

## Article

# School Walk Zone: Identifying Environments That Foster Walking and Biking to School

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**Abstract:** Today, few children walk or bike to school. According to the National Household Travel Survey, only 11% of children walk or bike to school. In 1969, almost 50% of children walked or biked to school in the US. Although our understanding is limited, previous research has shown that physical environments can influence non-automobile mode choices for travel to school. For example, landscape buffers and trees affect parents' perceptions of their children's safety and increase their willingness to let their children walk to school. We investigated how a number of physical attributes in the pedestrian environment influence children's commutes to school. A total of 186 parents from four school walk zones in College Station, TX, participated in this study. We found that children walked more in neighborhoods with mature trees. Moreover, the mean walking and biking distances differed from each other, and both were influenced by the location of the school within the walk zones. Concerns about traffic safety and convenience were negatively related to walking and biking. The findings here suggest ways to shape better school walk zone guidelines that include neighborhood design, planning, and engagement in support of active and healthy children.

**Keywords:** commute to school; children's health; school walk zone; pedestrian environments; walking and biking to school



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## 1. Introduction

Today, few children walk or bike to school. According to recent data from the National Household Travel Survey, around 11% of children walk or bike to school [1]. This figure has not changed in about 10 years. In 1969, almost 50% of children walked or biked to school in the United States [2]. Walking and biking to school involves physical activity, while riding in cars or buses is a sedentary activity. This begs the questions of what current factors influence children's travel modes to school and what important health implications are related to these different travel modes. If it is possible to increase walking and biking by reducing real or perceived barriers to choosing these options, then it may be possible to increase the health benefits in children.

### 1.1. Childhood Obesity

Child obesity is a serious public health problem in the United States. Obese children can experience high blood pressure and type 2 diabetes. These health outcomes are on the rise and are linked with increases in childhood overweight and obesity [3]. Between 2017 and 2020, the prevalence of obesity among children and adolescents aged 2 to 19 was about 19.7% and was affecting about 14.7 million people. Obesity in children increases with age; the prevalence is 12.7% for ages 2 to 5, 20.7% for 6 to 11, and 22.2% for ages 12 to 19 years old [4]. A dire warning was forecast in 2016 that the number of obese children could reach 91 million globally in 2025 if there is no policy intervention [5]. Unfortunately, World Obesity, in its "Obesity: Global Goal Missing for 2025" report, estimated that 205.5 million

children aged 5–19 will be affected by obesity by 2025, exceeding previous projections [6]. Overweight and obesity in childhood can increase the probability of obesity in adulthood and the risk of mortality in adulthood [3,7,8].

In many previous studies, it was shown that physical activities such as walking and biking can reduce obesity in children. When compared with those who continued to use private transport, children who switched to walking or cycling had less body fat (0.55% less, on average) and a lower BMI (0.21 kg/m<sup>2</sup> less, on average) [9]. As one way to prevent childhood obesity, experiencing walking or biking to school every day from an early age can be effective [10,11]. Although the study sample was small, Napier et al. found that students who walked to school were significantly associated with lower BMI [12]. Students who were engaged in “Active commuting to school” programs during childhood were more likely to continue their travel habits [1].

### 1.2. School Walk Zones

A school “walk zone” or “no-transport zone” is the area in which publicly funded school bus transportation is not provided [13]. Texas, along with many other states, established 2-mile school walk zones measured by the nearest practical route from the attended school [14]. Texas also has hazardous street legislation that provides publicly funded school bus transportation to children living within two miles of the school they attend who would be subjected to hazardous traffic conditions if they walked to school [14]. As a result, children who live within 2 miles of their school, without any hazardous streets, are left to commute by walking, biking, or riding in a car.

Even though this legislation suggested that two miles was a walkable distance for children to walk to school, it is difficult to find research or logical reasoning that supports a prescribed walking distance for children to walk to school. One previous study indicated that children who lived less than 800 m (0.5 mile) from their school were more likely to actively commute [15].

### 1.3. Factors Influencing Walking and Biking to School

Children’s school commute mode choice is affected by diverse factors. For example, at the individual level, boys and older-aged children were positively associated with walking or biking [16–18]. From a socioeconomic point of view, children of families with higher incomes and more vehicles per capita were not likely to walk [17,19]. On the other hand, in the study of Kelly and Fu (2014), students with siblings and whose families had lower rates of car ownership were more likely to walk to school [20].

Moreover, perceptions of the physical environment can affect children’s walking or cycling. Parents’ concerns over long distances to school, weather, convenience, and unsafe environments (the presence of one or more dangerous crossings, traffic volume around the school, and no lights or crossings) were all negatively associated with children’s walking or biking [15–17,21]. In addition, landscape buffers and trees added to parents’ perceptions of their children’s safety and increased their willingness to let their children walk to school [22]. At a micro level, streets with low residential density and a single land-use category, the existence of a cycle path, speed limits of 30 km/h, and a hedge separating the cycle path from motorized traffic were perceived as the most photographed settings for biking [23]. Parents’ perceptions of environmental attributes such as the sidewalk condition and shade-casting street trees were moderately associated with children’s walking or biking [24,25]. Safety was a major concern for parents who let their children walk or bike because children can be exposed to a higher risk of traffic-related danger [26–29]. Car crashes involving children as pedestrians and cyclists, as well as single-bicycle crashes, could have fatal consequences [30,31]. According to the National Highway Traffic Safety Administration (NHTSA) in the United States, in 2020, of the 1093 children under 14 years old who were killed in traffic crashes, 16% (177) were pedestrians and another 4% (48) were cyclists. The data showed that after school (noon–5:59) during weekdays the rates of child pedestrian and cyclist fatalities were considerably higher than in the dark or early in the morning [32].

Although both pedestrian crashes and bicycle crashes were associated with several non-infrastructure attributes (e.g., the types of vehicles, driver and bicyclist behaviors, and weather), one critical factor, the built environment, including right-of-way design, road maintenance, and roadside objects, was frequently highlighted [19,25,31,33].

Distance acts as a critical factor in determining whether children walk or bike to school [12,18,19,28,34–37]. Proximity to school was an important predictor for girls walking to/from school, as was the child-perceived convenience of walking (e.g., without crossing busy roads, low traffic, etc.) [37]. Timperio et al. (2006) found that children were more likely to engage in an active commute to school when the distance to school was less than 800 m [15]. In other studies, children tended to walk or cycle more when they lived within 1 km of school [16,36]. In a study by D’Haese et al., it was suggested that 1.5 km from school was a feasible distance for walking and 3 km was a feasible distance for biking [38]. Kelly and Fu suggested 2 km as a “splitting line” for children to switch school commute mode instead of walking through an analysis using both GIS and census data [20].

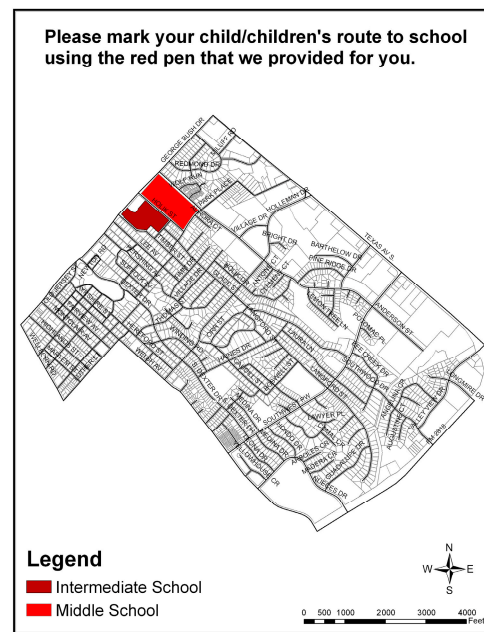
Studies also suggested that there was a consistent association between children’s walking or cycling and the physical environment. Intersection density (or other measures of street connectivity) was found to be one of the most frequently mentioned factors affecting children’s active travel to school [24,39]. Higher rates of walking were associated with lower traffic density, whereas greater land-use mix had negative effects [18]. Land-use mix, on the other hand, was positively associated with girls’ walking/cycling in a longitudinal study [40]. The presence of street trees and sidewalks were raised as other factors that were positively associated with walking or biking to school [19,34,41]. Meanwhile, certain environmental factors also influenced child-related walking and biking in the opposite direction, i.e., intersection density, residential density, and built coverage were significantly positively associated with walking but not bicycling [42].

In this research, we investigated how individual and household backgrounds, parents’ perceptions, and additional physical attributes (e.g., street pattern, land use, housing density, and environmental content) in the pedestrian environment influence children’s walking and biking to school. We also measured what school children consider to be walkable and bikeable distances to school.

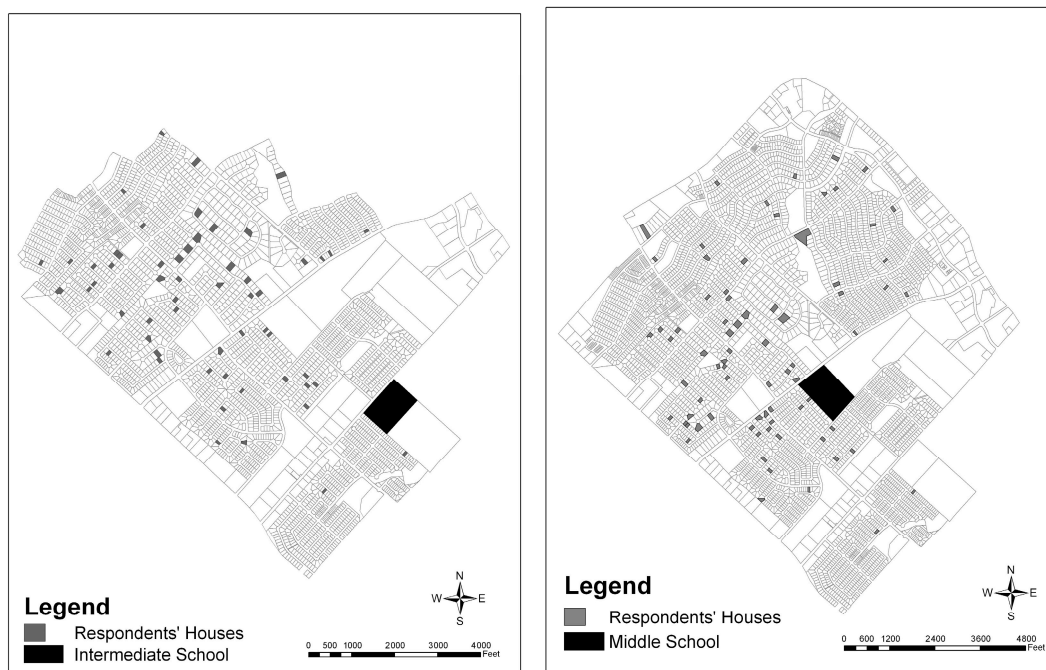
## 2. Materials and Methods

### 2.1. Sampling and Participants

We selected two intermediate (grades 5–6) and two middle (grades 7–8) schools in College Station, Texas. These four schools have three walk zones; that is, two of the four schools have the same walk zone (Figure 1). A total of 370 survey questionnaires were mailed to households with intermediate and middle school children within these school walk zones. Participants’ addresses were obtained from the Independent School District. Among the 370 survey questionnaires, 10 questionnaires (3%) were returned with a vacancy notice, while 186 questionnaires (50%) were completed and returned: 84 from the two different intermediate schools and 102 from the two middle schools. The participants were scattered throughout the study area (Figure 2).



**Figure 1.** Example of a school walk zone map that was included in the survey questionnaire.



**Figure 2.** Spatial distribution of respondents.

We asked parents about their children's ages, genders, ethnicities, heights, and weights. The mean age for the intermediate school children was 11.14, while the mean age for the middle school children was 13.25. The student gender distribution consisted of 46.5% male and 53.5% female. The majority of children were White (79.2%), followed by Hispanic (8.8%), Asian (8.2%), and African American (3.8%). The mean weight was about 62 pounds, while the mean height was about 107 inches.

Parents also provided background information about themselves such as age, gender, education, and marital status. The mean age of the parents was 42.37 and ranged from 29 to 71. Of the respondents, 146 (78%) were mothers and 35 (19%) were fathers. About 126 (68%) of the parents had at least a college degree.

They also provided household information such as the number of household members, the number of children, the number of cars, the number of licensed drivers, and the parents' employment status. The mean number of household members was 4.58, while the mean number of children was 2.74. The mean number of cars was 2.39, while the mean number of licensed drivers was 2.31. The overwhelming majority of fathers (92%) were employed full-time compared to 57% of mothers.

## 2.2. Measures

### 2.2.1. Self-Reported Data

The commute to school was measured with the question, "For each child, write the average number of times your child travels to and from school within one week." The list of commute modes included walk to school, bike to school, ride the school bus to school, ride in a car to school, ride in a carpool to school, and other (explain). We also asked parents to mark their children's route to school on a school walk zone map that was included in the questionnaire (see Figure 1).

To measure parents' perceptions about the walking and biking environments on the way to school, we asked about parents' concerns about their children's walking and biking environments on the way to school. Concerns about walking and biking environments within the school walk zones were measured with 15 items. We used a 4-point response scale where 1 = not a concern, 2 = concerns me a little, 3 = concerns me somewhat, and 4 = concerns me greatly.

A varimax rotated factor analysis of the 15 items generated three factors. The first factor—crime and other constraints—consisted of six items and had an internal consistency of 0.73. The six items had factor loadings in the range of 0.55 to 0.71. The items included crime, walking/bicycling alone to school, lack of parking at/near school, lack of place to store a bike, weather (e.g., heat, rain, etc.), and heavy backpacks. The second factor—traffic and pedestrian environments—consists of four items and had an internal consistency of 0.78. The four items had factor loadings in the range of 0.65 to 0.82. The items included traffic volume, traffic speed, a lack of sidewalk/bikeways, and a lack of separation between traffic and sidewalks/bikeways. The third factor—convenience—consisted of five items and had an internal consistency of 0.68. The five items had factor loadings in the range of 0.48 to 0.78. The items included distance, not enough time, after-school schedule, convenience, and child's unwillingness.

### 2.2.2. Geographic Information System (GIS) Data

Spatial data from the City of College Station Geographic Information Services were used to measure the school walk zone environments as well as individual commuting route environments. The walk zone environmental variables represented the physical characteristics of each walk zone (see Table 1). The variables included the intersection density, cul-de-sac density, sidewalk density, bike lane density, housing density, land-use mix, amount of greenery, block length, and average speed limit. Land-use mix ranged from 0 to 1 and captured how evenly the square footage of each land-use type was distributed within the walk zone (see the formula in Table 1). A lower value (0) indicated homogeneity, wherein all land uses were of a single type, while a higher value (1) indicated heterogeneity, wherein all land-use categories were evenly distributed throughout the area. The values for greenery were derived from 4 m multispectral satellite imagery (Ikonos). These data were processed with a computer using a normalized difference vegetation index formula (NDVI) to classify the areas with trees and shrubs. The amount (square feet) of tree/shrub cover (greenery) located within a school walk zone was calculated and recorded in the database.



**Table 1.** Variables and measures of the physical environment.

Variables	Measures
Walk Zone Environments	
Housing Density	Number of housing units per acre within a walk zone.
Intersection Density	Number of intersections within a walk zone/total length of streets within a walk zone
Cul-de-sac Density	Number of cul-de-sacs per acre within a walk zone
Sidewalk Density	Total length of sidewalks within a walk zone/total Length of streets within a walk zone
Bike Lane Density	Total length of bike lanes within a walk zone/total Length of streets within a walk zone
Land-Use Mix	Land-use mix = $-\left[\sum_{i=1}^n (p_i)(\ln p_i)\right] / \ln n$ $p_i$ = the total proportion of estimated square footage attributed to land use ( $i$ ) $n$ = the number of land uses
Greenery Density	Amount of trees and shrubs within a walk zone/total area of a walk zone
Speed Limit	Average speed limit within a walk zone
Block Length	Total length of streets within a walk zone/number of intersections within a walk zone
Individual Environments	
Street Distance	Street distance between home and school
Intersection Density	Number of intersections/street distance
Sidewalk Density	Total length of sidewalks between home and school/street distance
Bike Lane Density	Total length of bike lanes between home and school/street distance
Greenery Density	Amount of trees and shrubs along the commute route/street distance
Location of House	The location of a house was given a value of one (1) if on a cul-de-sac or dead end or two (2) if on grid street.

The individual commuting route environmental variables measured the street distance from home to school, intersection density, sidewalk density, bike lane density, greenery density along the commuting route, and location of a house (see Table 1). The street distance to school was measured along the children's route to school that the parents drew on a map provided in the questionnaire (see Figure 1). GIS was used to calculate the street distances from home to school for each child.

### 3. Results

In this section, we present descriptive statistics to investigate children's commute modes to school. We tested the results to compare the commute modes by gender and school level. In addition, we ran a path analysis with all individual and household background variables, three factors of parents' perceptions, and walk zone and individual environmental variables to reveal what influenced walking and biking to school.

#### 3.1. Commute Mode to School

The majority of children commuted to and from school by car. About 77% of school children rode a car to and from school at least once per week (see Table 2). About 39% of school children walked to and from school at least once a week. Note that more children walked home from school (38%) than walked to school (19%). About 23% of children biked to and from school.

**Table 2.** Comparison of commute modes to and from school.

	To School		From School		To/From School	
	<i>n</i>	Percentage	<i>n</i>	Percentage	<i>n</i>	Percentage
Walking	34	18.99	68	37.99	70	39.11
Biking	41	22.91	41	22.90	42	23.46
Car/Carpool	133	74.30	110	61.45	137	76.54
School Bus	10	5.59	15	8.38	15	8.38
Total	179		179		179	

We also looked at the commute modes by gender (see Table 3). Male children biked significantly more often per week than female children. Female children rode cars more often than males, although the relationship was only marginally significant.

**Table 3.** Mean frequency of commute mode per week by gender.

	Male		Female		Mean Difference	t-Value
	<i>n</i>	Mean (SD)	<i>n</i>	Mean (SD)		
Walking	74	2.03 (2.90)	85	1.79 (2.93)	0.241	0.519
Biking	74	2.56 (4.00)	85	1.28 (3.04)	1.287	2.258 *
Car/Carpool	74	5.11 (4.08)	85	6.31 (3.97)	−1.200	−1.878 †
School Bus	74	0.30 (1.52)	85	0.56 (1.93)	−0.260	−0.935

†  $p < 0.10$ , \*  $p < 0.05$ .

### 3.2. Commute Distance by Mode

Among children who walked to and from school, the mean walking street distance was 0.71 miles, while the mean biking distance was approximately 0.93 miles (see Table 4). For children who rode to school, the mean car/pool distance was 1.08 miles, while the mean bus distance was 1.44 miles.

**Table 4.** Mean street distance to school by school level (Unit of all distances is mile).

	Total		Intermediate		Middle		Mean Difference	t-Value
	<i>n</i>	Mean (SD)	<i>n</i>	Mean (SD)	<i>n</i>	Mean (SD)		
Walking	66	0.71 (0.44)	21	0.75 (0.46)	45	0.70 (0.43)	0.06	0.51
Biking	39	0.93 (0.41)	18	1.02 (0.44)	21	0.85 (0.38)	0.17	1.26
Car/Pool	126	1.08 (0.51)	55	1.29 (0.52)	71	0.92 (0.42)	0.38	4.30 ***
Bus	13	1.44 (0.68)	8	1.54 (0.83)	5	1.28 (0.35)	0.25	0.47

\*\*\*  $p < 0.001$ .

Comparing middle and intermediate schools, significant mode differences existed in the car/carpool driving distances. This may have been influenced by the location of the school, as can be seen in Figure 2. The middle school was more centrally located, while the intermediate school was located at the edge of the school zone. There was a slightly shorter trend for middle schools with respect to mean walking, biking, car/carpool, and school bus ridership distances. However, these differences were not significant.

### 3.3. Multicollinearity among Walk Zone Environmental Variables

As expected, there were significant multicollinearities among walk zone environmental variables. The land-use mix was highly correlated with the population density ( $r = 0.88$ ), sidewalk density ( $r = -0.89$ ), cul-de-sac density ( $r = -0.97$ ), and housing density ( $r = 0.88$ ). The greenery density was also highly correlated with the cul-de-sac density ( $r = -0.86$ ), speed limit ( $r = -0.88$ ), population density ( $r = 0.96$ ), and housing density ( $r = 0.96$ ). The intersection density was highly correlated with the speed limit ( $r = -0.94$ ), block length ( $r = -1.0$ ), street density ( $r = -1.0$ ), and bike lane density ( $r = 1.0$ ). In all further analyses, only land-use mix, greenery density, and intersection density were included to produce acceptable estimates for the walk zone environmental variables.

### 3.4. Who Tended to Walk or Bike?

Our correlational analysis indicated that walking to school was positively related to the location of the house and the amount of trees and shrubs along commuting routes but was negatively related to street distance and bike lanes. In other words, children

who walked to school at least once per week tended to live on a grid street rather than a cul-de-sac and lived closer to school. Along their commute routes, there were more trees and shrubs but fewer bike lanes. The correlational analysis also indicated that walkers tended to have more children in their household and lived in school walk zones with a greater mix of land uses. In addition, children whose parents were more concerned about crime and other constraints (factor 1), traffic and pedestrian environments (factor 2), and convenience (factor 3) were less likely to walk to school.

Biking to school was negatively related to gender, concern about convenience (factor 3), and intersections along the children's commute route but positively related to the location of the house. In other words, children who biked to school tended to be male and lived on a grid street rather than on a cul-de-sac. Moreover, their commuting routes tended to have fewer intersections, and their parents tended to have fewer concerns regarding convenience.

### 3.5. Factors Influencing the Frequency of Walking

A path analysis run using the AMOS stochastic regression imputation method was used to handle missing data and produced five imputed datasets. A path analysis was run with the five datasets combined to simultaneously test the relationships among individual and household background variables, three factors of parents' perceptions, and walk zone and individual environmental variables.

Figure 3 shows the final path analysis and the parameters that were estimated. This final analysis only included significant parameters. The fit indices for the analysis are presented in Table 5. The analysis indicated that age, concerns about traffic and pedestrian environments (factor 2) and convenience (factor 3), parent's education, the number of driver's licenses, individual bike lane density along the commuting route, and street distance had negative influences on the frequency of walking. On the contrary, children's heights, the number of children, intersection density, and trees and shrubs along children's commuting routes had positive influences on children's frequency of walking to school.

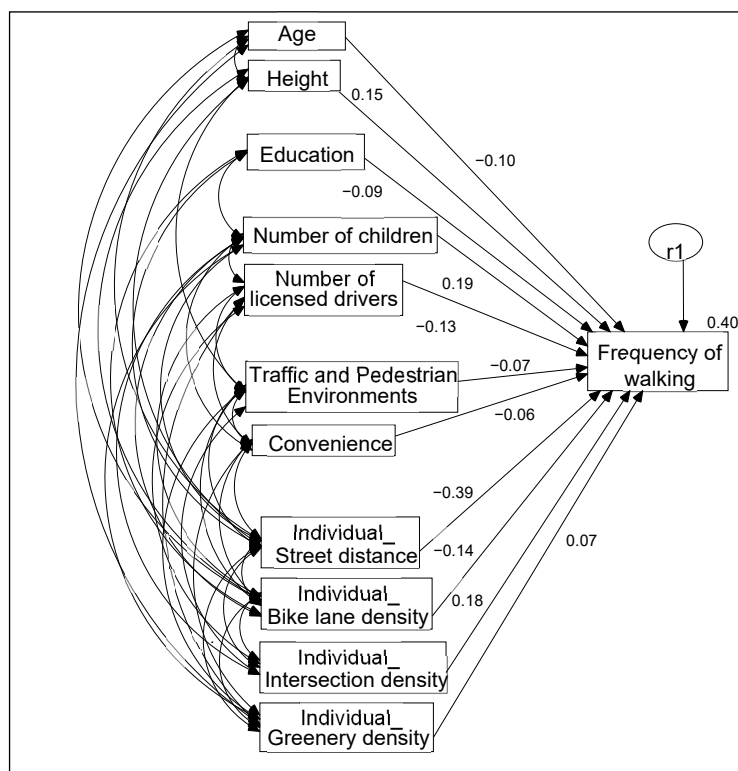


Figure 3. Path analysis for the frequency of walking.

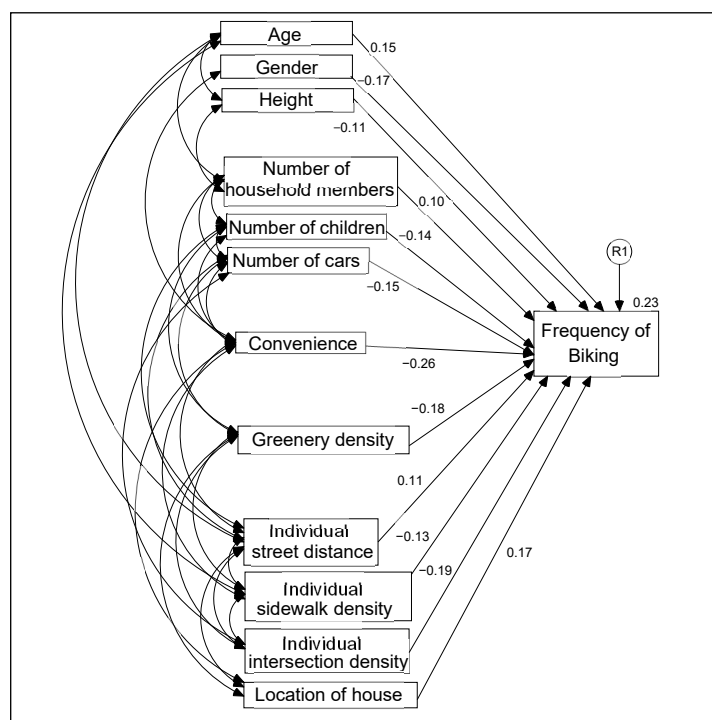


**Table 5.** Fit indices of the path analysis for the frequency of walking and biking.

Fit Index	Walking	Biking
Chi-square Test	$\chi^2 = 75.79$ , $df = 23$ , $p = 0.00$	$\chi^2 = 251.12$ , $df = 39$ , $p = 0.00$
Goodness of Fit Index (GFI)	0.99	0.96
Comparative Fit Index (CFI)	0.97	0.91
Normed Fit Index (NFI)	0.96	0.89
Root-Mean-Square Error of Approximation	0.05	0.08

### 3.6. Factors Influencing the Frequency of Biking

We also ran a path analysis for biking. Figure 4 shows the significant parameters that were estimated. Gender (0: female and 1: male), height, the number of children, the number of cars, concerns about convenience, greenery density, individual sidewalk density, and intersection density all negatively influenced the frequency of biking. Age, the number of household members, and the individual street distance all positively influenced the frequency of biking.

**Figure 4.** Path analysis for the frequency of biking.

## 4. Discussion

The results highlight several aspects of children walking and biking to school that are important to consider for design and planning purposes as well as for children's health. First, the average percentage of children walking to and from school in our study (39%) was higher than the national average (13%). These numbers may have been higher because we only sampled from children living inside of the school walk zone (up to two miles) and not the entire district where we conducted the study. That said, this percentage was still much lower than studies conducted in 1969 (87%) of schoolchildren living within 1 mile of their school who walked or cycled. This indicates that the majority of children in the study area have a less physically active commute to school than the average student in 1969. Less physical activity may be one factor that explains the increases in childhood obesity. Programs such as Walk or Bike to School Day should be supported in all communities to help reverse this trend.

The location of a school within a walk zone may influence the distance traveled by each mode. The centrally located school in our study resulted in lower travel distances than the peripherally located school. The average distance for children who walked was shortest, followed by biking, car/carpool, and finally taking a bus. To optimize active commuting by walking or biking, school systems might consider choosing new school locations that minimize the travel distances within the walk zone boundaries. It is important to point out, however, that this study only examined two schools, so the conclusions have limited generalizability.

Street patterns and intersections influenced both walking and biking. However, the findings suggest taking a somewhat cautious approach to designing right-of-way layouts. We found that intersection density had a positive relationship with walking but a negative relationship with biking. This confirmed previous findings [42]. Since both modes involve physical exercise, any manipulation of intersection density in design may involve a tradeoff of one mode over another. With respect to cul-de-sacs, although these may be popular quiet locations to raise a family, they were shown in our study to reduce biking to school. Thus, cul-de-sac patterns may relate to less active lifestyles. It is worth noting, however, that the cul-de-sacs in our study did not have easements that allowed pedestrian or cyclist movement between blocks. It is possible that cul-de-sac patterns that include through-block easements may lead to different results. More research is needed in this area.

Our results suggest that a two-mile walk zone might not be a practical distance for intermediate and middle school children. Different distance considerations should probably be made for different age groups, and the actual distance threshold should be determined using a more scientific approach. One approach would be to examine the mean walking, biking, car/carpool, and busing distances across all grade levels to see whether different behaviors exist for each group. Another approach might be to look at the range of walking and biking distances across all grade levels to estimate the maximum walking distance. If clearly measurable differences exist between groups, then a more refined walk zone policy might be warranted.

It is interesting to note that walking was positively related to the amount of greenness. This was consistent with a number of previous studies [19,22–25,34,41]. Given the growing literature on the benefits of green space, there may be a number of explanations for this relationship. In this case, since the study area was located in central Texas, which is known for its heat, it is possible that shade from trees may provide some protection from the heat for children who walk to and from school. Examining this relationship in other geographies might help to bring more focus on whether the condition is unique to Texas or is consistent across other regions. Understanding if the relationship holds across regions would help to determine if right-of-way design should include more green space within walk zone areas to increase walking to school.

A less intuitive finding is that sidewalk density was related more to biking than to walking, although the relationship is negative. This suggests that children bike less when there are more sidewalks present. Conversely, bike lane density was negatively related to walking, suggesting that children walk less when there are more bike lanes present. It is not clear what the implications of these findings may be. One would expect that the presence of sidewalks would result in more walking or that more bike lanes would lead to more biking. However, the data did not support or refute these expectations. Additional research with a more comprehensive set of questions about sidewalk density and bike lane density might shed light on these questions.

Concerns about convenience and traffic safety were both negatively related to walking to school. This was consistent with previous research [26–28]. Concerns about convenience were also negatively related to biking to school. While these concerns make sense, it would be good to look deeper into these issues to determine whether these obstacles can be overcome to make walking and biking more attractive. Recent research on sidewalk buffers [22] and their relationship to perceptions of safety may help to answer the traffic safety questions. Overcoming concerns about convenience may prove to be more difficult

to ascertain. As discussed above, greater sidewalk and bike lane density did not result in significantly more walking or biking. It is possible that more education and training could address concerns about convenience. This is an open question that may benefit from additional research.

## 5. Conclusions

By 2030, the UN Habitat goals are to provide access to safe, affordable, accessible, and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities, and older persons [43]. Our research study investigated how the physical attributes of the pedestrian environment influence children's walking and biking to school. The results indicate that the distance to school, street pattern (grid vs. cul-de-sac), land-use mix, greenery, sidewalks, bike lanes, intersections, and housing density all show significant relationships with children's walking and biking to school. We offer a number of recommendations for those seeking to encourage walking and biking to school, such as supporting Walk and Bike to School Day, building new schools at the center of walk zones rather than along the periphery, carefully planning for intersection density and the use of cul-de-sacs, setting walk zone distances to match student ages or school level, considering additional green spaces along walking routes, and providing educational opportunities for parents to learn about traffic safety and the tradeoff between convenience and physical activity. These findings can be used to shape better school walk zone transportation infrastructure that may have lasting health consequences for young school children.

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**Institutional Review Board Statement:** This study was conducted according to the guideline of the Declaration of Helsinki, and approved by the Institutional Review Board of Texas A&M University.

**Informed Consent Statement:** The survey materials clearly stated that by responding to the questions and mailing the survey back, the recipients have agreed to participate in the research.

**Data Availability Statement:** The data that support the findings of this study are available from the corresponding author, Byoung-Suk Kweon, upon reasonable request.

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

1. DeWeese, R.S.; Acciai, F.; Tulloch, D.; Lloyd, K.; Yedidia, M.J.; Ohri-Vachaspati, P. Active commuting to school: A longitudinal analysis examining persistence of behavior over time in four New Jersey cities. *Prev. Med. Rep.* **2022**, *26*, 101718. [CrossRef]
2. U.S. Environmental Protection Agency. Travel and Environmental Implications of School Siting (Publication EPA 231-R-03-004). 2003. Available online: <http://www.epa.gov/smartgrowth> (accessed on 25 October 2022).
3. Sahoo, K.; Sahoo, B.; Choudhury, A.K.; Sofi, N.Y.; Kumar, R.; Bhadoria, A.S. Childhood obesity: Causes and consequences. *J. Family Med. Prim. Care* **2015**, *4*, 187–192. [CrossRef]
4. Stierman, B.; Afful, J.; Carroll, M.; Chen, T.; Davy, O.; Fink, S.; Fryar, C.; Gu, Q.; Hales, C.; Hughes, J.; et al. National Health and Nutrition Examination Survey 2017–March 2020 Prepandemic Data Files—Development of Files and Prevalence Estimates for Selected Health Outcomes. *Natl. Health Stat. Rep.* **2021**, *2021*, 158.
5. Lobstein, T.; Jackson-Leach, R. Planning for the worst: Estimates of obesity and comorbidities in school-age children in 2025. *Pediatr. Obes.* **2016**, *11*, 321–325. [CrossRef]
6. World Obesity, Obesity: Missing the 2025 Global Targets—Trends, Costs and Country Reports. 2020. Available online: <https://www.worldobesity.org/resources/resource-library/world-obesity-day-missing-the-targets-report> (accessed on 25 October 2022).
7. Lifshitz, F. Obesity in Children. *J. Clin. Res. Pediatr. Endocrinol.* **2008**, *1*, 53–60. [CrossRef]

8. Lindberg, L.; Danielsson, P.; Persson, M.; Marcus, C.; Hagman, E. Association of childhood obesity with risk of early all-cause and cause-specific mortality: A Swedish prospective cohort study. *PLoS Med.* **2020**, *17*, e1003078. [\[CrossRef\]](#)
9. Lavery, A.A.; Hone, T.; Goodman, A.; Kelly, Y.; Millett, C. Associations of active travel with adiposity among children and socioeconomic differentials: A longitudinal study. *Phys. Act. Exerc.* **2021**, *11*, e036041. [\[CrossRef\]](#)
10. Drake, K.M.; Beach, M.L.; Longacre, M.R.; MacKenzie, T.; Titus, L.J.; Rundle, A.G.; Dalton, M.A. Influence of sports, physical education, and active commuting to school on adolescent weight status. *Pediatrics* **2012**, *130*, 296–304. [\[CrossRef\]](#)
11. Sun, Y.; Liu, Y.; Tao, F.B. Associations between active commuting to school, body fat, and mental well-being: Population-based, cross-sectional study in China. *J. Adolesc. Health* **2015**, *57*, 679–685. [\[CrossRef\]](#)
12. Napier, M.; Brown, B.; Werner, C.; Gallimore, J. Walking to school: Community design and child and parent barriers. *J. Environ. Psychol.* **2010**, *31*, 45–51. [\[CrossRef\]](#)
13. North Carolina Department of Transportation. An analysis of North Carolina Guidelines and Criteria for Establishing School Walk Zones. 2001. Available online: <https://digital.ncdcr.gov/digital/collection/p249901coll22/id/657182/rec/42> (accessed on 2 November 2022).
14. Texas Education Agency, School Transportation Allotment Handbook. 2021. Available online: <https://tea.texas.gov/sites/default/files/school-transportation-allotment-handbook.pdf> (accessed on 5 August 2022).
15. Timperio, A.; Ball, K.; Salmon, J.; Roberts, R.; Giles-Corti, B.; Simmons, D.; Baur, L.A.; Crawford, D. Personal, family, social, and environmental correlates of active commuting to school. *Am. J. Prev. Med.* **2006**, *30*, 45–51. [\[CrossRef\]](#)
16. Mammen, G.; Faulkner, G.; Buliung, R.; Lay, J. Understanding the drive to escort: A cross-sectional analysis examining parental attitudes towards children's school travel and independent mobility. *BMC Public Health* **2012**, *12*, 862. [\[CrossRef\]](#)
17. Riazi, N.A.; Blanchette, S.; Trudeau, F.; Larouche, R.; Tremblay, M.S.; Faulkner, G. Correlates of Children's Independent Mobility in Canada: A Multi-Site Study. *Int. J. Environ. Res. Public Health* **2019**, *16*, 2862. [\[CrossRef\]](#) [\[PubMed\]](#)
18. Su, J.G.; Jerrett, M.; Mcconnell, R.; Berhane, K.; Dunton, G.; Shankardass, K.; Reynolds, K.; Chang, R.; Wolch, J. Factors Influencing whether Children Walk to School. *Health Place* **2013**, *22*, 153–161. [\[CrossRef\]](#) [\[PubMed\]](#)
19. Ewing, R.; Schroeder, W.; Greene, W. School Location and Student Travel: Analysis of Factors Affecting Mode Choice. *Transp. Res. Rec. J. Transp. Res. Board.* **2004**, *1895*, 55–63. [\[CrossRef\]](#)
20. Kelly, J.A.; Fu, M. Sustainable school commuting—understanding choices and identifying opportunities: A case study in Dublin, Ireland. *J. Transp. Geogr.* **2014**, *34*, 221–230. [\[CrossRef\]](#)
21. Aranda-Balboa, M.J.; Chillón, P.; Saucedo-Araujo, R.G.; Molina-García, J.; Huertas-Delgado, F.J. Children and Parental Barriers to Active Commuting to School: A Comparison Study. *Int. J. Environ. Res. Public Health* **2021**, *18*, 2504. [\[CrossRef\]](#)
22. Kweon, B.; Rosenblatt-Naderi, J.; Ellis, C.D.; Shin, W.H.; Danies, B.H. The Effects of Pedestrian Environments on Walking Behaviors and Perception of Pedestrian Safety. *Sustainability* **2021**, *13*, 8728. [\[CrossRef\]](#)
23. Ghekiere, A.; Cauwenberg, J.; Mertens, L.; Clarys, P.; Geus, B.; Cardon, G.; Nasar, J.; Salmon, J.; Bourdeaudhuij, I.; Deforche, B. Assessing cycling-friendly environments for children: Are micro-environmental factors equally important across different street settings? *Int. J. Behav. Nutr. Phys. Act.* **2015**, *12*, 54. [\[CrossRef\]](#)
24. Ozbil, A.; Yesiltepe, D.; Argin, G.; Rybarczyk, G. Children's Active School Travel: Examining the Combined Perceived and Objective Built-Environment Factors from Space Syntax. *Int. J. Environ. Res. Public Health* **2021**, *18*, 286. [\[CrossRef\]](#) [\[PubMed\]](#)
25. Evers, C.; Boles, S.; Johnson-Shelton, D.; Schlossberg, M.; Richey, D. Parent safety perceptions of child walking routes. *J. Transp. Health* **2014**, *1*, 108–115. [\[CrossRef\]](#) [\[PubMed\]](#)
26. Hillman, M.; Adams, J.; Whitelegg, J. One False Move: A Study of Children's Independent Mobility. 1990. Available online: <https://mayerhillman.files.wordpress.com/2014/10/one-false-move.pdf> (accessed on 18 July 2022).
27. Carver, A.; Timperio, A.; Hesketh, K.; Crawford, D. Are children and adolescents less active if parents restrict their physical activity and active transport due to perceived risk? *Soc. Sci. Med.* **2010**, *70*, 1799–1805. [\[CrossRef\]](#) [\[PubMed\]](#)
28. Martin, S.; Carlson, S. Barriers to children walking to or from school-United States, 2004 (Reprinted from MMWR 2005, 54, 949–952). *Jama J. Am. Med. Assoc.* **2005**, *294*, 2160.
29. Rella Riccardi, M.; Galante, F.; Scarano, A.; Montella, A. Econometric and Machine Learning Methods to Identify Pedestrian Crash Patterns. *Sustainability* **2022**, *14*, 15471. [\[CrossRef\]](#)
30. Rao, S.S.; Reddy, S.S.; Kumar, A. Bicycle handlebar injuries in children during the COVID-19 pandemic. *Indian Pediatr.* **2022**, *59*, 72. [\[CrossRef\]](#)
31. Axelsson, A.; Stigson, H. Characteristics of bicycle crashes among children and the effect of bicycle helmets. *Traffic Inj. Prev.* **2019**, *20*, 21–26. [\[CrossRef\]](#)
32. National Highway Traffic Safety Administration. Traffic Safety Facts: 2020 Data, Children. DOT HS 813 285, 2020. Available online: <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813285> (accessed on 18 July 2022).
33. Cloutier, M.S.; Beaulieu, E.; Fridman, L.; Macpherson, A.K.; Hagel, B.E.; Howard, A.W.; Rothman, L. State-of-the-art review: Preventing child and youth pedestrian motor vehicle collisions: Critical issues and future directions. *Inj. Prev.* **2021**, *27*, 77–84. [\[CrossRef\]](#)
34. Larsen, K.; Gilliland, J.; Hess, P.; Tucker, P.; Irwin, J.; He, M. The Influence of the Physical Environment and Sociodemographic Characteristics on Children's Mode of Travel to and from School. *Am. J. Public Health* **2009**, *99*, 520–526. [\[CrossRef\]](#) [\[PubMed\]](#)
35. Panter, J.R.; Jones, A.P.; van Sluijs, E.M.F. Environmental determinants of active travel in youth: A review and framework for future research. *Int. J. Behav. Nutr. Phys. Act.* **2008**, *5*, 1–14. [\[CrossRef\]](#)

36. Panter, J.R.; Jones, A.P.; van Sluijs, E.M.F.; Griffin, S.J. Attitudes, social support and environmental perceptions as predictors of active commuting behaviour in school children. *J. Epidemiol. Community Health* **2010**, *64*, 41–48. [[CrossRef](#)] [[PubMed](#)]
37. Trapp, G.S.A.; Giles-Corti, B.; Christian, H.E.; Bulsara, M.; Timperio, A.F.; McCormack, G.R.; Villaneuva, K.P. Increasing Children's Physical Activity: Individual, Social, and Environmental Factors Associated with Walking to and From School. *Health Educ. Behav.* **2012**, *39*, 172–182. [[CrossRef](#)]
38. D'Haese, S.; De Meester, F.; De Bourdeaudhuij, I.; Deforche, B.; Cardon, G. Criterion distances and environmental correlates of active commuting to school in children. *Int. J. Behav. Nutr. Phys. Act.* **2011**, *8*, 1–10. [[CrossRef](#)] [[PubMed](#)]
39. Ortegon-Sanchez, A.; McEachan, R.R.C.; Albert, A.; Cartwright, C.; Christie, N.; Dhanani, A.; Islam, S.; Ucci, M.; Vaughan, L. Measuring the Built Environment in Studies of Child Health—A Meta-Narrative Review of Associations. *Int. J. Environ. Res. Public Health* **2021**, *18*, 10741. [[CrossRef](#)] [[PubMed](#)]
40. Carvera, A.; Panter, J.; Jones, A.; Sluijsbc, E. Independent mobility on the journey to school: A joint cross-sectional and prospective exploration of social and physical environmental influences. *J. Transp. Health* **2014**, *1*, 25–32. [[CrossRef](#)] [[PubMed](#)]
41. Fulton, J.E.; Shisler, J.L.; Yore, M.M.; Caspersen, C.J. Active transportation to school: Findings from a national survey. *Res. Q. Exerc. Sport* **2005**, *76*, 352–357. [[CrossRef](#)] [[PubMed](#)]
42. Moran, M.; Plaut, P.; Baron-Epel, O. Do children walk where they bike? Exploring built environment correlates of children's walking and bicycling. *J. Transp. Land Use* **2015**, *9*, 1–23. [[CrossRef](#)]
43. UN General Assembly, Transforming Our World: The 2030 Agenda for Sustainable Development, 21 October 2015, A/RES/70/1. Available online: <https://www.refworld.org/docid/57b6e3e44.html> (accessed on 15 January 2023).

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