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Home/family, peer, school, and neighborhood correlates of obesity in adolescents

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Abstract

Objective—This study was designed to 1) identify the most important home/family, peer, school, and neighborhood environmental characteristics associated with weight status and 2) determine the overall contribution of these contexts to explaining weight status among an ethnically/racially diverse sample of adolescents.

Design and Methods—Surveys and anthropometric measures were completed in 2009–2010 by 2,793 adolescents (53.2% girls, mean age=14.4 ± 2.0, 81.1% nonwhite) in Minneapolis/St. Paul, Minnesota schools. Data representing characteristics of adolescents' environments were collected from parents/caregivers, friends, school personnel, and Geographic Information System sources. Multiple regression models controlled for adolescent age, race/ethnicity, and socioeconomic status.

Results—The variance in BMI z-scores explained by 51 multi-contextual characteristics was 24% for boys and 22% for girls. Across models, several characteristics of home/family (e.g., infrequent family meals) and peer environments (e.g., higher proportion of male friends who were overweight) were consistently associated with higher BMI z-scores among both boys and girls. Among girls, additional peer (e.g., lower physical activity among female friends) and neighborhood (e.g., perceived lack of safety) characteristics were consistently associated with higher BMI z-scores.

Conclusions—Results underscore the importance of addressing the home/family and peer environments in future research and intervention efforts designed to reduce adolescent obesity.

INTRODUCTION

The all-time high prevalence of adolescent obesity is of public health concern (1). Despite decades of research focused on the identification and modification of obesity-related behaviors, prevention efforts focusing on individual behavior change have had only limited

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success. Because many environmental characteristics have the potential to influence weight-related behaviors and risk for obesity, the development of more effective public health interventions will require consideration of the various contexts in which young people spend their time.

Recently, research paradigms have framed obesity as a complex system, which is influenced not only by individual choices but also by features of social and physical contexts (2). Although previous studies have examined how various environmental characteristics are related to weight status in children and adolescents (3–10), relatively few studies have comprehensively examined influences from multiple social and physical contexts in the same analysis. Most studies using such an ecological approach to assess multiple levels of influence have only examined a few contexts, such as family/home and school (3) or family/home and neighborhood (5, 6, 9). Few, if any, studies have examined the family/home, peer, school, and neighborhood environments together. Nor have many studies examined influences from multiple contexts in ethnically/racially diverse and low-income populations of youth who are most at risk for obesity.

The current multi-contextual study was designed to 1) identify the most important home/family, peer, school, and neighborhood characteristics associated with weight status and 2) determine the overall contribution of these contexts for explaining weight status among an ethnically/racially diverse adolescent sample. Potential correlates of weight status were identified for consideration using an ecological perspective as well as findings from previous studies focusing on one or more contexts. Since the aim was to inform the development of prevention interventions, the current study focused on characteristics of environments that are potentially modifiable and suitable for addressing within the framework of policies or health promotion programs.

METHODS AND PROCEDURES

Study Design and Population

The EAT 2010 (Eating and Activity in Teens) study was designed to examine factors associated with weight-related outcomes in adolescents. Classroom-administered surveys and anthropometric measures were completed by adolescents from 20 public middle schools and high schools in the Minneapolis/St. Paul metropolitan area of Minnesota during the 2009–2010 academic year. Following the ecological framework that guided the overall study, data were additionally collected from parents/caregivers, friends, school personnel, and Geographic Information System (GIS) data sources as described in detail below. All study procedures were approved by the University of Minnesota's Institutional Review Board Human Subjects Committee and by the research boards of participating school districts.

The study population included 2,793 adolescents with a mean age of 14.4 years (SD=2.0); 46.1% were in middle school (6th–8th grades) and 53.9% were in high school (9th–12th grades). Participants were equally divided by gender (53.2% girls). Approximately 71% of participants qualified for free or reduced-price school meals. The racial/ethnic backgrounds of participants were as follows: 18.9% white, 29.0% African American or Black, 19.9% Asian American, 16.9% Hispanic, 3.7% Native American, and 11.6% mixed or other.

Adolescent Assessments

Trained research staff administered surveys and measured adolescents' height and weight during selected health, physical education, and science classes. Surveys were administered during two class periods that were typically 45–50 minutes. Adolescents were given the opportunity to assent only if their parent/guardian did not return a signed consent form indicating refusal to have their child participate. Among adolescents who were at school on the days of survey administration, 96.3% had parental consent and chose to participate.

Weight status—Research staff measured adolescents' height and weight in a private area at each school. Height was assessed to the nearest 0.1 cm using a Shorr Board and weight to the nearest 0.1 kg using a calibrated scale. Body mass index (BMI) was calculated and converted to z-scores, standardized for sex and age.

Survey development and measures—Development of the EAT 2010 survey was guided by a review of previous Project EAT surveys to identify the most salient items; the study's theoretical framework; expert review by professionals from different disciplines; and extensive pilot testing with adolescents. The study's theoretical framework (available online at http://www.sph.umn.edu/epi/research/eat/EAT_2010/) integrates social cognitive theory with an ecological perspective (11, 12) to direct attention not only to individual-level personal (e.g., physical activity attitudes) and behavioral factors (e.g., meal patterns), but also to the multiple physical and social environments that potentially influence behavior. Survey items and response options used to assess adolescents' perceptions of home/family, peer, and neighborhood characteristics are described in Table 1, which includes survey measure sources (13–16) and the psychometric properties for scales in the study population where appropriate. Socioeconomic status (SES) and other sociodemographic characteristics were also assessed on the EAT 2010 survey; SES was determined primarily using the higher education level of either parent (17).

Parent/caregiver Survey

Parents/caregivers of adolescent participants were also asked to respond to a survey as part of Project F-EAT (Families and Eating and Activity among Teens) (18). A total of 3,709 parents provided informed consent and responded; 2,382 adolescents had at least one parent respond and 1,327 adolescents had two parents respond. For the current analysis, only data from the adolescent's primary parent (n=2,281, 95.5% female) were used to ensure the most accurate information on usual home environment and data independence. When two parents responded, primary parent status was determined using an algorithm that accounted for the family living situation (preference to parents who lived with their child more than half the time), relationship to the adolescent (preference to biological/adoptive parents), and the parent's gender (preference to females).

Parents were given the options of responding to a written survey by mail or completing a telephone interview. The initial mailing included an invitation letter describing the Project

FEAT study and a telephone number to call if the parent preferred to complete their survey by telephone. Additional follow-up contact attempts were made to non-responders by mail and telephone as needed. The majority of respondents (77.8%) completed a paper survey by mail. Measures included on the written survey and telephone interview were reviewed by a panel of content-area experts and bi-cultural research staff to address cultural sensitivity, and pilot tested with parents of adolescents. Parent survey items and response options used to assess perceptions of home/family and neighborhood environment characteristics are described in Table 1.

Friendship Nominations

Peer environment data were collected by asking adolescents to nominate up to six of their closest friends (up to three boys and three girls) within their school by selecting friends' identification numbers from a comprehensive school list (19). Adolescents were permitted to nominate fewer than six friends as well as to nominate friends outside of their school using a generic code number. Data provided by each nominated friend on his or her own EAT 2010 survey were linked back to the nominator, allowing for the creation of variables to describe peer environments (see Table 1). All nominated friend variables were calculated separately for male and female friends and all nominated friends were used, regardless of friendship reciprocity, to examine weight-related behaviors and the prevalence of overweight among peers of adolescent participants.

School Personnel Surveys

At each participating school, surveys were completed by an administrator, food service professional, and physical activity teacher. Administrators reported on policies and practices of relevance to weight-related health and their schools' commitment to promoting healthy eating and physical activity. Food service professionals reported on school food availability and policies. Teachers reported on the availability of physical education facilities and equipment. All participating personnel were instructed to respond in regard to the 2009–2010 academic year and encouraged to confer with others at their school if they were unsure of policies or practices. School survey items and response options used in the current analysis are described in Table 1.

GIS Data Sources

GIS data sources were used to examine food access, physical activity opportunities, and crime within residential neighborhood environments and food access within school neighborhoods. Network buffer distances of 1200 m were selected for examining access to fast-food restaurants and convenience stores in residential neighborhoods as prior research has found that adolescents perceive an easy walking distance to be about 15 minutes and the average participant in this study was not of driving age (20). For the school neighborhood assessment, smaller network buffers of 800 m were selected to better capture food access within a distance that might be easily traveled by students during the school day. ArcGIS Version 9.3.1 (Esri, 2009, Redlands, CA, USA, 2009) was used for geocoding each adolescent's home address and school addresses, and GIS variables were defined following previously published protocols (21, 22). GIS data sources included land-use data, transit route data from MetroGIS (23), police reports, and commercial databases (accessed through

Esri Business Analyst, 2010). Additional details of the GIS variables are described in Table 1.

Statistical Analysis

Analyses were conducted using the Statistical Analysis System (SAS, version 9.2, 2008, SAS Institute, Cary, NC, USA). In total, 51 variables representing characteristics of adolescents' environments were examined in terms of their association with and ability to predict BMI z-score. We used three different regression modeling strategies, which provided complementary information about the relationships between environmental characteristics and BMI z-score. First, separate linear regression models were used to examine the relationship between each environmental variable and BMI z-score (Model 1). A second model, simultaneously including all environmental variables, was then used to identify the strongest correlates of BMI z-score across the ecological contexts based on *P* values (Model 2). Third, we used an exhaustive search variable selection strategy that chose the best predictive subset from all 51 environmental variables according to the adjusted R-square (Model 3).

The third strategy provided a ranking in terms of adjusted R-square for all possible different models (i.e., combinations of included/excluded variables). Model 3 provided a compromise between Model 1 (each variable included separately) and Model 2 (all variables included simultaneously) by allowing for simultaneous controlling of variables, but only among those variables that independently added to the overall prediction. Using the Furnival and Wilson algorithm, this third strategy did not require that all 2^{51} possible models be examined in order to choose the top ranked models (24). In order to ensure robustness of the final set of variables for Model 3, we chose only those that were selected in all 100 top-ranked models. Results were also examined based on the 1,000 top-ranked models and were found to not differ substantially.

Both Model 2 and Model 3 simultaneously included variables from multiple contexts in the regression model. It is likely the case that some variables causally influence other variables in the model. For example, neighborhood fruit/vegetable availability likely influences home healthy food availability. Thus, it is important to recognize the interpretation of the resulting beta coefficients from these mutually-adjusted models as direct effects that are unmediated and unconfounded by the other variables being examined. To continue the example, a beta coefficient for neighborhood fruit/vegetable availability in a regression model that also includes home healthy food availability represents the direct association of neighborhood availability on BMI z-score that is unmediated (i.e., not explained) by home food availability while a beta coefficient for home food availability represents the direct association of this variable with BMI z-score that is not confounded by neighborhood availability. Through mutual adjustment and examination of significant beta coefficients, Models 2 and 3 identify the most salient set of variables that are independently and directly associated with BMI z-score.

All regression models were stratified by gender and controlled for adolescent age in years, SES, and race/ethnicity; peer environment variables representing nominated friend data were adjusted for the number of male and female friends nominated and present in the sample.

Additionally, all non-dichotomous variables were standardized to allow for relative comparisons of strength between observed associations. In Models 1 and 2, a random school-level effect was included when examining school environment variables to ensure that standard errors would correctly account for the number of participating schools. Adjusted R^2 values were examined for Models 2 and 3 to determine the total variance explained by all environmental variables. For Models 1 and 2, a *P* value of <0.05 was used to determine statistical significance. No explicit control for multiple comparisons was performed, but all *P* values are presented to three decimal places. Focusing on prediction, Model 3 does not utilize *P* values but does provide a standard error type estimate for the regression coefficients corresponding to the standard deviation of the coefficient estimates across the 100 top-ranked models.

There was a varying amount of missing data for each environmental variable, due largely to the use of multiple sources of data (EAT 2010 survey: 0–11%, parent/caregiver survey: 15–21%, friendship nominations: 40–44%, school personnel surveys: 0–2%, and GIS data sources: 2–10%). Taken together, these missing data would have led to the deletion of a substantial number of adolescents from analyses using listwise deletion and a small, biased analytic sample. To avoid dropping adolescent participants from the full analytical sample, multiple imputation for all missing environmental variables was implemented using Proc MI (25, 26). Twenty datasets were generated with all missing data randomly imputed under a multivariate normality and missing at random assumption. All regressions for Models 1 and 2 were performed across all imputed datasets and results were combined and summarized using Proc MIANALYZE, which incorporates uncertainty due to the missing values. Multiple imputation retains the advantage of single dataset imputation (i.e., analysis of a complete dataset) yet rectifies its major disadvantage, namely ignoring variability. Through the generation of several imputed datasets and the subsequent reanalysis of each imputed dataset, the uncertainty associated with the missing observations is accounted for by incorporating the error that arises from variability in the regression coefficients across the set of imputed datasets. Simulation studies routinely show decreased bias and improved efficiency using multiple imputation as compared to other techniques for handling missing data even when the missing fraction for some variables is as large as 50% (27, 28). The Model 3 exhaustive search method was performed on five imputed datasets and each one produced the same set of predictors from the 100 top-ranked models. Thus, only the beta coefficients from the first imputed dataset were presented.

RESULTS

Associations of BMI Z-score with Multi-contextual Characteristics of Environments

In models controlling for sociodemographics, the environmental characteristics found to be significantly associated with a higher BMI z-score among both boys (Table 2, Model 1) and girls (Table 3, Model 1) represented the home/family (lower home availability of unhealthy food, less frequent family meals, less parental pressure to eat, greater parental restriction of high-calorie foods, higher parental BMI), peer (a higher proportion of overweight male friends), and neighborhood (a lower proportion of neighborhood park/recreation space, perceived lack of neighborhood safety during the night and day) contexts. Standardized beta coefficients indicated that parental BMI was among the strongest of these correlates for both genders; the coefficient indicated that with every standard deviation increase in parental BMI (e.g., a shift of 6.2 kg/m^2 from the mean BMI of 28.6 to 34.8 kg/m^2), adolescent BMI z-score increased by approximately 0.27 standardized units or 7.0 BMI percentile points. For comparison, the beta coefficient for boys relating the proportion of male friends who were overweight to BMI z-score implied that for every standard deviation increase in the proportion overweight (e.g., a shift from no overweight friends to 42% of friends being overweight), adolescent BMI z-score increased by approximately 0.14 standardized units or 3.5 BMI percentile points. Among boys, additional characteristics of the home/family environment associated with higher BMI z-scores were household food insecurity and spending more time watching television with a parent. Among girls, additional characteristics associated with higher BMI z-score represented the home/family (e.g., lower home availability of healthy food), peer (e.g., lower moderate-to-vigorous physical activity among female friends), school (e.g., fewer food policies at school), and neighborhood (e.g., neighborhood access to a convenience store) contexts.

Overall Contribution of Environmental Characteristics to Explaining BMI Z-score

To estimate the total variance in adolescent BMI z-score explained by all of the environmental characteristics examined here, comprehensive models were examined that included home/family, peer, school, and neighborhood variables simultaneously along with sociodemographic variables. The total variance (adjusted R-square) explained was 24% for boys and 22% for girls. Of this total variance, the variance explained just by adolescent sociodemographics was 4% for boys and 3% for girls. The results observed for specific characteristics in these models that mutually adjusted for all other environmental characteristics were similar to the results from the initial models that controlled only for sociodemographics; however, fewer associations were statistically significant. Among boys (Table 2, Model 2) and girls (Table 3, Model 2), the environmental characteristics found to be significantly associated with a higher BMI z-score represented the home/family (lower home availability of unhealthy food, less frequent family meals, less parental pressure to eat, greater parental restriction of high-calorie foods, higher parental BMI) and peer (higher proportions of overweight male and female friends) contexts. Additional characteristics of home/family, peer, and neighborhood contexts were associated with higher BMI z-score, but only among girls.

Combinations of Environmental Characteristics Most Predictive of BMI Z-score

The most predictive yet parsimonious sets of environmental characteristics were identified separately for adolescent boys (Table 2, Model 3) and girls (Table 3, Model 3). The total variance explained (adjusted R-square) using the exhaustive search variable selection strategy was 25% for boys and 23% for girls. Environmental characteristics consistently selected in all 100 of the best models predicting higher BMI z-score for both boys and girls included all of the same characteristics identified in Model 2 along with greater encouragement to eat healthy foods, more frequent consumption of fast food among male friends, lower moderate-to-vigorous physical activity among female friends, lack of school neighborhood access to a convenience store, neighborhood access to a convenience store, and a lower proportion of neighborhood park/recreation space.

Additional characteristics were consistently chosen as predictive across all 100 best models, but only in the set of models for boys or girls. Among boys, other characteristics consistently included in all of the 100 best models and associated with higher BMI z-score represented the home/family (e.g., fewer healthy foods served at family meals) and neighborhood (e.g., longer distance to neighborhood recreation center) contexts. Among girls, other characteristics consistently included in all 100 best models and associated with higher BMI z-score also represented the home/family (e.g., less parental modeling of healthy food choices) and neighborhood (e.g., perceived lack of neighborhood safety during the night and day) as well as the peer (e.g., higher sedentary activity among female friends) and school (e.g., lower school commitment to promoting healthy eating) contexts.

DISCUSSION

This study examined a wide variety of potentially modifiable characteristics of adolescents' environments to inform the identification of obesity prevention targets. The results showed associations between adolescent weight status and characteristics of each context, and nearly one quarter of the variance in BMI z-score was explained for boys and girls when factors from within home/family, peer, school, and neighborhood contexts were examined together. The use of three different modeling strategies helped to confirm the relevance of identified characteristics for adolescent obesity. Despite some differences in the models examined for each statistical approach, several characteristics of home/family (e.g., less frequent family meals) and peer (e.g., higher proportion of overweight friends) contexts were consistently associated with weight status among both boys and girls. Additionally, neighborhood characteristics such as perceived lack of safety were consistently associated with higher BMI z-score among girls. Although no school-level characteristics were associated with adolescent weight status consistently across all models, the results suggest that school food access and commitment to promoting healthy lifestyle behaviors may also be influential.

Our results emphasizing the relevance of several home/family characteristics for adolescent weight status are in agreement with previous studies among school-age youth that have considered the potential influence of characteristics within multiple contexts (3–5, 9, 10); however, the cross-sectional nature of the current study should be carefully considered when interpreting observed associations. It is likely that parental recognition of adolescent weight status is reflected in the observed associations of BMI z-score with home unhealthy food availability, parental feeding practices, and parental support for physical activity. The consistent associations between higher BMI z-score and greater overt parental restriction of high-calorie foods is of some concern given previous experimental studies in preschool-age children have demonstrated that restricting access to these foods may lead to increased consumption when the unhealthy foods are subsequently available (29). Two longitudinal studies in older children and adolescents only examined adiposity and not food consumption patterns, but found no evidence to support an association between parental use of restrictive feeding practices and change in adiposity over time (30, 31). Together, these studies suggest overt restrictive feeding practices do not promote healthy eating or prevent excess weight gain. In contrast, covert restrictive practices such as limiting home availability of unhealthy foods have elsewhere shown promise for reducing obesity (32). It is possible the inverse association between home unhealthy food availability and BMI z-score observed in the current study could alternatively reflect a linkage between weight status and lower overall levels of food at home or marginal food insecurity not captured by our brief measure (13).

We identified only one other study that has examined associations of peer environments with adolescent weight status in conjunction with characteristics of other environmental contexts (10). Our findings are further unique in that the one other study relied solely on adolescents' perceptions of their friends' behaviors. In contrast to the findings of Brogan and colleagues (10), we did not find a relationship between perceptions of friends' attitudes about eating healthy foods and the index participant's weight status but instead observed associations with friends' weight status and report of their own behaviors. The observed linkages between adolescent weight status and characteristics of their peer environment could be explained by adolescents selecting friends who are similar to themselves. Alternatively, these associations may be due to various mechanisms of influence, including social facilitation (i.e., the presence of others promotes a behavior), modeling (i.e., beliefs, attitudes, and behavior are shaped by observed behaviors), and impression management (i.e., behavioral regulation to control the impressions formed by other people) (33). Studies addressing the potential influence of friends on adolescent weight status have been inconsistent and there is yet insufficient research available to determine the relative contribution of these different mechanisms to similarities between friends (33).

Among prior studies using an ecological approach to consider the potential influence of characteristics within multiple contexts on child/adolescent weight status, only three have included features of school environments (3, 4, 8). These studies have considered a limited set of potential school influences and either largely relied on the reports of staff and teachers for assessment (3, 8) or included only a small number of schools (4). While the current study enrolled just 20 schools and also relied mostly on school personnel reports, it built on previous studies by including a more comprehensive set of characteristics and utilized GIS to assess food access within school neighborhoods. Our results identified factors including school food policies and neighborhood access to fast-food restaurants as possible contributors to weight status in adolescents; however, in line with other multi-contextual studies (3, 4, 8), few statistically significant relationships were observed and the results were not consistent across gender or models. The findings of these few multi-contextual studies need to be interpreted with caution given their design limitations and mounting evidence in the broader literature which indicates characteristics of school environments that promote healthy eating and physical activity behaviors are important to the prevention of obesity (34).

Our results regarding the relevance of neighborhood characteristics also parallel those reported by other studies that have used an ecological approach in that overall few consistent relationships were observed. Nearly all identified ecological studies among school-age children have included measures of the neighborhood environment (4–9), but GIS was used to assess food retail availability by just one study (4) and one other study to assess access to recreational facilities (5). Both prior studies including GIS measures reported no associations with adolescent weight status. Although the results were not consistent across all models, the current study conversely found living within 1200 m of a convenience store and lower access to recreational facilities were associated with higher BMI z-score among boys and girls. In addition, our results add to the literature on the importance of perceived personal safety, which has been inconsistently related to weight status among youth (35). We found a perceived lack of safety was associated with having a higher BMI z-score among girls, but the same relationship was not found for boys after accounting for other environmental characteristics.

A number of strengths and limitations are important to note in drawing conclusions. The simultaneous assessment of adolescents' home/family, peer, school, and neighborhood environments is a unique strength which allowed for the concurrent examination of potential influences on weight status within each context. To the best of the authors' knowledge, this study represents the most comprehensive examination of environmental correlates of adolescent weight status. Direct collection of information on several aspects of environmental contexts from parents/caregivers, friends, school personnel, and GIS data sources was another strength that limited the potential for self-report bias. Additional strengths of this study include the large size and diversity of the population-based sample, collection of measured heights and weights, and extensive statistical analyses conducted to identify and cross-validate the selection of important correlates of weight status.

Study findings are also subject to certain limitations of the design. As all participants were drawn from just 20 schools within two metropolitan districts, lack of variability between schools and neighborhoods may have limited our ability to detect associations. In order to minimize respondent burden in a comprehensive survey, many of the measures included in the EAT 2010 and Project F-EAT surveys were brief. The brief nature of measures may have led to measurement error and also weakened our ability to detect associations of weight status with characteristics of family/home and peer environments. Similarly, the potential for classification and address errors in the GIS data and use of self-reported school environment data may have weakened observed associations with characteristics of neighborhood and school environments (36, 37). Given the large number of contextual characteristics considered, our regression models focused solely on main effects and specifically linear effects for characteristics modeled by continuous variables. A possible limitation of this modeling strategy is that some associations of BMI z-score with environmental characteristics would only be identified when moderated by others or only at the extreme ends of the variable distribution. Finally, a substantial proportion of adolescents' friends were not captured in the dataset leaving many with missing peer data. The uncertainty due to those missing observations was accounted for by using multiple imputation technique, which has the potential for introducing bias if the missing at random assumption used to generate the imputed data is incorrect. Since a large proportion of the peer data was missing due to our sampling design that included only a fixed number of classrooms, the missing peer data can be reasonably considered missing at random and comparison of demographics for those with and without peer data indicated there were no differences. The amount of missing data for other environmental contexts was relatively minor and multiple imputation technique was also used to avoid dropping a substantial number of adolescents with missing school personnel, parent/caregiver, or GIS data from analyses as doing so might have led to a biased analytic sample.

Conclusions and Implications

Study findings support the importance of responding to calls for obesity prevention research and intervention strategies that address factors of potential influence from multiple contexts (38, 39), particularly proximal social characteristics of home/family and peer environments. Additional research will be required to clarify the results reported here given the complexity of influences on obesity; however, the relationships observed can importantly provide some direction to guide the design of future interventions, policies, and multi-contextual studies. Our results suggest that interventions for parents should discourage the use of overt restrictive feeding practices and instead encourage covert strategies such as modeling healthful food choices at family meals. School-based interventions should consider targeting peer norms to encourage healthy food choices and physical activity. Additionally, while few school-level factors were related to weight status among boys, the observed associations in girls suggest that schools should implement policies that reflect a commitment to the promotion of healthy eating and physical activity. Finally, community-based interventions should consider addressing access to convenience stores and recreational facilities as well as safety concerns with particular attention to factors that may inhibit physical activity among adolescent girls.

In regards to future research, there is a particular need for longitudinal multi-contextual studies in diverse population groups to help clarify the temporal nature of relationships. While the current study examined 51 potential contextual influences, future studies will need to consider other environmental characteristics along with individual characteristics in order to explain additional variance in adolescent BMI z-score or changes in weight status over time. For example, given the cross-sectional design, the current study did not examine aspects of weight culture within various contexts (e.g., parental encouragement to diet, peer weight control behavior norms, school policies regarding weight-related teasing) or individual weight control behaviors. Multi-contextual longitudinal studies are needed to consider the contribution of such factors as several prospective studies have shown an association between restrictive weight control behaviors and weight gain during adolescence and the transition to adulthood (40). Further, studies that enroll adolescents disbursed within broader geographic areas are needed to examine other school and neighborhood-level factors such as open campus policies, food prices, and neighborhood connectedness. The observed differences across gender in identified correlates of adolescent BMI z-score additionally suggest that future population-based research should separately consider influences on weight status for boys and girls. Future studies will moreover need to examine potential interactions among individual and multi-contextual environmental characteristics to better inform obesity prevention efforts by answering important questions such as what home/family characteristics can buffer the influence of living in a disadvantaged neighborhood.

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Table 1

Description of home/family, peer, school, and neighborhood environment measures[a,b]

	Source[a]	Survey items or description
Home/family characteristics		
Home healthy food Availability	A	*How often are the following true?* Five statements (e.g., *Fruits and vegetables are available in my home*). Four responses ranging from *never* to *always*; Cronbach's α = 0.62.
Home unhealthy food Availability	A	*How often are the following true?* Four statements (e.g., *Potato chips or other salty snacks are available in my home*). Four responses ranging from *never* to *always*; Cronbach's α = 0.79.
Household food Insecurity	P	Six-item short form of the U.S. Household Food Security Survey Module (13). Households with scores ≥2 were categorized as food insecure.
Family meal frequency	A	*During the past seven days, how many times did all, or most, of your family living in your house eat a meal together?*
Healthy food served at family meals	P	*Think about a typical family dinner at your home.* Five questions (e.g., *Is a green salad served?)*. Four responses ranging from *never or rarely* to *always*; Cronbach's α = 0.54.
Fast food for family Meals	P	*During the past week, how many times was a family meal purchased from a fast-food restaurant and eaten together either at the restaurant or at home? (pizza counts)*
TV during dinner	A	*In my family, we often watch TV while eating dinner.* Four responses ranging from *strongly disagree* to *strongly agree*.
Encouragement to eat healthy foods	A	*My mother (father) encourages me to eat healthy foods.* Four responses ranging from *not at all* to *very much*. Average scores were determined based on responses for mother and father.
Parental pressure to eat	P	Pressure to eat subscale of the Child-Feeding Questionnaire (14). *How much do you agree with the following statements?* Four statements (e.g., *If my child says "I'm not hungry," I try to get him/her to eat anyway.).* Four responses ranging from *disagree* to *agree*; Cronbach's α = 0.70.
Parental restriction of high-calorie food	P	Modified restriction subscale of the Child-Feeding Questionnaire (14). *How much do you agree with the following statements?* Six statements (e.g., *If I did not guide or regulate my child's eating, he/she would eat too much of his/her favorite foods.*). Four responses ranging from *disagree* to *agree*; Cronbach's α = 0.86.
Parental role modeling of food choices	A	*My mother … (1) eats a lot of fruit; (2) eats vegetables at dinner; (3) drinks milk at dinner.* Same statements for father. Four responses ranging from *never* to *rarely*; Cronbach's α = 0.71.
Parental fast food intake	P	*In the past week, how often did you eat something from a fast-food restaurant, such as McDonald's, Burger King, Domino's, or similar places (pizza counts)?*
Home resources for PA	P	*Do you have the following items in your home, yard, or apartment complex that would be available to your child?* Five types of exercise equipment (e.g., *stationary aerobic equipment [bicycle, treadmill, etc.]).* Yes/no responses were summed to form a score.
Parental time spent supporting PA	P	*In a typical week, how many hours do you spend helping your child to be physically active (e.g., driving them to the gym or sport practice, watching them play a sport)?*
Parental time spent being active with adolescent	P	*In a typical week, how many hours do you spend being physically active with your child (e.g., throwing a ball around, taking a walk or bike ride together)?*
Parental time spent watching TV with adolescent	P	*In a typical week, how many hours do you spend watching TV/movies together with your child?*
Parental weight status	P	*How tall are you? How much do you weigh?* Body mass index was calculated.
Peer characteristics		

	Source[a]	Survey items or description
Friends' attitudes about eating healthy foods	A	*Many of my friends think it is important to eat healthy foods like fruits and vegetables.* Four response options ranging from *not at all* to *very much*.
Friends' support for PA	A	*How strongly do you agree with the following statements?* Three statements (e.g., *My friends often play sports or do something active.*). Four response options ranging from *strongly disagree* to *strongly agree*; Cronbach's $\alpha = 0.77$.
Friends' fast-food frequency	F	*In the past month, how often did you eat something from the following types of restaurants (include take-out and delivery)?* Responses for five types of fast-food restaurants were summed to determine total fast-food frequency and the average of nominated friends' responses was calculated.
Friends' moderate-to- vigorous PA	F	Modified version of the Leisure-time Exercise Questionnaire (16). Two questions assessed hours spent in strenuous or moderate PA behaviors in a usual week. The average of nominated friends' responses was calculated.
Friends' sedentary activity	F	*In your free time on an average weekday (Monday–Friday), how many hours do you spend doing the following activities? 1) Watching TV/DVDs/videos; 2) Using a computer (not for homework); 3) Xbox/Play-station/other electronic games that you play when sitting.* Same statements for an average weekend day. Responses were summed and weighted to yield average total number of sedentary hours per week. The average total number of sedentary hours per week among nominated friends' responses was calculated.
Friends' weight status	O	BMI was calculated and overweight status was determined for each nominated friend based on a sex- and age-specific reference value. The proportion of nominated friends who were overweight ($\geq 85^{th}$ percentile) was calculated.
School characteristics		
Presence of fast-food restaurant in 800 m	N	Commercial databases were used along with NAICS codes (722110, 722211, 722212, and 722213) to identify restaurants and both chain names and 18 key words (e.g., take out, fried, pizza) were used to identify fast-food restaurants within network buffers.
Presence of convenience store in 800 m	N	Commercial databases were used along with NAICS codes (44512, 44711, and 44719) to identify convenience stores, including gas stations, within network buffers.
Indoor campus PA facilities	ST	*Which of the following facilities does this school have access to for indoor physical education?* Yes/no responses for nine types of indoor facilities (e.g., *gym*) were summed to form a score.
Outdoor campus PA facilities	ST	*Which of the following facilities does this school have access to for outdoor physical education?* Yes/no responses for seven types of outdoor facilities (e.g., *outdoor basketball court*) were summed to form a score.
Campus availability of competitive foods	SF	*Are there any vending machines in your school that are available to students before or during the school day? Does your school offer a la carte options at lunch?* Yes/no responses were summed to form a score.
Competitive food policies	SF	*Are there any school policies about the types of food or beverages that can be sold in the school vending machines? Are there any school policies about the types of foods or beverages that can be sold a la carte at lunch?* Yes/no responses for vending and a la carte policies were combined with information about campus availability to form a score (0=no competitive food available, 1=policies for competitive foods available, 2=no policies for competitive foods available).
Other food policies	SF	*Does your school have any other food policies that are in addition to the school district wellness policy?* Yes/no response option.
Classroom food policies	SA	*Please indicate whether any of the following practices occur at your school.* Three response options included *no; yes, it is up to the teacher; yes, but it is discouraged.* Responses were dichotomized for three practices: 1) students are allowed to eat breakfast during class; 2) students are allowed to consume food and/or beverages other than water during class; and 3) food is used as a reward for good behavior and/or academic performance.
Schools' commitment to promoting healthy eating	SA	*In your opinion, to what extent has your school made a serious/real effort to promote healthy food and beverage habits among students?* Five response options ranging from *not at all* to *a very great extent*.
Schools' commitment to promoting PA	SA	*In your opinion, to what extent has your school made a serious/real effort to promote increased physical activity among students?* Five response options ranging from *not at all* to *a very great extent*.
Neighborhood characteristics		

	Source[a]	Survey items or description
Presence of fast-food restaurant in 1200 m	N	Commercial databases were used along with NAICS codes (722110, 722211, 722212, and 722213) to identify restaurants and both chain names and 18 key words (e.g., take out, fried, pizza) were used to identify fast-food restaurants within network buffers.
Presence of convenience store in 1200 m	N	Commercial databases were used along with NAICS codes (44512, 44711, and 44719) to identify convenience stores, including gas stations, within network buffers.
Limited variety of fruits/vegetables	P	*At the store where I buy my groceries, the variety of fresh fruits and vegetables is limited.* Four response options ranging from *strongly disagree* to *strongly agree*.
Poor quality of fruits/vegetables	P	*At the store where I buy my groceries, the condition of fruits and vegetables is poor.* Four response options ranging from *strongly disagree* to *strongly agree*.
Distance to nearest recreation center	N	Commercial and public databases were used to identify the nearest recreation center, community center, or school along the road network. Distance in meters was dichotomized at the median.
Distance to nearest gym/fitness center	N	Commercial databases were used along with NAICS code 71394 (71394001 through 71394028) to identify the nearest gym/fitness center along the road network. Distance in meters was dichotomized at the median.
Distance to walking/biking trail	N	Data from the Metropolitan Council were used to determine the straight line distance in meters to the closest pedestrian or biking trail. Distance in meters was dichotomized at the median.
Park/recreation space within 1600 m	N	Data from the Metropolitan Council were used to determine the proportion of land used for parks and other recreational purposes within straight line buffers. Percent area was dichotomized at the median.
Perceived lack of safety (%)	A	Two items from the Neighborhood Environment Walkability Scale (15). *Please choose the answer that best applies to you and the neighborhood where you lived for the majority of the past year. 1) The crime rate in my neighborhood makes it unsafe to go on walks during the day; 2) The crime rate in my neighborhood makes it unsafe to go on walks at night.* Response options were dichotomized (disagree vs. agree) to form a score indicating perceived safety in the day and night.
Density of total crime incidents	N	Data from local police departments were used to determine counts of all personal and property crimes committed in 2010. The total count per hectare was dichotomized at the median.

[a] A, adolescent report; F, friend report; N, Geographic Information System data sources; O, measured; P, parent report; SA, school administrator; SF, school foodservice manager; ST, school physical activity teacher

[b] NAICS, North American Industrial Classification System; PA, physical activity

Table 2

Boys (n=1,307): Associations of social and physical environment characteristics with adolescent BMI z-score

	Model 1		Model 2		Model 3
	β (SE)[b,c]	*P*	β (SE)[b,d]	*P*	β (SE)[b,e]
Home/family characteristics					
Home healthy food availability	−0.034 (0.029)	0.241	0.001 (0.033)	0.968	-
Home unhealthy food availability	**−0.075 (0.028)**	**0.008**	**−0.073 (0.029)**	**0.011**	**−0.074 (0.002)**
Household food insecurity	**0.131 (0.065)**	**0.042**	0.048 (0.063)	0.449	-
Family meal frequency	**−0.056 (0.028)**	**0.048**	**−0.062 (0.028)**	**0.025**	**−0.058 (0.003)**
Healthy food served at family meals	−0.057 (0.031)	0.067	−0.038 (0.030)	0.204	**−0.052 (0.001)**
Fast food for family meals	0.011 (0.030)	0.715	−0.009 (0.031)	0.775	-
TV during dinner	−0.019 (0.028)	0.496	−0.036 (0.028)	0.186	**−0.040 (0.002)**
Encouragement to eat healthy foods	0.038 (0.029)	0.184	0.059 (0.032)	0.069	**0.054 (0.006)**
Parental pressure to eat	**−0.236 (0.033)**	**<0.001**	**−0.280 (0.031)**	**<0.001**	**−0.291 (0.001)**
Parental restriction of high-calorie food	**0.177 (0.030)**	**<0.001**	**0.201 (0.029)**	**<0.001**	**0.210 (0.001)**
Parental role modeling of food choices	−0.014 (0.029)	0.629	−0.022 (0.033)	0.506	-
Parental fast food intake	0.013 (0.030)	.662	0.019 (0.032)	0.550	-
Home resources for PA	−0.003 (0.032)	0.914	0.015 (0.033)	0.651	-
Parental time spent supporting PA	−0.011 (0.030)	0.721	0.005 (0.032)	0.870	-
Parental time spent being active with adolescent	0.019 (0.030)	0.530	0.015 (0.032)	0.631	**0.049 (0.002)**
Parental time spent watching TV with adolescent	**0.076 (0.031)**	**0.014**	0.027 (0.032)	0.389	-
Parental weight status	**0.265 (0.031)**	**<0.001**	**0.216 (0.031)**	**<0.001**	**0.223 (0.002)**
Peer characteristics					
Friends' attitudes about eating healthy foods	0.020 (0.029)	0.496	0.039 (0.028)	0.171	-
Friends' support for PA	−0.043 (0.028)	0.119	−0.015 (0.028)	0.601	-
Male friends'					
Fast-food frequency	0.043 (0.036)	0.233	0.043 (0.033)	0.191	**0.037 (0.002)**
Moderate-to-vigorous PA	−0.015 (0.034)	0.671	0.0004 (0.034)	0.990	-
Sedentary activity	0.007 (0.034)	0.841	−0.015 (0.031)	0.632	-
Weight status	**0.138 (0.034)**	**<0.001**	**0.105 (0.030)**	**<0.001**	**0.117 (0.002)**
Female friends'					

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	Model 1		Model 2		Model 3
	β (SE)[b,c]	*P*	β (SE)[b,d]	*P*	β (SE)[b,e]
Fast-food frequency	−0.043 (0.038)	0.264	−0.025 (0.033)	0.449	-
Moderate-to-vigorous PA	−0.041 (0.038)	0.277	−0.049 (0.034)	0.154	**−0.064 (0.001)**
Sedentary activity	−0.056 (0.037)	0.129	−0.026 (0.034)	0.447	-
Weight status	0.052 (0.038)	0.173	**0.078 (0.035)**	**0.028**	**0.092 (0.001)**
School characteristics					
Presence of fast-food restaurant in 800 m	−0.008 (0.072)	0.915	0.242 (0.149)	0.104	**0.238 (0.043)**
Presence of convenience store in 800 m	−0.096 (0.058)	0.113	−0.262 (0.143)	0.066	**−0.192 (0.037)**
Indoor campus PA facilities	0.009 (0.034)	0.793	−0.018 (0.061)	0.767	-
Outdoor campus PA facilities	0.052 (0.032)	0.125	0.071 (0.076)	0.352	-
Campus availability of competitive foods	0.019 (0.059)	0.749	−0.028 (0.182)	0.876	-
Competitive food policies					
Available with no competitive food policies	−0.024 (0.117)	0.842	0.213 (0.341)	0.532	-
Available with competitive food policies	0.063 (0.096)	0.523	0.049 (0.290)	0.866	-
Competitive foods not available	-	-	-	-	-
Other food policies	0.012 (0.103)	0.911	−0.319 (0.227)	0.159	-
Classroom food policies					
Allow eating breakfast in class	−0.015 (0.073)	0.832	0.079 (0.110)	0.472	-
Allow other food and beverage in class	−0.009 (0.088)	0.916	0.056 (0.182)	0.758	-
Food used as a reward for grades/behavior	0.080 (0.070)	0.271	0.141 (0.175)	0.422	-
Schools' commitment to promoting healthy eating	0.024 (0.034)	0.483	0.078 (0.078)	0.315	-
Schools' commitment to promoting PA	0.037 (0.036)	0.321	0.053 (0.083)	0.522	-
Neighborhood characteristics					
Presence of fast-food restaurant in 1200 m	0.082 (0.067)	0.222	0.050 (0.069)	0.467	-
Presence of convenience store in 1200 m	0.164 (0.088)	0.063	0.160 (0.092)	0.083	**0.147 (0.005)**
Limited variety of available fruits and vegetables	−0.052 (0.031)	0.088	−0.061 (0.037)	0.098	**−0.059 (0.002)**
Poor quality of available fruits and vegetables	−0.019 (0.030)	0.532	0.009 (0.036)	0.802	-
Distance to nearest recreation center	0.023 (0.056)	0.683	0.065 (0.056)	0.240	**0.087 (0.003)**
Distance to nearest gym/fitness center	0.016 (0.057)	0.783	0.038 (0.056)	0.495	-
Distance to walking/biking trail	−0.036 (0.056)	0.522	−0.017 (0.055)	0.751	-
Park/recreation space	**−0.139 (0.057)**	**0.014**	−0.099 (0.061)	0.102	**−0.096 (0.004)**

	Model 1		Model 2		Model 3
	β (SE)[b,c]	*P*	β (SE)[b,d]	*P*	β (SE)[b,e]
Perceived lack of safety					
During the night	−0.075 (0.069)	0.276	−0.108 (0.067)	0.108	**−0.114 (0.004)**
During the night and day	**0.180 (0.074)**	**0.015**	0.104 (0.072)	0.146	-
Density of total crime incidents	0.013 (0.061)	0.835	−0.013 (0.064)	0.836	-

[a]PA, physical activity

[b]β coefficients are standardized and are interpreted as the amount of standard deviation change in BMI z-scores associated with a 1 standard deviation change in the environmental characteristic.

[c]Model 1 estimates are from separate linear regressions of BMI z-score on specific environmental characteristics adjusted for socioeconomic status, age, and race/ethnicity. Statistically significant associations (*P* value <0.05) are shown in bold.

[d]Model 2 estimates are from a linear regression of BMI z-score that simultaneously included all named environmental characteristics along with socioeconomic status, age, and race/ethnicity. Statistically significant associations (*P* value <0.05) are shown in bold.

[e]Model 3 estimates represent the mean regression coefficient across the 100 most predictive (based on adjusted R-square) models with adjustment for socioeconomic status, age, and race/ethnicity. Standard deviations of those regression coefficients are shown in parentheses. Only estimates for environmental characteristics which appeared in each of the 100 most predictive models are shown and all estimates are shown in bold.

Table 3

Girls (n=1,486): Associations of social and physical environment characteristics with adolescent BMI z-score

	Model 1		Model 2		Model 3
	β (SE)[b,c]	*P*	β (SE)[b,d]	*P*	β (SE)[b,e]
Home/family characteristics					
Home healthy food availability	**−0.070 (0.027)**	**0.010**	−0.009 (0.030)	0.774	-
Home unhealthy food availability	**−0.130 (0.026)**	**<0.001**	**−0.110 (0.026)**	**<0.001**	**−0.106 (0.002)**
Household food insecurity	0.034 (0.060)	0.575	−0.045 (0.058)	0.433	-
Family meal frequency	**−0.122 (0.026)**	**<0.001**	**−0.086 (0.026)**	**<0.001**	**−0.087 (0.001)**
Healthy food served at family meals	−0.025 (0.029)	0.385	−0.027 (0.027)	0.314	-
Fast food for family meals	0.018 (0.028)	0.524	−0.014 (0.029)	0.645	-
TV during dinner	0.029 (0.026)	0.268	0.022 (0.025)	0.379	-
Encouragement to eat healthy foods	0.037 (0.027)	0.165	**0.076 (0.031)**	**0.013**	**0.067 (0.001)**
Parental pressure to eat	**−0.206 (0.030)**	**<0.001**	**−0.260 (0.030)**	**<0.001**	**−0.250 (0.002)**
Parental restriction of high-calorie food	**0.220 (0.028)**	**<0.001**	**0.258 (0.028)**	**<0.001**	**0.251 (0.002)**
Parental role modeling of food choices	**−0.064 (0.027)**	**0.016**	**−0.062 (0.031)**	**0.044**	**−0.072 (0.001)**
Parental fast food intake	**0.068 (0.028)**	**0.016**	0.049 (0.031)	0.111	**0.051 (0.006)**
Home resources for PA	0.034 (0.029)	0.240	0.004 (0.027)	0.874	-
Parental time spent supporting PA	0.047 (0.028)	0.092	**0.064 (0.031)**	**0.039**	**0.080 (0.002)**
Parental time spent being active with adolescent	0.011 (0.028)	0.695	0.001 (0.030)	0.977	-
Parental time spent watching TV with adolescent	0.015 (0.028)	0.582	−0.006 (0.029)	0.836	-
Parental weight status	**0.273 (0.028)**	**<0.001**	**0.216 (0.027)**	**<0.001**	**0.196 (0.001)**
Peer characteristics					
Friends' attitudes about eating healthy foods	0.023 (0.028)	0.416	0.016 (0.028)	0.571	-
Friends' support for PA	−0.008 (0.026)	0.766	0.003 (0.027)	0.919	-
Male friends'					
Fast-food frequency	−0.035 (0.038)	0.356	−0.016 (0.029)	0.581	**−0.036 (0.002)**
Moderate-to-vigorous PA	−0.025 (0.037)	0.502	−0.016 (0.032)	0.609	-
Sedentary activity	0.003 (0.037)	0.938	−0.0002 (0.034)	0.996	**−0.037 (0.001)**
Weight status	**0.095 (0.037)**	**0.010**	**0.067 (0.033)**	**0.047**	**0.035 (0.001)**
Female friends'					

	Model 1		Model 2		Model 3
	β (SE)[b,c]	*P*	β (SE)[b,d]	*P*	β (SE)[b,e]
Fast-food frequency	0.030 (0.033)	0.359	0.010 (0.031)	0.751	-
Moderate-to-vigorous PA	**−0.073 (0.032)**	**0.025**	**−0.065 (0.031)**	**0.039**	**−0.073 (0.002)**
Sedentary activity	0.024 (0.032)	0.448	0.017 (0.031)	0.581	**0.038 (0.002)**
Weight status	**0.115 (0.032)**	**<0.001**	**0.072 (0.027)**	**0.007**	**0.093 (0.003)**
School characteristics					
Presence of fast-food restaurant in 800 m	0.035 (0.057)	0.550	−0.012 (0.139)	0.932	-
Presence of convenience store in 800 m	0.021 (0.056)	0.717	−0.153 (0.129)	0.238	**−0.129 (0.018)**
Indoor campus PA facilities	−0.024 (0.028)	0.405	−0.049 (0.056)	0.378	-
Outdoor campus PA facilities	−0.015 (0.027)	0.581	0.025 (0.066)	0.698	-
Campus availability of competitive foods	−0.013 (0.048)	0.790	0.020 (0.166)	0.903	-
Competitive food policies					
Available with no competitive food policies	−0.128 (0.098)	0.213	0.064 (0.326)	0.845	-
Available with competitive food policies	−0.080 (0.081)	0.337	−0.028 (0.269)	0.916	-
Competitive foods not available	-	-	-	-	-
Other food policies	**−0.170 (0.077)**	**0.042**	−0.090 (0.220)	0.681	-
Classroom food policies					
Allow eating breakfast in class	−0.016 (0.058)	0.785	−0.013 (0.101)	0.898	-
Allow other food and beverage in class	0.086 (0.065)	0.204	0.075 (0.162)	0.641	-
Food used as a reward for grades/behavior	0.053 (0.061)	0.392	0.004 (0.153)	0.979	-
Schools' commitment to promoting healthy eating	−0.057 (0.028)	0.058	−0.074 (0.075)	0.325	**−0.088 (0.011)**
Schools' commitment to promoting PA	**−0.071 (0.029)**	**0.026)**	−0.034 (0.074)	0.643	-
Neighborhood characteristics					
Presence of fast-food restaurant in 1200 m	0.046 (0.062)	0.458	−0.059 (0.065)	0.365	-
Presence of convenience store in 1200 m	**0.227 (0.080)**	**0.004**	**0.180 (0.083)**	**0.030**	**0.181 (0.010)**
Limited variety of available fruits and vegetables	**−0.058 (0.028)**	**0.038**	−0.047 (0.033)	0.156	-
Poor quality of available fruits and vegetables	−0.029 (0.028)	0.298	−0.028 (0.033)	0.387	**−0.049 (0.005)**
Distance to nearest recreation center	0.003 (0.052)	0.959	−0.015 (0.053)	0.770	-
Distance to nearest gym/fitness center	0.023 (0.052)	0.651	0.059 (0.053)	0.264	-
Distance to walking/biking trail	0.066 (0.052)	0.207	−0.017 (0.053)	0.755	-
Park/recreation space	**−0.131 (0.052)**	**0.012**	−0.069 (0.054)	0.200	**−0.077 (0.004)**

	Model 1		Model 2		Model 3
	β (SE)[b,c]	*P*	β (SE)[b,d]	*P*	β (SE)[b,e]
Perceived lack of safety					
During the night	**0.105 (0.064)**	**0.101**	0.049 (0.060)	0.412	-
During the night and day	**0.229 (0.064)**	**<0.001**	**0.135 (0.062)**	**0.030**	**0.117 (0.004)**
Density of total crime incidents	**0.150 (0.057)**	**0.008**	0.024 (0.057)	0.670	-

[a]PA, physical activity

[b]β coefficients are standardized and are interpreted as the amount of standard deviation change in BMI z-scores associated with a 1 standard deviation change in the environmental characteristic.

[c]Model 1 estimates are from separate linear regressions of BMI z-score on specific environmental characteristics adjusted for socioeconomic status, age, and race/ethnicity. Statistically significant associations (*P* value <0.05) are shown in bold.

[d]Model 2 estimates are from a linear regression of BMI z-score that simultaneously included all named environmental characteristics along with socioeconomic status, age, and race/ethnicity. Statistically significant associations (*P* value <0.05) are shown in bold.

[e]Model 3 estimates represent the mean regression coefficient across the 100 most predictive (based on adjusted R-square) models with adjustment for socioeconomic status, age, and race/ethnicity. Standard deviations of those regression coefficients are shown in parentheses. Only estimates for environmental characteristics which appeared in each of the 100 most predictive models are shown and all estimates are shown in bold.