The Relationship between Walkable Communities and Adolescent Weight

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ABSTRACT

Objective: This study examined the association between walkability and adolescent weight in a national sample of public secondary school students and the communities in which they live. **Methods:** Data were collected through student surveys and community observations between February and August 2010, and analyses were conducted in spring 2012. The sample size was 154 communities and 11,041 students. A community walkability index and measures of the prevalence of adolescent overweight and obesity were constructed. Multivariable analyses from a cross-sectional survey of a nationally representative sample of 8^{th}, 10^{th} and 12^{th} grade public school students in the US were run. **Results:** The odds of students being overweight (OR, 0.975; 95% CI: 0.94, 0.99) or obese (OR, 0.971; 95% CI: 0.94, 0.99) decreased if they lived in communities with higher walkability index scores. **Conclusions:** Results suggest that living in more walkable communities is associated with reduced prevalence of adolescent overweight and obesity.

Background

Obesity is a problem in this country and worsening. One-third of our children are at higher risk for serious health problems because of their weight[1]. Research has shown that part of the problem is caused by the neighborhoods in which we live, work, shop and play[2-3]. While obesity rates have grown over time, active travel (e.g., walking or bicycling to school) by youth—one form of physical activity—has declined over the past several decades[4-5]. Results of the National Household Travel Survey show that for trips at a distance of only 1-2 miles Americans still drive 90 percent of the time[6].

Physical activity is proven to have protective effects against both obesity and related health problems[7]. Research has shown that the presence of sidewalks, public transit, controlled intersection crossings, and mixed land use (a mix of residential, commercial, and recreational destinations) are associated with increased walking and lower prevalence of obesity[2, 8-19]. However, these studies examined only one or a few locations and those that were conducted nationally relied upon secondary environmental data sources rather than street scale data collected directly from communities[2, 8-19]. This study builds on existing evidence[2, 8-19] by examining the impact of community-level walkability on the prevalence of adolescent obesity using street data collected on the ground in a national sample of communities; to our knowledge this is the first study to do this.

Methods

This study combined cross-sectional individual-level data collected in Spring 2010 from 8th, 10th, and 12th grade public school students participating in the Monitoring the Future (MTF) survey[20].

In any given year, half the MTF schools are either in year 1 or 2 of participation. Only the traditional public schools involved in Year 2 of MTF participation were included in this study (N=154 schools, 11,041 students). Community-level environmental measures for the MTF school enrollment zones, the area from which schools draw their student population (area square miles: median size=39.8, range 0.26-1,517), were developed through the Community Obesity Measures Project (BTG-COMP), an ongoing, large-scale effort conducted by the Bridging the Gap research team. BTG-COMP identifies local policy and environmental factors that are likely to be important determinants of healthy eating, physical activity and obesity among children and adolescents[21].

Community Measures

For this study, street segments, defined as two facing sides of a street block, were divided into three sampling strata by street type: streets falling within a 2-mile buffer around the sampled school; residential streets; and arterial (i.e., commercial) streets. Sample sizes were then calculated to provide estimates with 20 percent width confidence intervals at the 90 percent confidence level. The required sample size was then proportionally allocated between the three strata to preserve the original distribution of street segments for a community. A random sample of street segments was drawn based on the proportion of population of youth (aged 0-17 years) associated with the nearest census block to the street segment and overall proportion of street segments located in each strata. Street segment data were then weighted to account for their probability of selection and then aggregated to construct community-level measures representing, for example the proportion of streets, in a community, having sidewalks.

A walkability index was constructed using data collected from April-September, 2010 with the BTG-COMP Street Segment Observation Form, which has been shown to have good reliability[22] (all measures included in the index had kappas/ICCs with almost perfect or substantial agreement 0.61-1.00, or >90 percent agreement between raters). The tool, which is described in detail elsewhere[21], is designed to assess key street-level features of the neighborhood environment that are thought to be related to physical activity behavior. Briefly, an expert panel of researchers who were previously involved in developing or using similar audit tools was formed. Street segment measures were compiled from existing data collection instruments[23-28]. After multiple calls with the experts, the final audit tool was developed and includes information on: 1) land use and opportunities for play/physical activity, which included a mix of residential and non-residential destinations; 2) traffic and pedestrians, including the presence of sidewalks, shoulders, bike lanes, traffic calming and control features; 3) physical disorder (e.g., presence of graffiti, litter, yard debris); and, 4) aesthetics and amenities (e.g., public transportation, flowers, planters, benches). The walkability index (Cronbach's Alpha=0.77) was constructed by drawing upon the study's overarching socio-ecological framework in combination with existing evidence[2, 8-17] showing a connection between built environment correlates and physical activity behavior and weight. Specifically, these previous studies[2, 8-17] have found sidewalks and other street characteristics, pedestrian crossings, traffic signals, features that calm/slow traffic, measures of destinations, and presence of public transit were associated with physical activity/walking. The final index, which could range from 0-35, is a sum of the proportion of streets in a community that have: mixed land use; sidewalks; sidewalk buffers; sidewalk/street lighting; other sidewalk elements (e.g., sidewalk continuity; shade); traffic lights; pedestrian signal at traffic light; marked crosswalks; pedestrian crossing and other signage; and, public transit.

A community physical disorder scale was constructed using street data from the same audit tool as described above and includes dichotomous measures representing the presence of: vacant lots/buildings; bars on windows; broken/boarded up windows; graffiti/tagging; and, yard debris (possible range=0-5). Using existing methods[29] a community compactness index, which includes measures of residential density and street connectivity, was developed to control for urbanization.

Individual-level Measures

Using self-reported height and weight, age- and gender-specific BMI was calculated (=weight (kg)/height (m)^2). Individuals' body weight status was classified based on BMI for children and teens using the 2000 CDC Growth Chart[30], overweight was classified as BMI $\geq$ 85th percentile, but < 95th percentile; obesity was classified as BMI $\geq$ 95th percentile. Although self-report data has been shown to under-report weight, these data have been shown to reliably predict obesity-related morbidities and behaviors in adolescents [33-34],

Statistical Analysis

Cross-sectional, multivariable logistic regression analyses were conducted in spring 2012 using survey commands in Stata 12.0[31] after applying sampling weights to adjust for differential selection probabilities and computing robust standard errors by adjusting for student clustering within sites. To explore the relative magnitude of the walkability index on weight, marginal effects were calculated to examine expected changes in the weight-related outcome measures using the coefficients in the models and testing varying ranges of the walkability index (0, 9, 12, and 18) while holding all other independent variables at their mean. All models controlled for gender, race/ethnicity, grade, parental education, community physical disorder scale, presence of bike lanes, presence of off-road trails, student perception of safety going to and from school, community-level median household income, and a community compactness index.

Results

Table 1 includes descriptive statistics. The average prevalence of adolescent overweight and obesity across communities was 15 and 12 percent, respectively. The mean walkability index across communities was 6.38 (Range 0.28-18.4, N=154 communities). Table 2 shows the correlations between the control variables and the walkability index. For example, the walkability index is positively correlated with more urbanized areas and presence of bike lanes, and negatively correlated with communities with lower median household incomes. Table 3 presents the results of the adjusted logistic models and marginal effects. Communities with more walkable streets were significantly negatively associated with the prevalence of adolescent overweight (OR: 0.98, 95% CI: 0.95, 0.99) and obesity (OR: 0.97, 95% CI: 0.95, 0.99). Results of the marginal effects suggest even a modest increase in the presence of street features that support walking in a community (an increase in the mean walkability score of just under 7 to 9 markers of walkable street features) was associated with a lower obesity rate—10.6 versus 12 percent. Further analyses were conducted to examine the non-linear effects of the walkability index by dividing communities into quartiles based on the value of the index. Only the fourth quartile (highest walkability index score) had a significant negative association between the walkability index and prevalence of both overweight and obesity (OR 0.76, 95% CI: 0.61, 0.94 and OR 0.73, 95% CI: 0.57, 0.93 respectively) (results not shown).

Sensitivity analyses showed the key street features associated with reduced prevalence of obesity were increased presence of sidewalks and public transit, and reduced prevalence of overweight was associated with increased presence of sidewalks, having a pedestrian signal at traffic lights, and presence of marked crosswalks. The interactive effects between micro- (walkability index) and macro-scale (community compactness index) environmental measures were tested in the model, but found to be statistically insignificant. Additional analyses that combined the micro- and macro-scale measures into one index were also tested. Results (not shown) were consistent with those found using the originally constructed walkability index.

Discussion and Conclusions

This is the first national study to provide evidence that street features collected directly from communities are associated with decreased prevalence of youth weight outcomes in those communities. Results suggest certain street features, which are less likely to be present in low-income communities (sidewalks and marked crosswalks)[32], were important measures associated with weight. These results, although statistically significant, may be understated due to existing evidence showing adolescents consistently under-report their weight[33-34], and analytic rigor in simultaneously controlling for student perception of safety, community physical disorder and community-level median household income, all of which have been associated with higher prevalence of adolescent obesity[29]. Another study limitation is the inability to directly examine the association of the walkability index on physical activity, particularly utilitarian travel, which is not available in this dataset. Future studies should address this gap in the research. An additional study limitation is the missing information of home addresses for the students participating in the MTF survey. Because this information is unavailable, rather than constructing buffers around individuals home addresses, we collect data from the entire school enrollment zone. In some cases these boundaries are very small, but in very rural communities they can be quite large. However, this limitation is accounted for by employing a proportionate to population (0-17 years) sampling strategy to ensure streets were audited where the target youth live. Further, the walkability index was constructed in two-mile buffers around each school in the sample and results were consistent with those analyses using the full sample of street segments (results not shown).

Although, this study was cross-sectional and cannot establish causality, these findings provide additional support for the growing evidence base that there is a connection between the built environment, operating either through physical activity and the food environment, or self-selection, and obesity[35-36]. This is particularly relevant given that recent research has shown the environment can influence youth physical activity behavior independently of parental neighborhood selection preferences[37], and that the largest proportion of moderate to vigorous physical activity in adolescents has been associated with active travel[38]. Importantly, the findings from this study can be used to inform any federal Transportation Bill reauthorization debates and policy decisions at all levels of government related to funding for pedestrian and bicycling infrastructure and highlight the important role that such infrastructure can play in mitigating adolescent overweight and obesity.

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Table 1
SUMMARY DESCRIPTIVES

	Mean	**Std.Dev.**
Outcome Variables		
Obese	0.12	0.33
Overweight	0.15	0.36
Explanatory Variable		
Walkability Index[a]	6.38	4.24
Control Variables		
Community Measures		
Presence of Bike Lanes	0.01	0.03
Presence of Off-road Trails	0.01	0.01
Community Physical Disorder Scale[a]	0.37	0.25
Community Compactness Index[a]	-0.02	0.88
High Community Median Household Income	0.59	0.49
Low Community Median Household Income	0.41	0.49
Individual Measures		
Grade 8	0.39	0.49
Grade 10	0.45	0.50
Grade 12	0.16	0.37
Student Perception of Safety	0.10	0.07
White	0.61	0.49
African American	0.09	0.29
Latino	0.18	0.38
Other Race	0.12	0.32
Male	0.48	0.50
Parental Education (some college or higher)	0.71	0.45

[a]Variables are indices; all other variables are expressed as percents.

Table 2

CORRELATIONS BETWEEN WALKABILITY INDEX AND COVARIATES

	Correlation with Walkability Index
Community Measures	
Presence of Bike Lanes	0.37
Presence of Off-road Trails	-0.05
Community Physical Disorder Scale	0.32
Community Compactness Index	0.57
High Community Median House Income	0.24
Low Community Median House Income	-0.24
Individual Measures	
Grade 8	0.05
Grade 10	-0.02
Grade 12	-0.03
Student Perception of Safety	0.19
White	-0.27
African American	0.04
Latino	0.22
Other Race	0.12
Male	-0.01
Parental Education (some college or higher)	0.02

Table 3
RESULTS OF ASSOCIATION BETWEEN WALKABILITY INDEX AND ADOLESCENT WEIGHT MEASURES

	Overweight		**Obese**	
Independent Variables	Adjusted OR	95% CI	Adjusted OR	95% CI
Walkability Index	0.98	0.95 – 0.99	0.97	0.95 – 0.99
[a]Walkability Index=0	*0.170 (0.011)*		*0.133 (0.009)*	
[a]Walkability Index=9	*0.141 (0.005)*		*0.106 (0.005)*	
[a]Walkability Index=12	*0.132 (0.008)*		*0.098 (0.007)*	
[a]Walkability Index=18	*0.115 (0.015)*		*0.084 (0.011)*	

[a]Results of predicted probability models are expressed as marginal effects, with standard errors in parentheses, and are italicized below the walkability index variable.
Models controlled for: gender, race/ethnicity, grade, parental education, community physical disorder scale, presence of bike lanes, presence of off-road trails, student perception of safety, community median household income, and local compactness index.