANOVA approaches (Cnaan et al., 1997; Gueorguieva & Krystal, 2004; Jacqmin-Gadda et al., 2007): (1) it is robust to error distribution misspecification and (2) it maximizes use of all available data because participants are not dropped from the analyses when missing data at a single time point. Random effects included participants (n=54), who were nested within schools (n=4), which accounts for within-child correlation and within-school correlation from Time 1 to Time 2, respectively. Fixed effects included experimental group, time point, and a group × time interaction term. Because participants were randomized to intervention or control groups, the group × time interaction term estimates how changes from Time 1 to Time 2 differ between intervention and control groups. Coefficients were standardized to show the difference in differences in terms of standard deviations. We adjusted for the following covariates (fixed effects): age, sex, race/ethnicity, BMI z-score, neighborhood disorder, distance from home to school, and Bike Score.

Results

54 participants were successfully enrolled in the study, 24 from the two intervention schools and 30 from the two control schools. Only one school did not enroll the expected 15 students, and this reflected the smaller size of the school; the other three schools had a waitlist of >40 students who fell outside of the enrollment cap. Overall, the mean age was 9.9 ± 0.7 years with 64.8% females (Table 2). 27.8% were Latino, 24.0% were non-Latino Black, 20.4% were Asian, 5.6% were Non-Latino White, and 14.8% were Other race/ethnicity. Mean child BMI z-score was 0.84 ± 1.00, mean neighborhood disorder was 15.7 ± 7.4 out of 24, mean distance from home to school was 0.8 ± 0.6 miles, and mean Bike Score was 63.2 ± 16.9 out of 100. No adverse events, such as injuries requiring medical help, were reported throughout the study.

For child self-efficacy, the intraclass correlation coefficient (ICC) was 0.003 (95% CI [<0.001, 0.13]) and Cronbach's α was 0.89. In an unadjusted linear mixed effects model, the intervention group had an increase in child self-efficacy of 0.93 standard deviations (95% CI [0.46, 1.40]) compared to the control group from Times 1 to 2. In an adjusted linear mixed effects model (Table 3), the intervention group had an increase in child self-efficacy of 0.84 standard deviations (95% CI [0.37, 1.31]) compared to the control group from Times 1 to 2. This difference was due to an average decrease in child self-efficacy of 0.43 standard deviations (95% CI [−0.76, −0.11]) in the control group and an average increase of 0.40 standard deviations (95% CI [0.05, 0.75]) in the intervention group from Times 1 to 2.

For parent self-efficacy, the ICC was 0.10 (95% CI [<0.001, 0.36]) and Cronbach's α was 0.92. In an unadjusted linear mixed effects model, the intervention group had an increase in parent self-efficacy of 0.63 standard deviations (95% CI [0.21, 1.04]) compared to the control group from Times 1 to 2. In an adjusted linear mixed effects model (Table 4), the intervention group had an increase in parent self-efficacy of 0.46 standard deviations (95% CI [0.05, 0.86]) compared to the control group from Times 1 to 2. This difference was due to an average decrease in parent self-efficacy of 0.25 standard deviations (95% CI [−0.52, 0.03]) in the control group and an average increase of 0.21 standard deviations (95% CI [−0.09, 0.51]) in the intervention group from Times 1 to 2.

For parent outcome expectations, the ICC was 0.04 (95% CI [<0.001, 0.23]) and Cronbach's α was 0.78. In an unadjusted linear mixed effects model, the intervention group had an increase in parent outcome expectations of 0.65 standard deviations (95% CI [0.33, 0.98]) compared to the control group from Times 1 to 2. In an adjusted linear mixed effects model (Table 4), the intervention group had an increase in parent outcome expectations of 0.47 standard deviations (95% CI [0.17, 0.76]) compared to the control group from Times 1 to 2. This difference was due to an average decrease in parent outcome expectations of 0.32 standard deviations (95% CI [−0.52, −0.12]) in the control group and an average increase of 0.14 standard deviations (95% CI [−0.07, 0.36]) in the intervention group from Times 1 to 2.

Discussion

Our pilot cluster RCT results show that a BTI improved child and parent self-efficacy as well as parent outcome expectations for their child cycling to and from school in the short term. These increases of 0.46 to 0.84 standard deviations were all statistically significant and consistently positive, as hypothesized. Because the intervention group had significant increases in all three outcomes, these findings warrant future research on using BTIs to improve self-efficacy, outcome expectations and ultimately PA in children.

Our findings vary in similarity to previous studies on the association between ACS and child or parent self-efficacy or parent outcome expectations, although most previous studies were observational and reported on cross-sectional associations. For example, in a cross-sectional ACS study, there was a significant association (β = 0.18) between parent self-efficacy and children's ACS (Mendoza et al., 2010). A large study on ACS conducted in Texas identified that both child self-efficacy (β = 0.16) and parent self-efficacy (β = 0.63) were significantly associated with children's ACS (Lu et al., 2015). In adjusted analyses from a walking school bus pilot RCT, parent outcome expectations were significantly associated (coefficient=1.6) with increases in children's ACS (Mendoza et al., 2011) In contrast to our results, the walking school bus pilot RCT found that child and parent self-efficacy were not significantly associated with increases in ACS, possibly due to a lack of power or alternatively that there needs to be a certain level of confidence in the child's ability to cycle but not in their ability to walk.

Child self-efficacy could serve as a mediator of the intervention on the outcome, i.e., bicycle trains improve self-efficacy, which in turn increases cycling to school and PA (Bauman, Sallis, Dzewaltowski, & Owen, 2002). Our study suggests that a BTI can be an effective way to target and improve children's self-efficacy for cycling to and from school. Future larger studies should examine self-efficacy as a mediator of the intervention on cycling to school by using rigorous mediation analytic methods (Brown, 1997; Little et al., 2007; VanderWeele, 2015). Our research also suggests that simply giving a child a bicycle and related equipment, which was the control condition in our study, is not as effective as providing a behavioral intervention that also incorporates cycling to and from school to build their confidence in cycling. In fact, child self-efficacy decreased in the control group, indicating that a child's confidence in their ability may decrease further once given the tools to cycle without being provided with adequate support to succeed.

Parental influences such as their own self-efficacy and outcome expectations for allowing their child to cycle to and from school can affect a child's PA levels, sometimes even more so than the child's own attitudes (Lu et al., 2015; Sallis et al., 2000; Van Der Horst et al., 2007). It has been shown that parental constraints due to factors such as perceived risk could lower active commuting and PA in their children (Carver, Timperio, Hesketh, & Crawford, 2016). Our study shows that a BTI could potentially improve parents' positive outcome expectations and mitigate negative outcome expectations. These findings suggest that certain components of a BTI (chaperoned, riding in a group) may address the concerns that contribute toward parental limitations on their children's ACS. Future research should further examine the role of parental support and its effects on ACS and PA in children.

Some of the limitations of our pilot study included the small sample size, which precluded using mediation analyses, and the short duration of the intervention. The outcomes of our study may not reflect those of a long-term BTI. Our results may not be generalizable to children who are not in the 4th or 5th grade or who are not of low SES. We provided bicycles and safety gear to the participants of this study, but obtaining cycling equipment could present as a barrier to joining bicycle trains for many low-SES children. Blinding after randomization was not possible due to the visible nature of the intervention. Strengths of the study included its rigorous cluster RCT design and low-SES sample, a population at high risk for inadequate PA and child obesity (Rogers et al., 2015). Finally, to the best of our knowledge, this was the first experimental BTI study.

The results of our study show that implementing BTIs in schools could be an effective way to increase PA in children. Our 4–6 week intervention showed that offering a voluntary BTI for transportation to and from school leads to improved behavioral indicators of children's cycling to and from school among parents and children. Child self-efficacy, parent self-efficacy, and parent outcome expectations may all contribute to the cycling to school behavior, ultimately leading to the increased PA seen in SRTS programs (McDonald et al., 2014; Mendoza et al., 2017), including in a BTI. Because this was a pilot study, the extent to which these behavioral constructs contribute to cycling to school should be further studied in a fully-powered RCT in which analyses could attempt to partition the effect of each construct on the behavior.

While Seattle, the city in which the pilot RCT took place, is known as a bike-friendly city, the neighborhoods in which this study was conducted had poorer infrastructure than wealthier parts of the city. Seattle also has its own barriers to cycling, including an abundance of hills and traffic, indicating that our results may be translatable to a range of other city environments. To improve generalizability, various ages, settings, distances and other factors should be examined. Further research is also needed to determine the circumstances in which bicycle trains could be most effective in the long term and with a larger sample of children. Other considerations include school siting, school resources (e.g. availability of bicycle racks), cost effectiveness, and availability of staff to supervise ACS programs. Future research should examine the sustainability of these programs and the means to ensure equitable participation in low-income communities. Bicycle trains may play a valuable role in addressing inadequate PA and childhood obesity, and it is worthwhile to determine how to successfully implement sustainable BTIs in schools.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

The components of the BTI and the constructs they targeted.

Intervention Component	Targeted Construct(s)
Riding with adult staff	Parent self-efficacy, parent outcome expectations
Riding with peers	Child self-efficacy
Designated route	Parent self-efficacy, parent outcome expectations
Daily occurrence	Child self-efficacy

Table 2.

Characteristics of child participants pre-intervention for the bicycle train pilot cluster randomized controlled trial.

	Intervention (n=24)		Control (n=30)		All (n=54)	
	n (%)	mean±SD	n (%)	mean±SD	n (%)	mean±SD
Child age (years)		9.8±0.8		10.0±0.7		9.9±0.7
Female	13 (54.1%)		22 (73.3%)		35 (64.8%)	
Race/Ethnicity						
Non-Latino White	1 (4.2%)		2 (6.7%)		3 (5.6%)	
Non-Latino Black	9 (37.5%)		4 (13.3%)		13 (24.0%)	
Latino	5 (20.8%)		10 (33.3%)		15 (27.8%)	
Asian	3 (12.5%)		8 (26.7%)		11 (20.4%)	
Other	4 (16.7%)		4 (13.3%)		8 (14.8%)	
Not Specified	2 (8.3%)		2 (6.7%)		4 (7.4%)	
Child BMI z-score		0.96 ± 0.94		0.75 ± 1.05		0.84 ± 1.00
Neighborhood disorder		17.0 ± 7.5		14.7 ± 7.2		15.7 ± 7.4
Distance from home to school (miles)		0.8 ± 0.4		0.9 ± 0.6		0.8 ± 0.6
Bike Score		67.6 ± 15.1		59.3 ± 17.7		63.2 ± 16.9

Table 3.

Adjusted linear mixed effects model for child self-efficacy (n=54)

	β Coefficient	95% Confidence Interval
Group		
Control	Reference	
Intervention	−0.33	−0.88, 0.22
Time		
1	Reference	
2	**−0.43**	**−0.76, −0.11**
Group × Time	**0.84**	**0.37, 1.31**
Age	−0.01	−0.15, 0.13
Sex		
Female	Reference	
Male	0.03	−0.20, 0.27
Race/Ethnicity		
Non-Latino White	Reference	
Non-Latino Black	−0.12	−0.66, 0.43
Latino	−0.02	−0.54, 0.49
Asian	−0.22	−0.76, 0.31
Other	−0.30	−0.85, 0.25
BMI z-score	0.07	−0.05, 0.20
Neighborhood disorder	0.007	−0.005, 0.02
Distance from home to school (miles)	−0.15	−0.36, 0.07
Bike Score	−0.001	−0.008, 0.006

Bolded = $p<0.05$

Table 4.

Adjusted linear mixed effects model for parent self-efficacy (n=54)

	β Coefficient	95% Confidence Interval
Group		
Control	Reference	
Intervention	0.02	−0.50, −0.53
Time		
1	Reference	
2	−0.25	−0.52, 0.03
Group × Time	**0.46**	**0.05, 0.86**
Age	−0.04	−0.21, 0.13
Sex		
Female	Reference	
Male	0.22	−0.06, 0.51
Race/Ethnicity		
Non-Latino White	Reference	
Non-Latino Black	−0.17	−0.82, 0.49
Latino	0.11	−0.51, 0.74
Asian	−0.07	−0.72,0.57
Other	0.03	−0.63, 0.69
BMI z-score	−0.08	−0.23, 0.07
Neighborhood disorder	−0.005	−0.02, 0.009
Distance from home to school (miles)	−0.22	−0.48, 0.04
Bike Score	0.01	−0.002, 0.02

Bolded = $p<0.05$

Table 5.

Adjusted linear mixed effects model for parent outcome expectations (n=54)

	β Coefficient	95% Confidence Interval
Group		
Control	Reference	
Intervention	−0.005	−0.58, 0.57
Time		
1	Reference	
2	**−0.32**	**−0.52, −0.12**
Group × Time	**0.47**	**0.17, 0.76**
Age	−0.05	−0.15, 0.06
Sex		
Female	Reference	
Male	0.10	−0.10, 0.30
Race/Ethnicity		
Non-Latino White	Reference	
Non-Latino Black	0.02	−0.45, 0.49
Latino	0.08	−0.37, 0.53
Asian	−0.13	−0.60, 0.33
Other	−0.13	−0.60, 0.34
BMI z-score	−0.05	−0.15, 0.06
Neighborhood disorder	−0.01	−0.01, 0.001
Distance from home to school (miles)	−0.05	−0.23, 0.14
Bike Score	0.003	−0.003, 0.01

Bolded = $p<0.05$