DO NEIGHBORHOOD PARKS AND PLAYGROUNDS REDUCE CHILDHOOD OBESITY?

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ABSTRACT:

Using the 2007 National Survey of Children's Health data, we find a statistically and economically significant effect of neighborhood parks and playgrounds on childhood obesity based on covariate matching estimators. The park/playground effect depends on gender, age, race, household income, neighborhood safety, and other neighborhood amenities. The results suggest that adding a neighborhood park/playground may reduce the obesity rate and make children more fit, but relevant interventions must consider socioeconomic status of the targeted children as well as other neighborhood amenities

KEYWORDS: CHILDHOOD OBESITY, PARK/PLAYGROUND, NEIGHBORHOOD AMENITY, MATCHING

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The prevalence of childhood obesity in the United States has risen dramatically across all racial, gender, and ethnic groups since 1980 (Dehghan, Akhtar-Danesh and Merchant, 2005). Childhood obesity has significantly negative health, psychological, and social consequences due to impaired quality of life and increased morbidity (Must and Strauss, 1999; Reilly et al., 2003).

Obesity results from an energy imbalance involving too much caloric intake and/or insufficient physical activity. Lakdawalla and Philipson (2002) find that much of the increase in body weight over the 20th century is due to decreased physical activity, largely from workers moving away from physically demanding jobs/activities and toward sedentary ones. The 2009 National Youth Risk Behavior Survey conducted among 9th through 12th graders in both public and private schools in the United States reports that 23% of students did not participate in at least 60 minutes of physical activity on at least one day over a period of seven days before the survey (NYRBS, 2009). The notion of an "obesogenic environment" has been proposed and modeled to investigate how the built environment and socio-economic deprivation at the community level affect childhood obesity (Caballero, 2007; Papas et al., 2007). Among all the factors incorporated in the models of an obesogenic environment, availability of and access to neighborhood amenities (e.g., physical facilities) is regarded as one of the most important elements affecting childhood obesity and has gained increasing attention in primary prevention (Koplan, Liverman and Kraak, 2005; Papas et al., 2007; USDHHS, 2001). The literature has documented a positive association between a higher level of physical activity and the density of neighborhood recreational facilities (McInnes and Shinogle, 2009) or their proximity and attractiveness (Yancey et al., 2007). This study focuses on neighborhood parks and playgrounds, as they provide physical locations for children to engage in outdoor physical activity and to develop physically active lifestyles. Furthermore, adding a park/playground to a neighborhood is a relatively feasible policy intervention in the battle against childhood obesity.

The objective of this article is twofold. First, we estimate the effect of neighborhood parks/playgrounds on childhood obesity, measured by body mass index (BMI) and the risk of being overweight or obese. Second, we further explore how neighborhood attributes and individual socioeconomic status influence the park/playground effect. We use the 2007 National Survey of Children's Health (NSCH) for the empirical analysis. The 2007 NSCH survey collected information on neighborhood characteristics, particularly, the existence of parks/playgrounds, sidewalks/pathways, and community centers/kids' clubs in each respondent's neighborhood. It also collected a rich set of socioeconomic information about the respondents. The respondents are not randomly assigned to neighborhoods with different amenities. Therefore, we face an endogeneity problem in evaluating the effect of neighborhood parks/playgrounds on obesity using cross-sectional data because a health-conscious individual may self-select into a neighborhood promoting physical activity. We employ a covariate matching technique to address the selection problem and compare the weight status of children having access to neighborhood amenities with that of similar children having no access to neighborhood amenities.

We find that neighborhood parks/playgrounds make children more fit. The reduction in BMI and the risk of being overweight or obese is both statistically and economically significant. We also find that the effect depends on gender, age, race, household income level, neighborhood safety, and other neighborhood amenities. The park/playground effect is greater for girls than boys, for younger cohorts aged 10-13 than adolescents aged 14-17, for non-Hispanic whites than blacks and Hispanics, for children in low-income households than those in high-income households, and for children living in unsafe neighborhoods than those living in safe neighborhoods. Community centers/kids' clubs attenuate the park/playground effect on both boys and girls, but sidewalks/pathways enhance (attenuate) the park/playground effect on boys (girls).

Literature Review

Previous studies in the public health literature support the association between access to neighborhood amenities and more outdoor physical activity and/or less sedentary activity (Gordon-Larsen et al., 2006; Norman et al., 2006; Roemmich et al., 2006; Timperio et al., 2004; Veugelers et al., 2008). Living in a neighborhood with walkable and connected sidewalks and crosswalks, a large density of different types of destinations such as schools, stores, and parks, and high levels of connectivity between destinations is found to be associated with an increase in physical activity. However, the effectiveness of neighborhood amenities on physical activity depends significantly on neighborhood safety because concerns about neighborhood safety may decrease residents' willingness to engage in outdoor physical activity and curb active commuting (e.g., bicycling). Furthermore, residing in an unsafe neighborhood may also increase stress and result in a less active lifestyle (Björntorp, 2001; Roemmich et al., 2007), especially when exposed to neighborhood violence (Kliewer, 2006).

Although the association between neighborhood amenities and physical activity is well established in the literature, the relationship between neighborhood amenities and obesity is less clear. Some studies find that neighborhood amenities are related to a lower prevalence of overweight or obesity (Gordon-Larsen et al., 2006; Veugelers et al., 2008), but others find no statistically significant relationship (Burdette and Whitaker, 2004; Norman et al., 2006). Using the Children's Lifestyle and School Performance Study of Canada, Veugelers et al. (2008) find that children in neighborhoods with good access to playgrounds, parks, and recreational facilities are less likely to be overweight or obese. Using a survey of low-income preschoolers living in Cincinnati, Ohio, Burdette and Whitaker (2004) find that proximity to playgrounds is not related to the prevalence of being overweight.

Economic studies investigating the causal link between neighborhood environment and childhood obesity are sparse. Kling et al. (2007) take advantage of the Moving to Opportunity (MTO) program to investigate the neighborhood effect on adult health. The MTO program is a randomized housing mobility experiment in which families living in a distressed poor neighborhood in one of five cities (Baltimore, Boston, Chicago, Los Angeles, and New York) were randomly offered vouchers to move to private housing units in a lower-poverty neighborhood. The authors find a significant reduction in the prevalence of adult obesity for the treated group relative to the control group. However, the MTO program is expensive. Kling et al. (2007) do not identify the specific neighborhood factors contributing to the reduction in obesity, which limits the study's practical relevance for interventions. Sandy et al. (2009) combine data on recreational trails and violent crimes with anthropomorphic and diagnostic data from children's clinic visits in Indianapolis between 1996 and 2005 to study the effects of urban environment on childhood obesity. The authors assume that any change in neighborhood amenities were exogenous to children who remained at the same address prior to and following the change. They find that the arrival of amenities are unrelated to children's BMI, but physical facilities, such as fitness areas and volleyball courts, lead to statistically significant weight reduction among eight-year old boys.

In a closely related paper, Sandy et al. (2013) find that the presence of a trail nearby reduces children's weight but that the nearby violent crime rate may undermine the trail effect. They attribute the credibility of the trail effect to two facts: (1) the location of trails is likely to be exogenous because trails follow river banks and abandoned railways; and (2) trails are unlikely to be factored into the house location choice among families, as there is very limited time between their announcement and construction. However, as the authors admit, families may self-select into neighborhoods with different neighborhood crime levels.

Overall, the literature on childhood obesity focusing on the built environment investigates the association rather than causality and offers conflicting results. The documented association between childhood obesity and neighborhood amenities is not adequate to establish a causal relationship and provide policy implications given the possibility of self-selection (Plantinga and Bernell, 2007; Sandy et al., 2009). The built environment may be associated with obesity through either self-selection or environmental determinism. That is, individuals who want to be physically active may select an environment that promotes physical activity (self-selection); or a good environment causes individuals to become more physically active than they would be otherwise, thus reducing the risk of being overweight or obese (environmental determinism). This article focuses on the causal relationship between neighborhood parks/playgrounds and childhood obesity.

Methodologies

This article employs a matching estimator to identify and quantify the causal impacts of neighborhood parks/playgrounds on childhood obesity. Matching techniques have distinct advantages over other non-experimental evaluation techniques. First, matching does not impose any specific functional form between the dependent variable and independent variables, thus avoiding possible model misspecification errors (Rosenbaum and Rubin, 1983). The so-called LaLonde's (1986) critiques suggest that non-experimental estimates are sensitive to model specification and differ greatly from the experimental estimates. Second, matching may impose a common support requirement. The poor overlap on support between the treated and untreated groups raises questions about the robustness of parametric methods relying on the functional form to extrapolate outside the common support (Smith and Todd, 2005). Third, matching allows endogenous covariates (Caliendo and Kopeinig, 2008). However, the validity of matching techniques depends on the assumption of selection on observables. Therefore, falsification tests are necessary to show that unobservables are not driving the matching results.

There are two major types of matching techniques: propensity score matching (PSM) and covariate matching (CVM). This article employs CVM because it allows exact matching on certain variables. Crucial variables such as age and race require exact matching. Age is very important to be controlled precisely because adolescence is a period of increasing self-control over food choices and time use (Haywood, 1991) and the period of fastest growth after infancy. Racial background also needs to be controlled precisely because the literature of childhood obesity has documented significant differences in BMI and the obesity prevalence across racial groups.

The basic idea of CVM is to impute counterfactual outcomes for treated individuals using untreated individuals with similar values of covariates.[1] If the decision to take the treatment is "random" for individuals with similar values of the pretreatment variables or covariates, we can use the average outcome of similar individuals who were not exposed to the treatment as the counterfactual outcome for each individual. Intuitively, comparing two individuals with the same predetermined characteristics, where one is treated and the other is not, is like comparing these two individuals in a randomized experiment. A more detailed technical discussion of the matching techniques can be found in Appendix A online.

Data and Diagnosis Analysis

The article uses the 2007 NSCH dataset, which contains a nationally representative random sample of households in each of the 50 states and the District of Columbia. The survey was designed to examine the physical and emotional health of children from birth to age 17. One child is randomly selected from each household. The 2007 NSCH collected a rich set of demographic, health, family, school, neighborhood and community information. In particular, three questions were asked about different types of neighborhood amenities: (a) Does a park or playground area exist in your neighborhood? (b) Do sidewalks or walking paths exist in your neighborhood? and (c) Does a recreation center, community center, or boys' or girls' club exist in your neighborhood? We create three dummy variables for these three neighborhood amenities. The respondents were also asked to state their perception of neighborhood safety by answering the question, "How often do you (surveyed child) feel safe in your community or neighborhood?" Respondents were given four choices: Never, Sometimes, Usually, and Always. We classify a neighborhood as safe if the respondents answered "Always" and as non-safe if the respondents answered "never" or "sometimes." [2]

The article focuses on children aged 10-17 because only 44,015 individuals aged 10-17 out of all 91,532 individuals surveyed were asked to report both weight and height from which their BMI is calculated. BMI, the most popular measurement to determine overweight and obesity, is a reasonable indicator of body fatness for most children and teens. To determine the overweight and obese status, we calculate the z-score based on age- and gender-specific reference percentiles for BMI. Overweight (obesity) is defined as at or above the 85th (95th) percentiles of age- and gender-specific BMI.[3]

Table 1 presents the summary statistics for the three outcome variables across age cohorts as well as by gender, race, and household income levels.[4] It shows that the overweight and obesity rates in our sample are 35.74% and 17.89% for the pre- and early adolescent group (19,999 individuals aged 10-13) and 25.56% and 11.97% for the adolescent group (24,816 individuals aged 14-17). Compared with the younger cohort, the older cohort has an increasing BMI but decreasing prevalence of overweight or obesity, which is consistent with the literature (Flegal and Troiano, 2000). Table 1 also shows that the BMI and the prevalence of being overweight or obese is higher among boys than girls, among Hispanic and Black children than non-Hispanic white children, and among those living below 133% of the federal poverty level than those living above it. The t-tests reported in table 1 show that the weight difference by age cohort, gender, race, and income is statistically significant at the 1% level.

Table 2 compares the prevalence of overweight and obesity between neighborhoods with and without different types of physical facilities. As shown in table 2, a neighborhood with amenities such as playgrounds/parks, sidewalks/pathways, or community centers/kids' clubs, or perceived as being safe is associated with lower BMI as well as a lower prevalence of overweight or obesity. The differences in the weight measures between neighborhoods with and without a particular amenity are statistically significant at the 5% level with an exception of sidewalks/pathways. We also compare distributions of BMI between children living in a neighborhood with and without a park/playground (see Figure D1 in Appendix D online). The comparison suggests a gender-invariant pattern – children living in neighborhoods with a park/playground have a lower probability of being overweight or obese based on the kernel density estimates of BMI. The pattern is consistent across subgroups.

To gauge how the park/playground effect is affected by neighborhood attributes, we also summarize the weight measures for those living in a neighborhood with and without parks/playgrounds conditional on other neighborhood amenities in the second part of table 2. The respondents living in a neighborhood with a park/playground, on average, have a lower BMI and a lower risk of being overweight or obese irrespective of other neighborhood amenities. The only exceptions are for the obesity risk in the neighborhoods where community centers/kids' clubs exist but no sidewalks/pathways as well as in the neighborhoods that are perceived to be always safe, and for the overweight risk in the neighborhoods where both community centers/kids' clubs and sidewalks/pathways exist. Furthermore, regardless of the existence of parks/playgrounds, neighborhoods perceived as being safe, having community centers/kids' clubs but no sidewalks/pathways, or having both sidewalks/playgrounds and community centers/kids' clubs are associated with a lower BMI and a lower prevalence of overweight or obesity compared with their counterparts.

The summary statistics discussed above suggest that (a) both BMI and the prevalence of overweight or obesity differ significantly by age, gender, race, household income level, and the existence of neighborhood amenities; and (b) the impact of neighborhood parks/playgrounds may vary by different socio-demographic groups, perceived neighborhood safety level, and availability of other neighborhood amenities.

Matching Strategies and Main Results

We focus on the average treatment effects of neighborhood parks/playgrounds on the untreated group (*ATU*) because understanding the potential park/playground effect on childhood obesity in neighborhoods without this particular amenity has practical policy implications. The average treatment effect on the untreated group can be written as follows:

(1) $$ATU = E\left(Y_{1i} - Y_{0i} \mid P_i = 0\right)$$

where P_i is the neighborhood park/playground status for individual i and Y_{ti} is the outcome when treated ($t = 1$) and untreated ($t = 0$)

Selection of Matching Variables and Balance Tests

We match on male and female subsamples separately for the following three reasons. First, males and females experience substantially different metabolic processes and types of body development when they are teenagers and adolescents (Tarnopolsky, 1999). Second, neighborhood amenities may affect males and females differently (Gomez et al., 2004; Carver et al., 2008). Third, the data set is sufficiently large to conduct matching separately on males (N = 22,906) and females (N = 21,109).

Implementing covariate matching requires choosing a set of matching variables. No statistical algorithms or rules are available to choose a set of variables that satisfy the identification condition of matching estimators. A rule of thumb is that not all relevant variables should be matching covariates if the sample size of the treated or untreated group is not large enough. Covariates that are not correlated or weakly correlated with outcome or the treatment indicators may exacerbate the common support problem and result in large variances (Imbens, 2004).

Our selection of matching covariates depends on theoretical considerations, regression analyses, and data availability. First, socio-demographic information includes age and race for both genders and whether born in the United States for males. BMI is found to be highly age-dependent among children and adolescents (Cole, Freeman and Preece, 1995; Cole et al., 2000). Racial background is a good way to control for certain genetic factors in a cross-section data set. Because age and race are two extremely important BMI-determining variables, we match age and race precisely. Second, health information includes children's general health status and teeth condition for both genders and whether having a depression problem for females. Third, the physical activity-related information includes television watching time, whether having a TV in the bedroom, and weekly exercise time for both genders, as well as whether the respondents participate in after-school sports for females. Fourth, parental and family information consists of mother's education level, mother's health status, whether the mother was born in the United States, and family income level for both genders, as well as the total number of children in the family for males. Parental and household information is important. For example, the mother's educational level and birth place would be a proxy for the awareness of nutrition and dietary habit. We would expect family income level and the number of children to reflect the unobserved information about household resources and intra-household resource allocation. Fifth, perceived neighborhood characteristics include whether having sidewalks/pathways, whether having community centers and kids' clubs, how often people help each other in the neighborhood, and the perceived neighborhood safety level.

The Overall Treatment Effects of Neighborhood Parks and Playgrounds

The average treatment effects of neighborhood parks/playgrounds on weight status for the untreated group and the corresponding standard errors are presented in panel A of table 3.

The results strongly suggest that neighborhood parks/playgrounds may make children more fit as they decrease BMI as well as the risk of being overweight or obese. The impacts are stronger on females than on males. More specifically, neighborhood parks/playgrounds may reduce the probability of being overweight or obese by approximately three percentage points for males and by five to six percentage points for females. To demonstrate the size of the impact, we divide the treatment effects by the corresponding sample means of the weight status among the untreated group and calculate the percentage change. The results show that neighborhood parks/playgrounds may decrease BMI and the probability of being overweight or obese by 1%, 9%, and 23% for males.[5] The corresponding numbers for females are even greater, namely 2%, 17%, and 28%. We conclude that the effects of neighborhood parks/playgrounds are both statistically and economically significant and that the effects are greater for females than for males.

Childhood obesity causes significant costs. The estimates of the annual direct medical cost for children with excess weight in the United States range from $3 billion (Trasande and Chatterjee, 2009) to $14 billion (Marder and Chang, 2006). The hospital costs alone increased from $35 million during 1979-1981 to $127 million during 1997–1999 measured in 2001 constant U.S. dollars (Ebbeling, et al., 2002). Given the significant decrease in the probability of being overweight or obese resulted from the addition of neighborhood parks/playgrounds, we expect a significant cost saving. Furthermore, childhood obesity has long-lasting negative impacts on adult health, employment, productivity and socioeconomic status (Case, Fretig and Paxson, 2005). From this perspective, the cost saving could be more significant in the long run.

Matching Quality and Robustness Checks of the Main Matching Results

To assess the quality of the estimated treatment effects, we perform the following tasks: (a) assessing the balance of matching variables between the treated and untreated groups before and after matching; (b) adding regional dummies to re-estimate the park/playground effect for a robustness check; and (c) conducting falsification tests to show whether unobserved individual and/or neighborhood characteristics are driving the main results.

A. Balancing Tests

To assess whether matching has been effective, for each matching covariate, we report the mean differences between the treated and untreated groups before and after matching as well as the p-values of t-statistics in table 4.[6] The results show a clear lack of balance for samples before matching: 19 (16) of 23 mean differences for males (females) are statistically significant at the 5% level. Matching improves the balance significantly. After matching, the number of mean differences of statistical significance reduces to 10 for both males and females. Among these 10 covariates whose mean differences are still statistically significant, 6 (7) of them have smaller differences after matching for females (males). The balance is not perfect after matching. First, the statistically significant mean difference continues to exist after matching. Second, for children's health condition, the exercise time and number of kids in the household, and whether people help each other in the neighborhood either become statistically significant, or the size increases after matching. The imperfect match is largely due to the imposed precise match on gender, age, and racial background because precisely matched variables are weighted 1,000 times more than other regular matching variables.

B. Robustness check by incorporating regional dummies as matching variables

Regional variations in food environment and climate conditions may affect the park/playground effect. We re-estimate the main results by including regional dummies as matching variables. However, adding 50 state dummies as matching variables is impractical due to the curse of dimensionality. Instead, we construct two smaller sets of regional dummies using different criteria. First, 50 states are divided into quintiles according to their state prevalence of overweight and obesity among children aged 10 to 17.[7] We then include four quintile dummy variables as matching variables. Second, we divide the whole country into 9 regions according to the definition of the U.S. Census, including New England and Middle Atlantic in the Northeast region; East North Central and West North Central in the Midwest region; South Atlantic, East South Central, and West South Central in the South region; and Mountain and Pacific in the West region.[8] Using the Pacific census division as a base, we include the dummy variables for the other eight census divisions to capture the regional effect. The results using both sets of regional dummies are shown in Appendix B online. It is clear that the estimated treatment effects are qualitatively similar to the main results when regional dummies are not included.

Since we want to use the same set of matching variables when we further explore how individual characteristics and neighborhood attributes affect the park/playground effect on obesity, including these regional dummies will make it harder to find a good match between the treated and untreated groups given the further division of the sample by individual characteristics and neighborhood attributes. Thus, we do not include these regional dummies for the main results, but provide the results of incorporating the regional dummies as a robustness check instead.

C. Falsification Tests

The validity of the main results relies on the assumption of selection on observables. Although covariate matching has been effective in finding similar counterparts in the treated group for each untreated individual and isolating the effect of neighborhood parks/playgrounds on obesity, it remains possible that some unobserved differences between children living in neighborhoods with and without parks/playgrounds may cause bias in the estimated treatment effects. To provide evidence that unobserved individual characteristics and neighborhood attributes are not the major driving factors of the main results, we conduct two types of falsification tests.

First, individuals living in neighborhoods with parks/playgrounds may be more health conscious, potentially leading the park/playground effect to be confounded. In addition, unobserved neighborhood characteristics (e.g., local supply of medical services) may have health impacts on children's health status (e.g., weight status) and consequently result in bias. To test this possibility, we replace the weight measure with a different health indicator, asthma, as the dependent variable. The asthma variable is coded as one if the respondents were diagnosed by a doctor or other health professionals as having asthma and zero otherwise. If the park/playground effect is not confounded by other unobservables affecting health, we should not expect neighborhood parks/playgrounds to have a significant impact on the asthma risk. As shown in panel B of table 3, neighborhood parks/playgrounds have no statistically and economically significant effect on the asthma risk for the untreated group. The result suggests that it is unlikely that some unobserved factors affecting health are driving our main results.

Second, we choose a subgroup of children from the treated group who are similar to the untreated children as a fictitious untreated group. The fictitious untreated children differ from the actual untreated children as the former ones actually live in a neighborhood with parks/playgrounds. We re-estimate the treatment effect of parks/playgrounds on the fictitious untreated group (see panel C of table 3). If unobserved confounding factors affecting children's behavior such as physical activity are driving the results, we should also find significant treatment effects on the fictitious treated group because the fictitious untreated respondents are similar to the actual untreated respondents other than the availability of parks/playgrounds.[9] If there is no confounding factor influencing the park/playground effect on obesity, the estimated park/playground effect for the fictitious untreated group should not be negative and statistically significant.

To construct the fictitious untreated group, we estimate a probit model using the full sample.[10] We then only keep the actually treated group (respondents reporting to have a park/playground in their neighborhoods) and predict the probability of having a neighborhood park/playground for every individual using the estimated probit model. We assign the respondents whose predicted probability of having a neighborhood park/playground is less than half into the fictitious untreated group and the rest into the new treated group. To assess whether the fictitious untreated group successfully mimics the actual untreated group, we compare a large set of characteristics including children's socio-demographic variables, school types, health conditions, and physical activity-related information of children; parental and household information; and neighborhood situations between two groups (see details in Appendix C online). Out of 52 characteristics compared, only 5 (7) out of these 52 characteristics show a significant difference at the 5% level between the two groups for males (females). This finding indicates that the actual and fictitious untreated groups are statistically similar based on the observables. We then re-estimate the park/playground effect on obesity for the fictitious untreated group with the full set of matching variables used for the main results.

As shown in panel C of table 3, none of the estimated park/playground effects for the fictitious untreated group is negative and significant. The evidence that neighborhood parks/playgrounds do not cause the fictitious untreated group to have a lower BMI or a lower probability of being overweight or obese provides support that the unobservables are not likely to be the driving factors of the park/playground effect.

Park/playground Effects by Neighborhood Attributes or Individual Characteristics

We investigate whether the park/playground effect on obesity depends on individual characteristics or neighborhood attributes. [11] More specifically, we examine how the park/playground effect varies by the existence of other neighborhood amenities and perceived neighborhood safety as well as by household income level, age, and race.

DOES THE PARK/PLAYGROUND EFFECT DEPEND ON OTHER NEIGHBORHOOD AMENITIES?

We expect that the effects of a park/playground on the child's weight status depend on the other amenities in the same neighborhood because different amenities could be substitutes or complements for a park/playground to children for outdoor physical activity. The 2007 NSCH data allow us to examine how sidewalks/pathways as well as community centers/kids' clubs in the neighborhood influence the park/playground effect. To achieve this goal, we estimate *ATU* based on four subsamples with different combinations of these two neighborhood amenities. Consequently, the following treatment effects are estimated:

$$(2) \qquad ATU = \begin{cases} P_1 : E\left(Y_{1i} - Y_{0i} \mid P_i = 0,\ S_i = 1\right) \\ P_2 : E\left(Y_{1i} - Y_{0i} \mid P_i = 0,\ S_i = 0\right) \\ P_3 : E\left(Y_{1i} - Y_{0i} \mid P_i = 0,\ R_i = 1\right) \\ P_4 : E\left(Y_{1i} - Y_{0i} \mid P_i = 0,\ R_i = 0\right) \end{cases}$$

where S_i is the status of neighborhood sidewalks/pathways and R_i is the neighborhood community center/kids club for individual *i*. P_1 (P_2) represents the treatment effect of parks/playgrounds on the weight status when sidewalks/pathways are (not) available in the same neighborhood. Similarly, P_3 (P_4) represents the treatment effect of parks/playgrounds when community centers/kids' clubs are (not) available in the same neighborhood. The comparisons between P_1 and P_2, as well as between P_3 and P_4, allow us to investigate whether other neighborhood amenities enhance or attenuate the impacts of neighborhood parks/playgrounds.

The results presented in Panel A of table 5 clearly show that the presence of other amenities affects the neighborhood park/playground effect. In the case of neighborhood sidewalks/pathways, for boys the treatment effects are statistically insignificant when a park/playground coexists with sidewalks/pathways but become statistically significant and greater in magnitude when sidewalks/pathways do not coexist with parks/playgrounds (P_1 vs. P_2 for males). This finding indicates that sidewalks/pathways are likely to be substitutes for neighborhood parks/playgrounds. The situation differs for girls. More specifically, the reduction in the overweight or obesity risk is approximately doubled when a park/playground coexists with sidewalks/pathways (P_1 vs. P_2 for females). However, for girls the results for BMI are not consistent with those for overweight or obesity risk. That is, an absence of neighborhood sidewalks/pathways is associated with a statistically significant and stronger park/playground effect, but the park/playground effect is not statistically significant otherwise. The above results may suggest that parks/playgrounds and sidewalks/pathways are more likely to be complements than substitutes for girls. The comparison between P_3 and P_4 shows that the community centers and/or kids' clubs attenuate the effect of neighborhood parks/playgrounds for both girls and boys. This finding suggests that neighborhood parks/playgrounds and community centers are likely to be substitutes.

Does the Perceived Neighborhood Safety Affect the Park/Playground Effect?

Neighborhood safety may play an important role in the use of neighborhood amenities and affect obesity prevalence. First, concerns about neighborhood safety might decrease residents' willingness to engage in outdoor physical activity, encourage sedentary activity and/or curb active commuting (e.g., bicycling, walking). In the case of modes of active commuting between school and home, approximately half of schoolchildren in the United States walked or bicycled to or from school in 1969 (USFHA, 1972), but fewer than 15% of schoolchildren used active modes of transportation in 2002 (USEPA, 2003). Second, the increased time spent on sedentary activity such as television watching and video game playing may also increase snacking and inappropriate food choices due to television advertising (Speiser, et al., 2005). Finally, residing in an unsafe neighborhood may also increase stress and lead to overweight (Björntorp, 2001, Roemmich, et al., 2007), especially when exposed to neighborhood violence (Kliewer, 2006). The increased sedentary activity, the choice of inactive commute modes, and the decreased physical activity all contribute to overweight and obesity (Must and Tybor, 2005, USDHHS, 2001).

A majority of previous studies measure neighborhood safety by parental or children's subjective assessments. Some studies find a statistical relationship between neighborhood safety and the level of physical activity and/or childhood obesity among girls but not boys (Gomez, et al., 2004), among adolescents but not preschoolers (Burdette and Whitaker, 2005, Burdette and Whitaker, 2004), or in some ethnic groups but not the entire study population (Duncan, et al., 2009). Romero, et al. (2001) find that fourth graders in eight northern California elementary schools reported engaging in a lower level of physical activity when they perceive neighborhood hazards. Duncan, et al. (2009) find that the parental perception of their neighborhood's safety is associated with a low obesity rate. The inconsistent results may be partly due to the complexity of neighborhood safety measures. Neighborhood safety is a complex concept including, but not limited to, diverse components such as traffic safety (Alton et al., 2007), personal injury, bullying, harm from strangers (Alton et al., 2007; Timperio et al., 2004), and threats of interpersonal violence (Carver, Timperio and Crawford, 2008). It is not easy for the respondent to assess the safety level of their neighborhood given the complexity of this concept.

We re-estimate the treatment effect for the untreated group on safe and unsafe subsamples. The safe subsample includes those who report believing that their neighborhood is "always" safe (55.25% of a total of 44,015 observations). The unsafe subsample includes those who report perceiving their neighborhoods as "never" or "sometimes" being safe (9.28% of a total of 44,015 observations).

Estimates are presented in panel B of table 5. Results show that providing a park/playground may lead to a greater reduction in BMI and the probability of being overweight or obese for both boys and girls in an unsafe neighborhood relative to a safe neighborhood. The only exception is for the risk of obesity among boys. Furthermore, the differences in the park/playground effect between safe and unsafe neighborhoods are more significant for females than males. Therefore, adding a neighborhood park/playground to an unsafe neighborhood may be more effective in helping children stay fit than to a safe neighborhood. The reason for this finding may be that neighborhood parks/playgrounds are important locations for children in unsafe neighborhoods to play safely, but children in a safer neighborhood may have other outlets for indoor/outdoor physical activity. For example, over 70% of neighborhoods with parks/playgrounds also have community centers/kids' clubs, whereas less than 40% of neighborhoods without parks/playground have the same facilities. Therefore, the addition of a park/playground provides an opportunity for children to play in a relatively safer place in an unsafe neighborhood, thus encouraging more outdoor physical activity and leading to better weight outcomes.

DOES THE PARK/PLAYGROUND EFFECT DIFFER BY RACIAL AND ETHNIC GROUPS?

There are significant racial and ethnic disparities in obesity prevalence among U.S. children and adolescents (USCDC, 2010). According to the NHANES 2007-2008, among adolescents aged 12-19, Mexican-American boys have the highest prevalence of obesity (28.6%), followed by non-Hispanic black boys (19.8%) and non-Hispanic white boys (16.7%). In addition, non-Hispanic black girls have the highest prevalence of obesity (29.8%), followed by Mexican-American girls (17.4%) and non-Hispanic white girls (14.5%). The 2007 NSCH also provides evidence for racial and ethnic disparities in obesity prevalence. As shown in table 1, the prevalence of obesity among Hispanic and black children aged 10-17 is 21.66%, a rate double that for non-Hispanic white children (11.40%). And the prevalence of overweight for non-Hispanic white children is only 2/3 of that for Hispanic and black children (39.72% vs. 25.75%). Furthermore, the NHANES data for 1988-1994 and 2007-2008 suggest that the racial and ethnic disparities in the prevalence of obesity widened in 2007-2008 (USCDC, 2010). The prevalence of obesity increased by 79% among non-Hispanic girls and 63% among non-Hispanic white girls. During the same periods, the growth rate of the prevalence of obesity doubled among Mexican-American and non-Hispanic black boys (85-90%) compared to non-Hispanic white boys (44%). Based on these statistics, policy interventions targeting Hispanic and black populations are more urgent than other racial groups in combating the childhood obesity epidemic.

We re-estimate the treatment effects on the black and Hispanic subsample and non-Hispanic white subsample and present the results in panel C of table 5. The park/playground effects are negative and statistically significant in all weight measures for non-Hispanic white children. The magnitude of the impact on boys is approximately two to three times larger than that on girls. However, the treatment effects for Hispanic and black children are not as large and significant as that for non-Hispanic white children. The results show that a neighborhood park/playground may reduce the obesity risk among girls and increase the BMI of boys without making them more overweight or obese. Although the results show that the policy intervention targeting non-Hispanic white children is expected to be more effective, we cannot ignore the significance of helping minority children, given that Hispanic and Black children have much higher obesity rates than non-Hispanic white children.

DOES FAMILY INCOME LEVEL AFFECT THE PARK/PLAYGROUND EFFECTS?

The causal effects of neighborhood amenities are likely to be different for children with different household income levels. The 2007 NSCH collected household income information in terms of categories outlined by different federal poverty levels. We divide the 2007 NSCH sample into two subsamples, below and above 133% of the federal poverty level, which is frequently used as a threshold for income eligibility for receiving food and nutrition subsidies through the National School Lunch Program, the School Breakfast Program, and the Supplemental Nutrition Assistance Program. As shown in table 1, compared with those with household income above 133% of the federal poverty level, respondents with household income level below 133% of the federal poverty level have a slightly higher BMI (22.86 vs. 21.29) but much higher overweight and obesity rates (42.32% vs. 26.94% and 24.18% vs. 12.05%).

The matching results of two subgroups are presented in panel D of table 5. We find that the treatment effect on obesity among those with household income below 133% of the federal poverty level is more than double than that among those with household income above 133% of the federal poverty level. This finding, together with the fact that the prevalence of overweight and obesity is documented to be significantly greater among the low-income population, provides support for intervention targeting those with low socioeconomic status.

ARE THE PARK/PLAYGROUND EFFECTS AGE-SPECIFIC?

Due to different metabolic processes and patterns of physical activity among children at different ages, neighborhood parks/playgrounds may affect different age groups differently. Estimating the treatment effect for each age year separately may be problematic because matching requires a large number of observations to obtain a good match, and the sample size of each age year subgroups is too small. Therefore, we divide the sample into two subgroups, the pre- and early adolescents aged 10-13 and adolescents aged 14-17, and re-estimate the treatment effects.

Estimates are presented in panel E of table 5. The results show that the treatment effects are stronger, and more statistically significant among the younger cohort aged 10-13 than the cohort aged 14-17 and that the effects are larger among females than males in the younger cohort. Among the older cohort aged 14-17, we find that the treatment effects on overweight and obesity are both negative and significant for females and that only the treatment on overweight is negative and significant for males. In conclusion, a neighborhood park/playground may be more beneficial to younger children, especially young girls.

Conclusions and Policy Implications

Stopping and reversing the childhood obesity epidemic requires promoting active lifestyle and increasing energy expenditure. Improving neighborhood physical facilities such as parks and playgrounds provides incentives for outdoor activity. However, it is necessary to build evidence on how to intervene. This article estimates the causal effect of neighborhood parks/playgrounds on childhood obesity; it also investigates how the causal effect is attenuated or enhanced by other neighborhood attributes and whether the magnitude of the effect depends on individual demographic and economic factors.

The results suggest that adding a park/playground to a neighborhood may reduce the obesity rate and make children more fit. The reduction in BMI as well as the probability of being overweight or obese is both statistically and economically significant. We also find the following: (1) the causal impact is gender-dependent – on average, the impact is greater among girls than boys; (2) the impact is age-specific – on average, the treatment effect is greater among the younger cohort aged 10-13 compared with those aged 14-17 for both gender groups; (3) the impact is race-specific – non-Hispanic white youth benefit from neighborhood parks and playgrounds much more than blacks and Hispanics; (4) the effect is greater among children in unsafe neighborhoods than among those living in safe neighborhoods; (5) the impact depends on the household income level – children living above 133% of the federal poverty level are more likely to benefit from neighborhood parks/playgrounds, but the magnitude of the effect is greater among those living below the 133% of the federal poverty level if it is statistically significant; and (6) the impact depends on other neighborhood amenities – the existence of community centers/kids' clubs attenuates the effect of parks/playground among both boys and girls, but sidewalks/pathways enhance (attenuate) the effect among boys (girls).

Policy interventions improving a neighborhood's build environment such as adding a park/playground are likely to be effective based on the findings of this article. Furthermore, interventions must consider the socioeconomic status of the targeted children as well as other neighborhood amenities.

Inspired by the park/playground effect found in this article, we envision future research documenting and analyzing the level and frequency of physical activity conditional on the current condition of neighborhood amenities as well as potential increases in physical activity if neighborhood amenities are provided. Such analyses require measures of actual physical activity in neighborhood physical facilities and at home and school to control for confoundness. Unfortunately, such information is not available in the NSCH data. We leave this research question on how to promote an active lifestyle for future research pending on available data and/or funding for field experiments.

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Table 1. Weight Status and Equal Mean Tests by Demographic Characteristics

	BMI		Overweight (%)		Obese (%)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Total sample	21.66	0.06	30.40	0.59	14.79	0.47
Young cohort: 10-13 (N=19,999)	20.69	0.10	35.74	0.87	17.89	0.73
10	19.61	0.18	38.42	1.75	20.28	1.46
11	20.86	0.27	38.44	1.84	20.92	1.65
12	20.75	0.17	33.18	1.76	16.67	1.51
13	21.48	0.15	33.34	1.60	14.06	1.15
Old cohort: 14-17 (N=24,816)	22.55	0.08	25.56	0.78	11.97	0.60
14	21.70	0.14	26.03	1.46	11.79	1.00
15	22.35	0.14	25.63	1.26	11.84	0.90
16	23.07	0.19	27.32	1.76	13.33	1.53
17	23.15	0.16	23.05	1.66	10.86	1.16
Equal mean t-test ($Mean_{young\ cohort} - Mean_{old\ cohort}$)	$t = -14.46^{***}$		$t = 8.61^{***}$		$t = 6.36^{***}$	
Female (N=21,109)	21.45	0.09	27.10	0.84	11.61	0.62
Male (N=22,906)	21.87	0.09	33.65	0.81	17.92	0.70
Equal mean t-test ($Mean_{male} - Mean_{female}$)	$t = 3.26^{***}$		$t = 4.98^{***}$		t = 5.90***	
Hispanic/Black (N=8,787)	22.75	0.14	38.98	1.34	20.88	1.10
Non-Hispanic white (N=31,012)	21.19	0.07	26.26	0.60	12.10	0.50
Equal mean t-test ($Mean_{Hispanic/Black} - Mean_{white}$)	$t = 9.73^{**}$		t = 9.81***		$t = 8.72^{***}$	
Household income relative to the 133% of the Federal poverty level						
Under (N=5,690)	22.90	0.16	41.54	1.46	22.73	1.19
Above (N=34,805)	21.37	0.08	27.88	0.67	12.81	0.53
Equal mean t-test ($Mean_{Under} - Mean_{Above}$)	$t = 8.61^{***}$		t = 9.71***		$t = 8.80^{***}$	

Note: Asterisks (***, **, and *) indicate the statistically significance level at the 1%, 5%, and 10% level, respectively.

Table 2. Weight Status and Equal Mean Tests by Neighborhood Characteristics

	BMI		Overweight (%)		Obese (%)	
Neighborhood Characteristics	No	Yes	No	Yes	No	Yes
Parks/playgrounds	21.94	21.59	33.15	29.63	16.22	14.41
(Yes/No)	(0.13)	(0.08)	(1.18)	(0.68)	(0.90)	(0.55)
Equal mean t-test ($Mean_{no} – Mean_{yes}$)	$t=2.42^{**}$		$t=2.88^{***}$		$t=2.06^{**}$	
Sidewalks/pathways	21.78	21.62	30.99	30.18	16.36	14.23
(Yes/No)	(0.12)	(0.08)	(0.93)	(0.73)	(0.80)	(0.57)
Equal mean t-test ($Mean_{no} – Mean_{yes}$)	t=1.19		t=1.20		$t=2.41^{**}$	
Kids' clubs /community centers	21.84	21.55	32.55	29.28	15.99	14.05
(Yes/No)	(0.12)	(0.08)	(0.99)	(0.74)	(0.80)	(0.58)
Equal mean t-test ($Mean_{no} – Mean_{yes}$)	$t=2.05^{**}$		$t=3.19^{***}$		$t=2.68^{***}$	
Perceived neighborhood safety	22.48	21.67	35.90	30.45	19.23	14.95
(safe vs. unsafe)	(0.21)	(0.09)	(1.76)	(0.82)	(1.39)	(0.65)
Equal mean t-test ($Mean_{unsafe} – Mean_{safe}$)	$t=3.61^{***}$		$t=3.22^{***}$		3.26^{***}	

	Without parks/playgrounds			With parks/playgrounds		
	BMI	Overweight	Obese	BMI	Overweight	Obese
Both sidewalks/pathways and	21.83	28.58	15.92	21.51	29.31	13.56
community centers/kids' clubs	(0.28)	(2.52)	(2.06)	(0.09)	(0.90)	(0.69)
	22.04	34.27	17.45	21.71	30.11	17.06
No sidewalks/pathways nor kids' clubs	(0.18)	(1.62)	(1.35)	(0.34)	(2.17)	(2.04)
Sidewalks/pathways only	22.06	37.23	15.53	21.72	31.30	14.93
	(0.39)	(3.87)	(2.57)	(0.18)	(1.49)	(1.23)
Community centers/kids' clubs only	21.82	31.55	15.35	21.56	27.90	15.61
	(0.24)	(2.08)	(1.69)	(0.21)	(1.71)	(1.52)
Safe neighborhoods	21.75	31.23	14.87	21.64	30.22	14.96

	(0.14)	(1.42)	(0.97)	(0.11)	(0.98)	(0.80)
Unsafe neighborhoods	23.60	43.63	28.99	22.20	33.88	16.80
	(0.63)	(4.02)	(3.97)	(0.20)	(1.93)	(1.36)

Note: Asterisks (***, **, and *) indicate the statistically significance level at the 1%, 5%, and 10% level, respectively.

Table 3. Main Treatment Effects of the Neighborhood Parks/Playground on Childhood Obesity and Falsification Tests

	Female			Male		
	BMI	Overweight	Obese	BMI	Overweight	Obese
			Panel A: Main Results [a]			
Treatment effects	-0.466***	-0.064***	-0.055***	-0.268**	-0.027**	-0.031***
	(0.117)	(0.011)	(0.008)	(0.126)	(0.013)	(0.010)
# of the treated (untreated)[b]		3930 (13441)			4209 (14603)	
			Panel B: Falsification Test 1 [a]			
Asthma as dependent variable		-0.002			-0.015	
		(0.007)			(0.010)	
			Panel C: Falsification Test 2 [a]			
Fictitious treated group	0.931***	0.028	0.015	0.372	0.024	0
	(0.202)	(0.024)	(0.018)	-0.345	-0.029	-0.017

Note: Asterisks (***, **, and *) indicate the 1%, 5%, and 10% statistical significance level, respectively. The NNM uses one neighbor in the untreated group. Numbers in the parenthesis are standard deviation of the estimated treatment effects.

[a] The results are based on the one-neighbor match.

[b] The number of treated and untreated children is the same for all three outcome variables.

Table 4. Balancing Tests of Matching Covariates

		Females		Males	
		Difference[a]	*p*	Difference[a]	*p*
Social-demographic information of children					
Age (year)	Unmatched	0.12***	0.00	0.04	0.29
	Matched	0.00	1.00	0.00	1.00
Non-Hispanic White (yes/no)	Unmatched	0.05***	0.00	0.06***	0.00
	Matched	0.00	1.00	0.00	1.00
Hispanic (yes/no)	Unmatched	-0.03***	0.00	-0.02***	0.00
	Matched	0.00	1.00	0.00	1.00
Black (yes/no)	Unmatched	-0.01*	0.04	-0.02***	0.00
	Matched	0.00	1.00	0.00	1.00
Other race (yes/no)	Unmatched	0.00	0.40	-0.01***	0.00
	Matched	0.00	1.00	0.00	1.00
Child born in the U.S.A. (yes/no)	Unmatched	NA	NA	0.01***	0.00
	Matched	NA	NA	0.00	0.88
Children's health information					
Health condition of the child	Unmatched	0.05***	0.00	0.02	0.17
(from 1=excellent to 5=poor)	Matched	0.10***	0.00	0.08***	0.00
Teeth (1=good; 0=bad)	Unmatched	-0.01	0.12	-0.01***	0.00
	Matched	-0.01	0.12	-0.01	0.30
Child having a depression problem	Unmatched	0.00	0.81	NA	NA
(yes/no)	Matched	0.00	0.46	NA	NA
Physical activity related information of children					
Television watch time (minute)	Unmatched	5.31***	0.00	1.93	0.29
	Matched	9.95***	0.00	9.44***	0.00
A TV set in the kid's bedroom (yes/no)	Unmatched	0.05***	0.00	0.05***	0.00

	Matched	0.01	0.27	-0.01	0.27
Exercise time (minute)	Unmatched	-0.13	0.00	-0.13***	0.00
	Matched	-0.11*	0.02	-0.20***	0.00
Take after-school sports lessons	Unmatched	-0.04***	0.00	NA	NA
(yes/no)	Matched	-0.03*	0.02	NA	NA
Parental and household information					
Mother's education below high school	Unmatched	0.01*	0.04	0.01**	0.01
(yes/no)	Matched	0.01	0.26	0.01	0.23
Mother's education above high school	Unmatched	0.04***	0.00	0.05***	0.00
(yes/no)	Matched	0.02*	0.02	0.02**	0.01
Mother's health condition	Unmatched	0.11***	0.00	0.11***	0.00
(from 1=excellent to 5=poor)	Matched	0.09***	0.00	0.09***	0.00
Mother born in the U.S.A. (yes/no)	Unmatched	0.03***	0.00	0.04***	0.00
	Matched	-0.01	0.16	-0.01	0.14
No. of kids in the household	Unmatched	NA	NA	-0.05***	0.00
	Matched	NA	NA	0.06***	0.00
Household income below the poverty	Unmatched	0.01***	0.00	0.01***	0.00
line (yes/no)	Matched	0.01	0.09	0.01	0.18
Household income in 100-200% of the	Unmatched	0.01	0.15	0.01*	0.03
poverty line (yes/no)	Matched	0.01	0.15	0.01	0.10
Household income in 200-300% of the	Unmatched	0.00	0.77	0.01	0.22
poverty line (yes/no)	Matched	0.01	0.21	0.01	0.46
Perceived neighborhood characteristics					
Neighborhood sidewalks and pathways	Unmatched	-0.52***	0.00	-0.54***	0.00
(yes/no)	Matched	-0.13***	0.00	-0.11***	0.00
Community center/kids' club (yes/no)	Unmatched	-0.30***	0.00	-0.31***	0.00
	Matched	-0.08***	0.00	-0.06***	0.00

Help each other in the neighborhood	Unmatched	-0.02	0.11	-0.05***	0.00
(1=absolutely no to 4=absolutely yes)	Matched	-0.06***	0.00	-0.08***	0.00
Feeling safe in the neighborhood	Unmatched	0.07***	0.00	0.05***	0.00
(from 1=never to 4=always)	Matched	-0.03*	0.02	-0.04***	0.00

Note: Asterisks (***, **, and *) indicate the statistically significant level at zero, one, and five percent, respectively.

[a] Mean differences of each matching covariate between those in the untreated group and those in the treated group. All tests are based on Covariate Matching with one neighbor. The results from matching with five neighbors are similar. T-statistics are calculated as

$$t_{\left(\overline{X}_{Treated}-\overline{X}_{Control}\right)} = \frac{\overline{X}_{Treated} - \overline{X}_{Comparison}}{\sqrt{\frac{\sigma^2_{Treated}}{n_1} + \frac{\sigma^2_{Comparison}}{n_2}}}$$

where n_1 and n_2 are the number of observations for the treatment and untreated groups on the support, respectively.

Table 5. Treatment Effects of the Neighborhood Parks/Playground by Neighborhood Attributes and Individual Characteristics

	Female			Male		
	BMI	Overweight	Obese	BMI	Overweight	Obese
			Panel A			
P_1: With Sidewalks/Pathways	0.167	-0.080***	-0.052***	-0.120	-0.037	0.01
	(0.180)	(0.017)	(0.014)	(0.269)	(0.025)	(0.020)
# of the treated (untreated)		1174 (10979)			1189 (11974)	
P_2: Without	-0.581***	-0.045***	-0.030***	-0.577***	-0.061***	-0.063***
Sidewalks/Pathways	(0.133)	(0.015)	(0.011)	(0.151)	(0.015)	(0.011)
# of the treated (untreated)		2756 (2462)			3020 (2629)	
P_3: With Community	-0.481***	-0.034**	-0.021**	-0.206	-0.010	-0.030**
Centers/Kids' Clubs	(0.143)	(0.015)	(0.010)	(0.168)	(0.018)	(0.013)
# of the treated (untreated)		1624 (9597)			1718 (10412)	
P_4: Without Community	-0.164	-0.068***	-0.051***	-0.329**	-0.051***	-0.036***
Centers/Kids' Clubs	(0.212)	(0.021)	(0.018)	(0.168)	(0.018)	(0.012)
# of the treated (untreated)		2306 (3844)			2491 (4191)	
			Panel B			
In safest neighborhoods	-0.128	-0.013	0.015	-0.307**	-0.069***	-0.054***
	(0.115)	(0.013)	(0.010)	(0.131)	(0.015)	(0.009)
# of the treated (untreated)		2238 (6654)			2642 (8410)	
	-1.200***	-0.028	-0.130***	-0.939***	-0.095***	-0.022
In non-safe neighborhoods	(0.463)	(0.039)	(0.032)	(0.356)	(0.031)	(0.036)
# of the treated (untreated)		327 (1283)			337 (1179)	
			Panel C			
Non-Hispanic White	-0.351***	-0.044***	-0.022***	-0.691***	-0.072***	-0.069***
	(0.109)	(0.011)	(0.007)	(0.122)	(0.014)	(0.009)

# of the treated (untreated)		3046 (9676)			3307 (10556)	
Black and Hispanic	0.684*	0.007	-0.053**	0.965**	0.076**	0.050
	(0.359)	(0.034)	(0.027)	(0.406)	(0.039)	(0.035)
# of the treated (untreated)		600 (2642)			646 (2861)	
			Panel D			
Below 133% poverty line	0.761	-0.110***	-0.115***	-0.660*	-0.046	-0.076**
	(0.589)	(0.036)	0.032	(0.344)	(0.033)	(0.033)
# of the treated (untreated)		549 (1683)			598 (1749)	
Above 133% poverty line	-0.463***	-0.036***	-0.041***	-0.396***	-0.054***	-0.036***
	(0.105)	(0.011)	(0.007)	(0.127)	(0.014)	(0.009)
# of the treated (untreated)		3381 (11758)			3611 (12854)	
			Panel E			
Pre- and Early Adolescent	-0.664***	-0.094***	-0.074***	-0.466***	-0.042**	-0.044***
cohort (10-13)	(0.218)	(0.018)	(0.015)	(0.174)	(0.021)	(0.017)
# of the treated (untreated)		1673 (6035)			1795 (6387)	
Adolescent cohort (14-17)	-0.023	-0.037***	-0.038***	-0.282	-0.038**	-0.024*
	(0.143)	(0.013)	0.008	(0.180)	(0.017)	(0.012)
# of the treated (untreated)		2257 (7406)			2414 (8216)	

Note: Asterisks (***, **, and *) indicate the 1%, 5%, and 10% statistical significance level, respectively. The NNM uses one neighbor in the untreated group. Numbers in the parenthesis are standard deviation of the estimated treatment effects.

[1] See Abadie and Imbens (2011) for detailed discussion of covariate matching techniques.

[2] The respondents who chosen "Usually" were not included for the analysis focusing on neighborhood safety as their perception of neighborhood safety is not decisive.

[3] The growth chart can be found at the CDC website: http://www.cdc.gov/growthcharts/.

[4] Throughout the article, sampling weights are employed in empirical analysis.

[5] Let's take obesity among males as an example. The obesity rate among the untreated group is 19.23 percent. The treatment effect is 3 percentage points. Therefore, the percentage change equals 100%*3/19.23=23%.

[6] For the other matching models discussed in the rest of this paper, we do not present the balancing test for the matching variables due to the limited space.

[7] The state prevalence of obesity for children aged 10-17 in the United States is available at http://www.statehealthfacts.org/comparetable.jsp?ind=51&cat=2&sub=14&yr=62&typ=2. Last access on October 14, 2012.

[8] The definitions of nine census divisions are available at www.eia.gov/emeu/mecs/mecs2002/census.html.

[9] The implicit assumption of this falsification test is that neighborhood characteristics, whether they are unobserved or observed, are correlated to each other.

[10] The dependent variable of the probit function is a dummy variable indicating the existence of a neighborhood park/playground in each child's neighborhood. The independent variables consists of racial background, mother's education level, a dummy for mother born in US, income/poverty level, availability of other neighborhood amenities, and a complete set of state dummies. We also tried several different specifications of the probit model and the results are similar.

[11] The falsification tests for the park/playground effect on obesity by individual characteristics or neighborhood attributes can be done using the same procedure as that for the main results.