

# Is Safe Routes to School (SRTS) Effective to Encourage Students to Walk/Bike to School?

Jiguang Zhao<sup>\*</sup>  
Graduate Research Assistant  
Department of Civil Engineering  
Southern Illinois University Edwardsville  
Edwardsville, IL, 62026-1800  
Telephone: 618-650-2541  
Fax: 618-650-3374  
Email: [jzhao@siue.edu](mailto:jzhao@siue.edu)

Huaguo Zhou, Ph. D., P. E.  
Assistant Professor  
Department of Civil Engineering  
Southern Illinois University Edwardsville  
Edwardsville, IL, 62026-1800  
Telephone: 618-650-2533  
Fax: 618-650-3374  
Email: [hzhou@siue.edu](mailto:hzhou@siue.edu)

Word Count=145(abstract)+2800(body)+4×250(tables)+8×250(figures)=5945

\*Corresponding Author

## **ABSTRACT**

An evaluation on effectiveness of the SRTS programs was conducted with data collected before and after the implementation of the SRTS improvements at 13 schools in Hillsborough County, Florida. Descriptive Statistics indicate that the students' walking/biking rates and participants' subjective feelings towards walking/biking activity improved significantly at some schools. Those schools with significant increase on walking/biking rates have similar characteristics.

The school-level walking/biking rates and associated factors are discussed. A linear regression model is established to estimate the school-level walking/biking rates. Students' walking/biking rates is a function of weighted distance to school, weighted grade level, male student percentage, and average student family size. Other factors not included in the model, such as the walking/biking environments in the school areas, are found to play an important role as well. Model calibration results indicate the school flasher alone could increase the school-level walking/biking rates at about 3%.

## **KEYWORD**

SRTS, School-Level Walking/Biking Rate, Two-Proportion Z-Test, K-S Test

## INTRODUCTION

Traffic congestion and delay continue to be a problem for cities large and small. Studies showed that as many as 25% of morning rush-hour traffic can be school-related as automobiles are students' primary travel mode to school. Additionally, children have become less active and more overweight. The percentage of children who are considered severely overweight has tripled in the last 30 years.

The Safe Routes to School (SRTS) program is aimed at encouraging elementary and middle school students to walk or bike to school through Engineering, Education, Enforcement, Encouragement and Evaluation measures (5E). With the 2005 passage of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), the U.S. Congress designated \$612 million toward developing the National SRTS Program<sup>(1)</sup>. The program provides funds to states to substantially improve the ability of primary and middle school students to walk and bicycle to school safely.

A series of SRTS engineering and educational improvements programs were deployed in Hillsborough County, Florida, including 62 speed feedback signs in 18 elementary and 4 middle schools, 88 school flashers in 25 elementary and 9 middle schools, and educational programs in 38 elementary and 12 middle schools. Figure 1 shows the pictures of school flasher and speed feedback sign. For the 13 schools evaluated in this study, school flashers were installed in the school areas after the “before SRTS survey”.

Hillsborough County is the fourth most populous county in Florida. With a total area of 1,266 square miles, Hillsborough County has the eighth largest school district in the United States, consisting of 133 elementary schools, 42 middle schools, 2 K-8 schools, and 25 high schools<sup>(2)</sup>.



(a) School Flasher



(b) Speed Feedback Sign

**Figure 1 SRTS Improvements in Florida**

## SRTS SURVEY

To evaluate the effectiveness of the SRTS program, a before period and an after period survey was conducted. The standard survey form designed by the National Center for Safe Routes to School was adopted for the before survey. An additional question was added to the after survey to indicate the improvements around the school area.

### Before and After Period Survey

Before the implementation of those SRTS projects, a survey (denoted as “before period survey” below) on the students’ travel behavior was conducted in April 2007, at 14 schools which had applied for the national SRTS infrastructure improvement funding. To track the possible changes on student travel modes and the parental response to those SRTS projects, a second survey (denoted as “after period survey” below) was conducted at 13 of those 14 schools in April 2008, one year after the before period survey. The 13 schools that completed both the before and after period survey were included in this study.

### Student and Parent Survey

Both the before and after period survey consist of a student and a parent survey. In the student survey conducted in the classroom, teachers were asked to record how students arrived at school and their planned travel modes to home after school on three consecutive days (Tuesday to Thursday). The following information was recorded on the tally sheets distributed to the teachers: school name, survey date, class grade level, number of students enrolled in the class, weather of the weekday, and number of students with each travel mode to/from school. The parent survey was distributed as a homework assignment to the students with the following three categories of questions included: (1) questions on the student’s travel activities, such as travel modes to/from school, corresponding travel time, etc; (2) questions on student’s demographic information, such as grade level, distance to school, gender, family size and home location, etc; and (3) questions on participants’ subjective feelings/opinions on students’ walking/biking activities, such as school /child’s attitude, their feeling on fun, enjoyment and health of the activity, etc.

### Sample Size

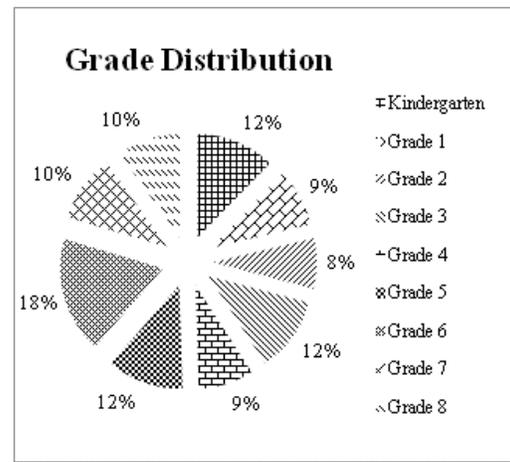
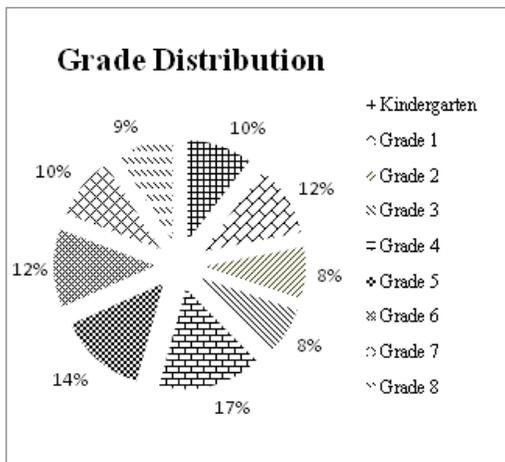
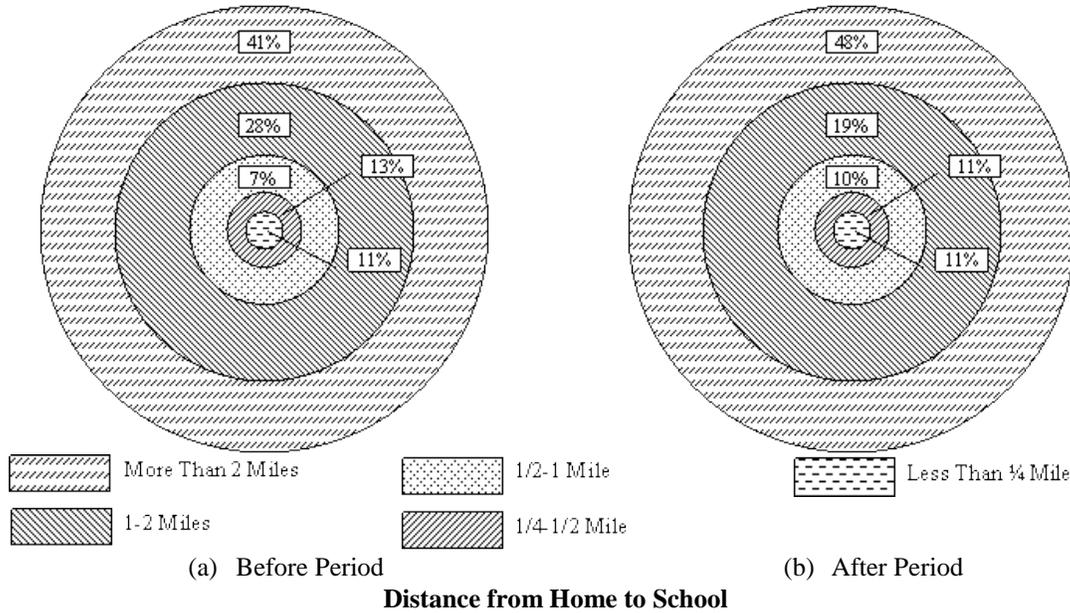
A total of 1,124 student survey forms and 19,386 parent survey forms were distributed in the before and after period survey, among which 797 student survey forms and 3,378 parents survey forms were returned<sup>(3), (4)</sup>. Table 1 summarized the sample size and response rate in the before and after period surveys.

**Table 1 Sample Size in the Before and After Period Survey**

Survey Period	Student Survey				Parent Survey		
	# of Survey Forms Distributed	# of Survey Forms Returned	Response Rate	# of Trips Recorded	# of Survey Forms Distributed	# of Survey Forms Returned	Response Rate
Before	457	383	84%	22,755	12,318	2,978	24%
After	635	381	60%	16,850	7,068	800	11%
Total	1,124	797	-	39,605	19,386	3,778	-

**Sample Distribution**

A one-year interval existed between the before and after period survey. Students surveyed in the after period were not exactly the same as that in the before period. Only when samples in the before and after periods were extracted from the same population could the students' walking/biking activity in the before and after period be compared. To see whether the two samples belong to the same population, the sample distribution on grade, gender, number of students in the family and distance from home to school were calculated, as shown in Figure 2.



(a) Before Period

(b) After Period

**Grade Level**



**Figure 2 Distribution of Sample Students in the Before and After Period**

The Kolmogorov-Smirnov test (K-S test) was applied to test whether the two samples were extracted from the same population. The K-S test is used to test whether two underlying probability distributions differ, or whether an underlying probability distribution differs from a hypothesized distribution; in either case probability is determined based on finite samples.

Test results indicated that no evidence existed against the hypothesis that the two samples were extracted from the same population, which justified the comparison between the before and after period.

## METHODOLOGY

### Two-Proportion Z-Test

The two-proportion Z-test was used to compare whether there was statistically significant difference between two proportions created by two random samples. Suppose the sample size was  $n_1$  and  $n_2$  respectively. Let  $X_1$  and  $X_2$  stand for the number of interested

members correspondingly, the  $Z$  values could be determined with the following equation<sup>(5)</sup>:

$$Z = \frac{p_1 - p_2}{\sqrt{p(1-p)\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} \quad (1)$$

in which,  $p_1 = \frac{X_1}{n_1}$ ,  $p_2 = \frac{X_2}{n_2}$  and  $p = \frac{X_1 + X_2}{n_1 + n_2}$ .

In the two-proportion  $Z$ -test, a threshold  $Z$  value is paired with each given significance level  $\alpha$  ( $Z_{\frac{\alpha}{2}}$  for two-tail test and  $Z_{\alpha}$  for one-tail test). Only when the calculated  $Z$  value

is greater than the threshold  $Z$  value were the two proportion values significantly different at the given significance level. One basic assumption for the two-proportion  $Z$ -test was that  $X_1$ ,  $X_2$ ,  $n_1 - X_1$  and  $n_2 - X_2$  should all be greater than 5.

### Linear Regression Model

Linear Regression estimates the coefficients of the linear equation that involves one or more independent variables that best predict the value of the dependent variable. The basic assumption for linear regression is that for each value of the independent variable, the distribution of the dependent variable must be normal, and the variance of the distribution of the dependent variable should be constant for all values of the independent variable. Also the relationship between the dependent variable and each independent variable should be linear, and all observations should be independent.

## DATA ANALYSIS AND RESULTS

### Walking/Biking Rates in the Before and After Period

To evaluate the effectiveness of the implemented SRTS projects, the walking/biking rates and participants' subjective opinions towards walking/biking in the before and after periods was compared. Table 2 listed the students' walking/biking rates at each school. On average the students' walking/biking rate was 4% before the SRTS improvements and increased to 7% in the after period.

Due to the limitation on sample size, the two-proportion  $Z$ -test was not implemented for school 4 and 6. At the confidence level of 90%, the walking/biking rates at schools 2, 3, 5 and 10 increased significantly after the SRTS projects, as underlined in Table 2. There is no significant increase at the schools 1, 7, 8, 9, 11, 12, and 13. However, the overall average students' walking/biking rate increased significantly after the implementation of the SRTS projects at the confidence level of 90%.

**Table 2 School Level Walking/Biking Rates in the Before and After Period**

School Name	Before Period			After Period		
	# of Walking /Biking	Total Trip	Walking/ Biking Rate	# of Walking /Biking	Total Trip	Walking/ Biking Rate
School 1	190	3,456	5%	94	1,790	5%
<u>School 2</u>	<u>150</u>	<u>3,838</u>	<u>4%</u>	<u>136</u>	<u>2,802</u>	<u>5%</u>
<u>School 3</u>	<u>209</u>	<u>4,829</u>	<u>4%</u>	<u>420</u>	<u>3,777</u>	<u>11%</u>
<i>School 4*</i>	<i>167</i>	<i>3,376</i>	<i>5%</i>	<i>0</i>	<i>1,341</i>	<i>0%</i>
<u>School 5</u>	<u>121</u>	<u>3,112</u>	<u>4%</u>	<u>587</u>	<u>2,024</u>	<u>29%</u>
<i>School 6*</i>	<i>105</i>	<i>2,321</i>	<i>5%</i>	<i>0</i>	<i>1,821</i>	<i>0%</i>
School 7	16	2,330	1%	12	3,173	0%
School 8	183	4,112	4%	29	2,367	1%
School 9	242	5,374	5%	124	3,765	3%
<u>School 10</u>	<u>81</u>	<u>2,644</u>	<u>3%</u>	<u>707</u>	<u>3,053</u>	<u>23%</u>
School 11	91	2,703	3%	50	2,669	2%
School 12	81	1,479	5%	90	1,640	5%
School 13	185	4,391	4%	104	2,849	4%
<u>Total</u>	<u>1,821</u>	<u>43,965</u>	<u>4%</u>	<u>2,353</u>	<u>33,071</u>	<u>7%</u>

Note: \* Samples italicized don't meet the requirement for two-proportion Z-test.

### Subjective Opinions

The subjective opinions of those participants involved on students' walking/biking activities including students, the schools and their parents in the before and after periods were compared as well. The following aspects on subjective opinions were considered: (1) Whether the students' school encouraged the walking/biking activities (abbreviated as "School Encourage" below); (2) Whether the parents thought it healthy to walk/bike to school (abbreviated as "Health" below); (3) Whether the students enjoyed the walking/biking activity (abbreviated as "Fun" below); (4) Whether the parents received walking/biking permission request from their child (abbreviated as "Permission Request" below); and (5) Whether the parent allowed their child to walk/bike to school alone (abbreviated as "Allowance on Walking/Biking Alone" below).

The percentage values of positive subjective opinions towards walking/biking in the before and after period at 13 schools are listed in Table 3. The two-proportion Z-test indicated that at the confidence level of 90%, the percentage value on "school encouragement" at school 4 and 5, "permission request" at school 1, 2 and 7, "fun" at school 5, and "allowance on walking/biking alone" at school 5 and 7 increased after the SRTS projects, as underlined in Table 3. On average the "school encouragement" increased significantly after the SRTS projects at the confidence level of 90%, as underlined in Table 3. The two-proportion Z-test wasn't conducted on some of the items italicized for failure to meet the requirement of minimum sample size.

**Table 3 Percentage Value with Positive Feelings towards Walking/Biking**

School Name	School Encouragement		Health		Fun		Permission Request		Allowance on Walking/Biking Alone	
	Before	After	Before	After	Before	After	Before	After	Before	After
School 1	5%	0%	68%	25%	46%	50%	12%	20%	31%	24%
School 2	5%	7%	70%	78%	45%	43%	13%	45%	31%	39%
School 3	13%	-*	75%	-*	30%	-*	42%	30%	37%	32%
School 4	5%	13%	70%	69%	47%	22%	12%	9%	31%	35%
School 5	12%	24%	84%	77%	24%	38%	41%	37%	35%	62%
School 6	5%	50%	72%	56%	49%	22%	9%	4%	36%	8%
School 7	4%	16%	69%	72%	33%	37%	7%	19%	7%	28%
School 8	6%	-*	70%	-*	46%	-*	12%	17%	31%	17%
School 9	16%	33%	74%	73%	31%	38%	48%	19%	43%	28%
School 10	12%	-*	76%	-*	30%	-*	47%	41%	51%	51%
School 11	5%	20%	71%	17%	47%	71%	12%	13%	32%	25%
School 12	5%	7%	71%	67%	45%	25%	12%	14%	34%	21%
School 13	6%	6%	71%	73%	47%	44%	11%	16%	32%	34%
Total	8%	14%	72%	71%	39%	35%	22%	23%	33%	33%

Note: \* No results were returned from the school.

### School-Level Walking/Biking Rate Analysis

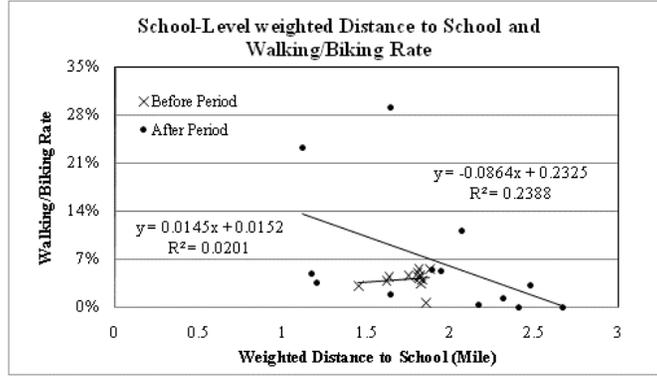
The SRTS improvements, including engineering, education, encouragement, etc, were commonly implemented at school level. To help maximize the benefit/cost ratio, it's crucial to select proper SRTS improvements for candidate schools when planning SRTS programs in the future. The purpose of this study is to determine those factors significantly associated with the schools' walking/biking rates by investigating the relationship between schools' walking/biking rates and some school-level factors, including demographic factors of students in the school (such as distribution of distance from home to school, age, gender, etc), social-economic and environmental factors in the school areas, etc. The results could facilitate to deploy the proper SRTS improvements for candidate schools in the future.

#### *Distance to School*

To investigate the impact of distance on walking/biking rate, the distribution of distance was converted to Weighted Distance (WD), which was defined as following:

$$WD = \frac{\sum_{i=1}^5 D_i n_i}{\sum_{i=1}^5 n_i} \quad (2)$$

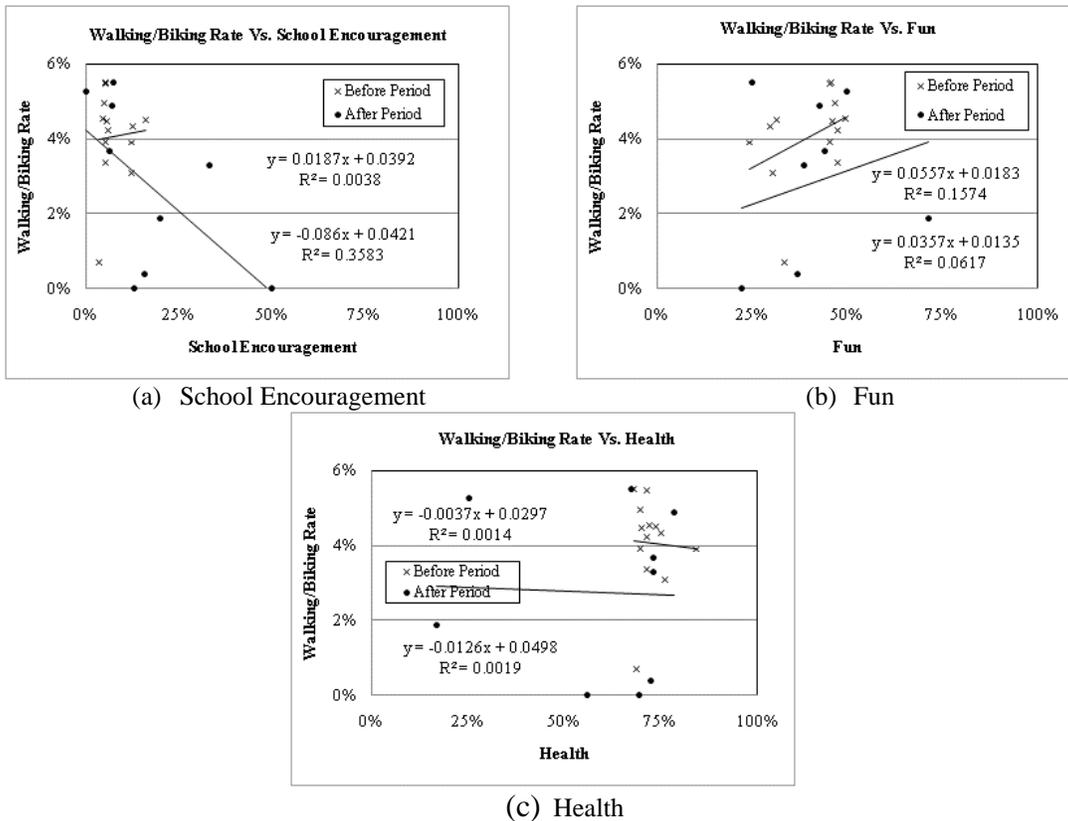
in which,  $i$  is the distance level ( $i=1$  for less than  $\frac{1}{4}$  mile,  $2$  for  $\frac{1}{4}$  -  $\frac{1}{2}$  mile,  $3$  for  $\frac{1}{2}$  -  $1$  mile,  $4$  for  $1-2$  miles and  $5$  for more than  $2$  miles);  $n_i$  is the number of students in distance level  $i$ ; and  $D_i$  is the average distance in distance level  $i$ , that is,  $D_1=1/8$ ,  $D_2=3/8$ ,  $D_3=3/4$ ,  $D_4=3/2$  and  $D_5=3$ , with unit in mile. The relationship between school-level walking/biking rates and weighted distance was plotted in Figure 3.



**Figure 3 Walking/Biking Rates and Weighted Distance to School at School Level**

*Subjective factor*

Students’ walking/biking activities were associated with subjective feelings/opinions as well<sup>(3), (4)</sup>. The relationship between school-level walking/biking rates and percentage of participants with positive opinions towards the walking/biking activity at school level, such as “school encouragement”, “fun” and “health” is plotted in Figure 4, which indicates that “fun” was linearly related with school-level walking/biking rates.



**Figure 4 School-Level Walking/Biking Rate and Other Factors**

*Grade level*

Grade level is another important factor that determined the walking/biking rate at each school<sup>(3), (4)</sup>. The walking/biking rates at middle school are expected to be higher than that

of elementary school had all the other factors been exactly the same. Even among middle schools, those with more upper grade level students are also expected to have higher walking/biking rates had all the other factors been exactly the same. To quantify the impact of grade level, the Weighted Grade (WG) level is introduced here. The weighted grade level is defined as following:

$$WG = \frac{\sum_{i=K}^8 (i+1)n_i}{\sum_{i=K}^8 n_i} \quad (3)$$

in which,  $i$  is the grade level ( $i=0$  for kindergarten) and  $n_i$  is the number of students in grade  $i$ . Figure 5 plots the relationship between the school-level walking/biking rates and schools' weighted grade level.

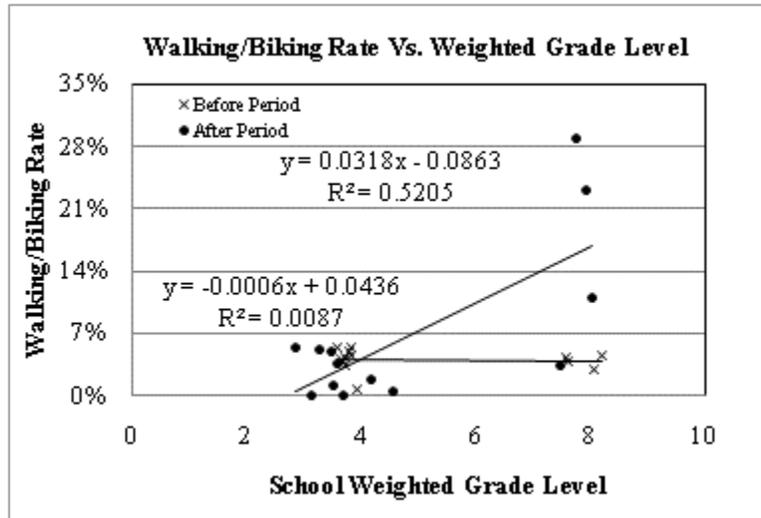


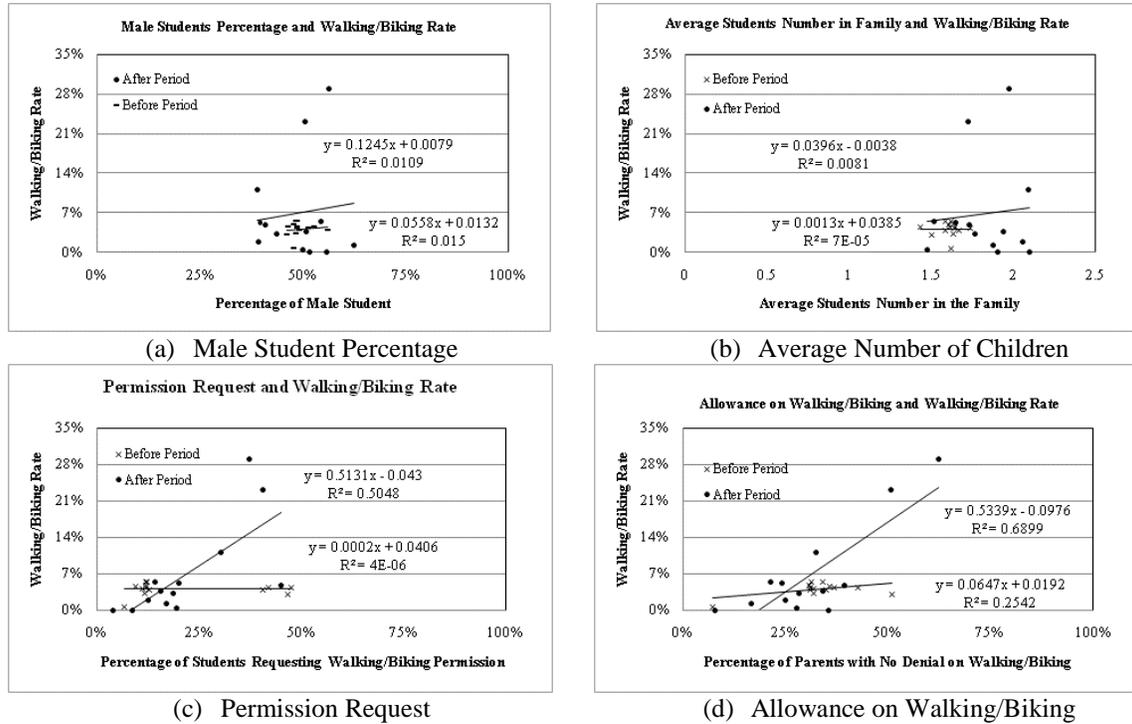
Figure 5 Walking/Biking Rate and Weighted Grade Level

*Other Factors*

Further analysis indicates that school-level walking/biking rates are also associated with some factors, such as male student percentage, average number of children in the family, percentage of students requesting walking/biking permission, and percentage of parents that allowed the walking/biking activities. These results are plotted in Figure 6.

# Is Safe Routes to School (SRTS) Effective to Encourage Students to Walk/Bike to School?

Zhao Jiguang, Zhou



**Figure 6 School-Level Walking/Biking Rate and Associated Factors**

## Linear School-Level Walking/Biking Rate Model

To predict the school-level walking/biking rate, a linear regression model was established with factors mentioned above. A dummy variable was designed to consider the impact of SRTS improvements (for example, school flasher in this study). To avoid counting the impact of improvements repeatedly, those subjective factors were not included in the model (for example, parents would be more likely to let child walk/biking to school after the SRTS engineering or educational programs).

$$y = a_0 + a_1x_1 + a_2x_2 + a_3x_3 + a_4x_4 + a_5x_5 \quad (4)$$

where,  $y$ - School-level walking/biking rate;  
 $x_1$ - Weighted distance from home to school;  
 $x_2$ - Male student percentage;  
 $x_3$ - Average number of children in the family;  
 $x_4$ - Weighted grade level;  
 $x_5$ - Dummy variable for improvement (0 for before period and 1 for after period).

The model was calibrated with the data collected in the before and after period survey, as shown in Table 4. Only 26 observation values were included (13 from the before period and 13 from the after period respectively). Better performance could be expected when the sample sizes are enlarged.

The model coefficient value indicated that, at school level, the walking/biking rate will increase with increase on weighted grade level, male student percentage and average children number in the student family; and on the other side, will decrease with increase on weighted distance. The school flasher alone could increase the walking/biking rates at about 3%. This model could be used to estimate the school-level walking/biking rates

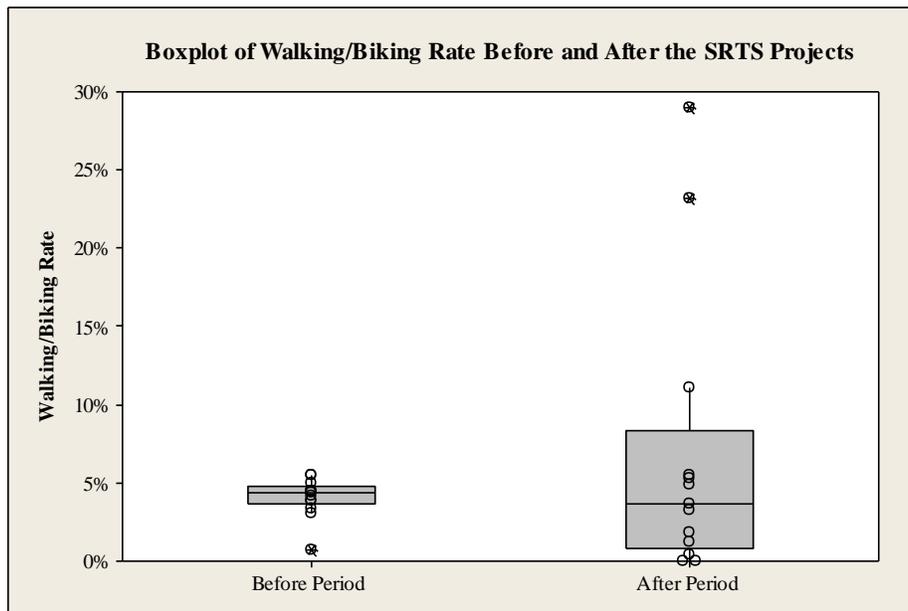
with fundamental student information available and predict the school-level walking/biking rates after the implementation of certain SRTS programs.

**Table 4 Coefficient Value of School-Level Walking/Biking Rate Model**

Model Parameters	$a_0$	$a_1$	$a_2$	$a_3$	$a_4$	$a_5$	$R^2$
Coefficient Value	-0.048	-0.074	0.205	0.038	0.012	0.031	0.435
Significance Level	0.763	0.029	0.317	0.610	0.048	0.267	

### Effects of Walking/Biking Environments

Results in Table 2 indicated that the walking/biking rates increased significantly at school 2, 3, 5, 10 and on average level at the confidence level of 90%. It was also observed that the walking/biking rates were extremely high at some schools, as plotted with the boxplot in Figure 7. To help provide guidance for future SRTS projects, besides those schools with significant increase on the walking/biking rate, those schools with relatively higher walking/biking rates should also be investigated to find out the real reasons that contributed to the high walking/biking rates.



**Figure 7 Distribution of the Walking/Biking Rate in the Before and After Period**

This section explores the relationship between school-level walking/biking rate and the walking/biking environment in the school area, which include connectivity of the roadway network, traffic volume/speed, residential density, and numbers/length of the pathways and sidewalks, etc.

Those school areas well interconnected by connectors and local roads, no separation from the adjacent residential communities by any interstate highways or major arterials, consisted mainly of roadway with function of accessibility, bearing only low traffic volume/speed, and located adjacent to large residential communities would favor the walking/biking activity, as shown in Figure 8 (a) and (c). High walking/biking rates, or with a significant increase on walking/biking rates had the before period rates been relatively low, were observed in these school areas, such as school 2, 3, 5, 10 and 13.

On the contrary, high traffic volume/speed, discontinuous sidewalk/pathway, low residential density along roadway, etc, would degrade the walking/biking environment and lower the school-level walking/biking rates, as shown in Figure 8 (b) and (d). In this study, the observed walking/biking rates were extremely low in schools with these properties, such as schools 4, 6 and 7. Conclusively, favorable walking/biking environments could help achieve better performance for the SRTS improvements.



**Figure 8 Walking/Biking Environments in School Areas**

## CONCLUSIONS AND RECOMMENDATIONS

An evaluation on effectiveness of the SRTS programs was conducted with the data collected before and after the implementation of the SRTS improvements. Statistical results indicated that the students' walking/biking rates and participants' subjective feelings towards the walking/biking activity improved significantly at some schools. Properties of those populations with significant increase on walking/biking rates were discussed as well. The survey results also indicated that although the improvements proved to be effective in some schools, there were still quite a few schools where no significant change in the walking/biking rate was observed. To increase the walking and biking trips to/from school, except for the school flashers and speed feedback signs, more effort should be made to build the walking/biking facilities and have better connections from home to school.

To help select proper improvements for candidate SRTS schools when planning SRTS in the future, the school-level walking/biking rates and its associated factors were discussed. A linear regression model was finally established to predict the school-level walking/biking rates. Schools with higher weighted grade level, higher percentage of

male students, and large student family size would achieve higher walking/biking rates. The walking/biking environments in the school areas were also found to play an important role. A school-level walking/biking rate predicting model with the walking/biking environmental factors included would be developed in the future.

Some drawbacks on data collection were also found to impede further analysis on decisive factors of the students' walking/biking activities. To investigate the students' walking/biking activity and the effectiveness of SRTS improvement, it's highly recommended to ensure the accuracy and consistency of the survey results by tracking and comparing the students' travel activities in the before and after period respectively.

## **ACKNOWLEDGEMENT**

The research was funded by the Florida Department of Transportation, District 7 under the Federal SRTS Programs. The authors wish to thank previous CUTR student research assistant Christopher Gonzalez and previous program assistant Jing Liu for their assistance with data collection. The authors would also like to show gratitude to FDOT District 7 official Peter Hsu and Jeannette Rose for their advice and support during the project.

## **REFERENCE**

1. Pedestrian and Bicycle Information Center. *Introduction to Safe Routes to School: the Health, Safety and Transportation Nexus*.
2. [Http://en.wikipedia.org/wiki/Hillsborough\\_County,\\_Florida#Education](http://en.wikipedia.org/wiki/Hillsborough_County,_Florida#Education), accessed on March 15, 2009.
3. Zhou H., J. Zhao. *Evaluation of the SRTS Projects in Hillsborough County: Based on a Before-and-After Survey*. Center for Urban Transportation Research, University of South Florida, 2008.
4. Zhou H., J. Zhao. *A Safe Routes to School Survey in Hillsborough County*. Center for Urban Transportation Research, University of South Florida, 2007.
5. Walople R.E., R. H. Myers, S. L. Myers and K. Ye. *Probability & Statistics for Engineers & Scientists (Eighth Edition)*. Pearson Prentice Hall, 2007.