The Relationship Between Neighborhood Socioeconomic Characteristics and Physical Inactivity Among Adolescents Living in Boston, Massachusetts

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Physical activity is important to the growth and development of children and adolescents.[1,2] Physical activity is associated with a decreased risk for overweight and obesity, type 2 diabetes, and other chronic morbidities.[1–3] Recent recommendations for physical activity among children and adolescents aged 6 to 17 years include at least 1 hour a day of moderate to vigorous physical activity.[3] However, research indicates that only 8% of American adolescents meet these recommendations.[4] In 2011, in the United States, 13.8% of students had not participated in at least 60 minutes of physical activity that increased their heart rate and made them breathe hard some of the time on any day during the 7 days before the survey.[5] A better understanding of factors that may influence physical inactivity is warranted.

Although individual and familial characteristics are known to be determinants,[6–12] growing evidence suggests that physical activity is associated with the socioeconomic environment.[13–17] The residential neighborhood, where children spend large portions of their time, may influence their health behaviors.

Socioeconomic features of the neighborhood have been shown to be associated with adolescent physical activity. Area-level economic deprivation, which is a collective measure of average socioeconomic position of populations living within a particular area,[13,17,18] is one such neighborhood characteristic that may influence health behavior. Economic deprivation may be an indication of the distribution of environmental resources and exposures at the area level. Previous work has shown economic deprivation as a significant predictor of physical activity levels.[13,17]

Social fragmentation, a dimension of the socioeconomic environment that is conceptually distinct from economic deprivation, is linked to the concept of anomie, which Emile Durkheim defined as a state of normlessness,[19]

Objectives. We sought to determine whether the socioeconomic environment was associated with no participation in physical activity among adolescents in Boston, Massachusetts.

Methods. We used cross-sectional data from 1878 urban adolescents living in 38 neighborhoods who participated in the 2008 Boston Youth Survey, a biennial survey of high school students (aged 14–19 years). We used multilevel multiple regression models to determine the association between neighborhood-level exposures of economic deprivation, social fragmentation, social cohesion, danger and disorder, and students' reports of no participation in physical activity in the previous week.

Results. High social fragmentation within the residential neighborhood was associated with an increased likelihood of being inactive (odds ratio = 1.53; 95% confidence interval = 1.14, 2.05). No other neighborhood exposures were associated with physical inactivity.

Conclusions. Social fragmentation might be an important correlate of physical inactivity among youths living in urban settings. Interventions might be needed to assist youths living in unstable neighborhoods to be physically active. (*Am J Public Health.* 2014;104:e142–e149. doi:10.2105/AJPH.2014.302109)

or the breakdown of social bonds between individuals and their communities, with fragmentation of social identity and rejection of self-regulatory values.[19] Instead of being a proxy for poverty, social fragmentation is an indication of rapid population turnover, single-person households, and rented tenancy, which are thought to be related to greater residential instability. Researchers have used census variables, such as the proportion of residents renting, to define specific social conditions. It is hypothesized that social fragmentation leads inhabitants to feel disconnected with their neighbors and their community. This might influence parents to disallow their youths to participate in forms of physical activity such as active transportation to school or work. In a previous study, we found an association between social fragmentation and walking for exercise among mothers of children who are at risk for obesity.[20]

Other area-level characteristics that have been shown to be associated with physical

activity behavior include social cohesion,[14] disorder,[15] and neighborhood safety.[15,21] Social cohesion has been defined as the connectedness and solidarity among individuals and groups in society.[22] Neighborhood disorder is composed of both social and physical disorder.[23] Social disorder involves the presence of threatening individuals or groups, and physical disorder is defined by the deterioration of urban landscapes.[23] Neighborhood safety has been measured objectively (e.g., crime rates[24–26]) and by respondents' perception of their neighborhoods.[15,27–31]

In the present study, we tested potential pathways through which neighborhood socioeconomics could influence youths' physical inactivity. First, we examined the potential mediation of the association between each of the neighborhood socioeconomic characteristics and physical inactivity via perceptions of neighborhood safety. For example, a neighborhood that is characterized by high social fragmentation, low social cohesion, high crime

rates, high poverty, and high physical disorder might elicit feelings of fear and perceptions of lack of safety. As a result, parents may be less likely to allow their children to use active modes of transportation or play outside. This is supported by numerous studies showing that youths who perceive their neighborhoods to be unsafe are more likely to be physically inactive.[15,32,33] A second possible pathway is represented by neighborhood differences in the level of individual-level social cohesion; i.e., communities with high levels of social fragmentation or high economic deprivation are also characterized by lower levels of cohesion between residents. In turn, an erosion of social cohesion is associated with physical inactivity because residents lack the effective means for the transmission of norms that encourage exercise among youths,[34,35] or they lack the collective efficacy to maintain the local physical infrastructure for physical activity (e.g., parks and playgrounds).[36]

The additive role of independent area-level socioeconomic factors has not been fully investigated. Also, the mechanisms in which socioenvironmental characteristics influence physical activity need to be better understood. Therefore, the objective of this investigation was to determine the association between neighborhood economic deprivation, social fragmentation, safety, and social disorder on physical inactivity among a sample of public high-school students in Boston, Massachusetts. We also investigated perception of neighborhood safety and student-reported social cohesion as mediators between socioeconomic characteristics and physical activity.

METHODS

Data for this study come from the 2008 Boston Youth Survey (BYS), a biennial survey of high-school students (aged 14–19 years in grades 9–12) in Boston Public Schools. Of 34 secondary schools in the Boston Public Schools system, 18 schools agreed to participate, 2 of which were exam schools (i.e., schools in which admission is based entirely on a student's grades and test scores from the Independent Schools Entrance Exam). Schools provided unique classroom lists (such that a student was only listed once), from which we randomly selected classrooms stratified by grade in

school. When the enrollment of classrooms randomly selected reached 100 to 120 students, selection was complete for that school. All students present the day of the survey in the selected classrooms were invited to participate.

We used passive consent (i.e., students' parents were asked to return a form if they did not want their child to participate) and students were read an assent form that assured them they were free to refuse to participate at any time before or during the survey on the day of the administration. A response rate of 69% was achieved (with those who were missing primarily students who were absent the day of the survey), yielding a sample size of 1878 students. Of the students with missing data, 91 were missing demographic data (gender, age, nativity, or race), 193 were missing physical activity data, 264 were missing neighborhood information, and 239 were missing data on potential mediators (individual social cohesion and perception of neighborhood safety). We used multiple imputations to replace missing social cohesion and perception of neighborhood safety data. Complete data were available for 1364 (72.6%) students. Those with missing data were more likely to be male, Black, older, and to have immigrated to the United States within the past 4 years.

The BYS study staff developed the questionnaire, combining many measures with previous psychometric work on reliability and validity. Topics included health behaviors, use of school and community resources, and indicators of positive youth development, with a particular emphasis on violence exposure. The paper-and-pencil survey was administered in classrooms by trained BYS staff in the spring of 2008.

Study Variables

Outcome. To measure physical inactivity, students were asked,

> In the past 7 days, on how many days did you exercise or participate in physical activity for at least 20 minutes that made you sweat and breathe hard? (Such as basketball, soccer, running, swimming laps, fast bicycling, fast dancing, or similar aerobic activities).

This question has been used previously in national surveillance studies, such as the Youth Risk Behavior Surveillance System. Although there have been a few studies that have assessed the validity of self-report measures of

physical activity, none has assessed the validity of reporting 0 days of participating in physical activity with accelerometer estimates. When self-reported measures of being physically active for 3 days or more were compared with accelerometer measurements, the test–retest intraclass correlations for the moderate and vigorous physical items were 0.51 and 0.46, respectively.[37] The sensitivity of this measure was high but specificity was low (0.23–0.26).[37] The κ coefficient of self-reported vigorous physical activity and accelerometer was very low.[37] We categorized participants into inactive (0 days) or active (1–7 days). We also determined whether findings were consistent when we dichotomized the outcome into active every day (7 days) or not (0–6 days). We wanted to determine whether neighborhood socioeconomic characteristics were consistently related to measures of inactivity as well as very high physical activity.

Individual-level characteristics. Student-level covariates included age, nativity (US-born, foreign-born arrived ≤ 4 years, and foreign-born arrived > 4 years), and race/ethnicity (White, Black, Asian, Hispanic, and other). Students were asked, "Do you feel safe in your neighborhood?" Response options were never or rarely, sometimes, and mostly or always.

To measure students' perception of social cohesion of their residential neighborhood, 5 statements (e.g., "People in my neighborhood can be trusted."), which have been used previously,[38] were administered in the BYS. Students were asked if they strongly disagreed, disagreed, agreed, or strongly agreed with each statement. We determined a summation score and the higher the score, the higher the social cohesion. The average social cohesion score was 12.0 (SD = 2.9) and the range was 5 to 20. We used tertile cutoffs to categorize social cohesion into low, moderate, and high.

Neighborhood characteristics. We used data from the 2010 US Census, a 2008 representative survey of adult neighborhood residents of Boston, and from the Boston Police Department to characterize each participant's residential neighborhood. Each student in the BYS was asked to name the nearest cross streets to his or her residence and was assigned to US Census tracts for geocoding. Starting with US Census tracts in Boston, community leaders and researchers performed a detailed

review of neighborhood boundaries to come up with 38 neighborhood clusters of US Census tracts.[39] We used principal components analyses to develop neighborhood-level indices for economic deprivation, social fragmentation, social cohesion, danger, and disorder based on the 3 data sources listed previously.

We used 2010 US Census data to characterize economic deprivation of each neighborhood. Economic deprivation was composed of the following indicators: proportion of residents below poverty level, proportion of households on public assistance, proportion of households with 2009 income less than $25 000, proportion of households with 2009 income greater than $100 000 (reverse coded), and proportion of residents with a college degree (reverse coded). Principal components analyses indicated that the variables loaded onto the same factor (Cronbach $\alpha =$ 0.87). We constructed a standardized economic deprivation variable by using the refined regression method. Economic deprivation scores ranged from −1.79 to 2.42 (mean = 0; SD = 1.0). A higher score theoretically reflects greater economic deprivation of the neighborhood in which the student resides. We categorized neighborhoods above the 75th percentile as high in economic deprivation.

Social fragmentation, which is a measure of the residential stability within the neighborhood, was composed of the following indicators taken from the 2010 US Census: proportion of residents who have lived in the same house less than 5 years, proportion of vacant house units, and proportion of owner-occupied housing (reverse coded). Social fragmentation scores ranged from −2.13 to 1.71 (also standardized to mean = 0; SD = 1.0; Cronbach α = 0.87). We categorized neighborhoods above the 75th percentile as high in social fragmentation.

To assess neighborhood disorder, we used data collected from the Boston Neighborhood Study, which has been described elsewhere.[39,40] Briefly, the BNS is a survey of approximately 1710 adults aged 18 years and older administered by telephone between January and September 2008 in Boston. We used the BNS data to supplement the BYS data with contextual information about neighborhood-level conditions and social processes as perceived by adult residents.[39] Disorder is a neighborhood exposure that is composed of both social and physical disorder. Respondents were asked whether the following 7 social disorder items, adapted from a previously used questionnaire,[38] are a big problem, a small problem, or not a problem:

1. presence or absence of adults loitering or congregating,
2. adults fighting or arguing in a hostile way,
3. people drinking alcohol in public,
4. peer groups with gang indicators,
5. public intoxication,
6. people selling drugs, and
7. prostitution.

Physical disorder comprised 10 items:

1. tagging graffiti,
2. graffiti painted over,
3. gang graffiti,
4. political graffiti,
5. cigarettes or cigars,
6. empty beer bottles,
7. abandoned cars,
8. condoms,
9. needles, and
10. syringes.

We created a combined score; a greater score is indicative of greater neighborhood disorder.

The BNS was also used to assess neighborhood social cohesion by adapting a previously used questionnaire with established reliability and validity in adults.[38] Participants were asked if they strongly agreed, agreed, disagreed, or strongly disagreed with 11 statements. Examples included "People in my neighborhood can be trusted"; "People in my neighborhood are willing to help their neighbors"; and "You can count on adults in my neighborhood." We created a combined score and a greater score indicated higher social cohesion.

To assess neighborhood danger, we added the counts of criminal homicide, robbery, aggravated assault, burglary, larceny theft, vehicle theft, and arson by using data from the Boston Police Department, matched to US Census tracts. The higher the score, the greater the danger is in the neighborhood. We conducted a principal component analysis and all indicators loaded on the same factor. We classified scores higher than the 75th percentile as neighborhoods with high danger.

The area-level variables were moderately correlated with the exception of the association between social cohesion and economic deprivation, which was highly correlated (Pearson r = −0.77; Table A, available as a supplement to the online version of this article at http://www.ajph.org).

Statistical Analysis

Because individual respondents were nested within neighborhoods, we used multilevel logistic modeling to determine the association between area-level socioeconomic characteristics of their residences and physical inactivity. Multilevel models are a generalization of the linear model used in traditional regression analysis. Further information regarding the application of this type of analysis in physical activity research is available.[41,42] Several authors[41] have shown that ignoring the hierarchical structure of data can lead to inferential errors and that estimating random effect coefficients can more adequately model data structures typically obtained in field research.

To investigate the potential effect of socioeconomic individual and neighborhood characteristics, we adopted a step-up approach[41] and conducted 3 different sets of analyses. A first set of analyses involved estimating the null model so that the 95% plausible value range could be computed, which is an indication of the degree of variability of the likelihood of participating in no physical activity across neighborhoods. Next, a set of analyses included the neighborhood-level socioeconomic characteristics. Finally, we added all individual-level characteristics. We tested gender-by-neighborhood characteristic interactions and these yielded insignificant findings (results not reported).

To determine whether individual-level perception of neighborhood safety and social cohesion acted as mediators between neighborhood social fragmentation and physical inactivity we applied the Baron and Kenny[43] method to test for mediation. To identify whether these covariates mediate the relationship between each of the neighborhood socioeconomic characteristics and physical activity, we assessed the following relationships: (1) each of the neighborhood-level characteristics and each of the potential mediators, (2) each of the neighborhood-level characteristics and physical inactivity, and (3) the relationship between each mediator with physical inactivity. Then we tested

the relationship between the neighborhood-level characteristics and physical inactivity with control for the potential mediators. If mediation was evident, the relationship between the social characteristics and physical inactivity should be attenuated.

RESULTS

Characteristics for the 1364 adolescents attending secondary schools in the Boston area are in Table 1. Overall the sample had slightly

TABLE 1—Sociodemographic Characteristics of Adolescents: Boston Youth Study, 2008

Covariate	No. (%)
Gender	
Female	765 (56.1)
Male	599 (43.9)
Age, y	
14	114 (8.3)
15	272 (19.9)
16	368 (27.0)
17	367 (26.9)
18	187 (13.7)
19	56 (4.1)
Race/ethnicity	
White	150 (11.5)
Black	598 (46.0)
Asian	109 (8.4)
Hispanic	350 (26.9)
Other	93 (7.2)
Immigrant status	
US-born	974 (71.4)
Immigrant ≤ 4 y	114 (8.4)
Immigrant > 4 y	276 (20.2)
Perception of neighborhood safety	
Unsafe	170 (12.5)
Sometimes safe	620 (45.5)
Always safe	574 (42.1)
Social cohesion—student reported	
Low	552 (40.5)
Moderate	403 (29.6)
High	409 (30.0)
Physically inactive	
No	1036 (76.0)
Yes	328 (24.0)

Note. The sample size was n = 1364.

more female students (56.1%). Approximately 46.0% of the students were Black, and 71.4% were US-born. Of the students participating in the BYS, 12.5% perceived their neighborhood to be unsafe 45.5% to be sometimes safe, and 42.1% to be always safe. Also, 24.1% (n = 328) of the sample reported that they did not participate in physical activity. This number is slightly less than the proportion of 26.9%, estimated with Youth Risk Behavior Surveillance System data of Boston high-school students in 2007.[44]

The 95% plausible value range determined from the null multilevel model showed that the proportion of adolescents reporting participation in no physical activity ranged from 15.5% to 39.8% across neighborhoods. The addition of the neighborhood-level characteristics (model 1, Table 2) revealed that only high social fragmentation in neighborhoods was associated with an increased likelihood of no reported participation in physical activity (odds ratio [OR] = 1.49; 95% confidence interval [CI] = 1.12, 1.97).

When we conducted analyses with only individual-level characteristics (model 2, Table 2), being female (OR = 3.09; 95% CI = 2.28, 4.18), Black (OR = 1.62; 95% CI = 1.02, 2.56), Asian (OR = 2.57; 95% CI = 1.53, 4.33), and aged 16 years or older (OR = 1.91; 95% CI = 1.13, 3.23) were significantly associated with increased risk for being physically inactive (Table 2).

When we added all neighborhood-level and individual demographic characteristics (model 3, Table 2), high social fragmentation remained significantly associated with no physical activity participation (OR = 1.51; 95% CI = 1.11, 2.05).

Results were somewhat consistent when we dichotomized participation into being highly physically active (i.e., participating in activity on all 7 days vs 0 to 6 days in the previous week). For example, in the fully adjusted model, those living in high socially fragmented neighborhoods were less likely to be physically active the past 7 days (OR = 0.67; 95% CI = 0.42, 1.06); however, these findings were not significant. Also, those living in high economically deprived neighborhoods were significantly less likely to participate in physical activity every day in the past 7 days (OR = 0.61; 95% CI = 0.43, 0.93).

The potential mediators, student-reported social cohesion and perception of neighborhood safety, are found in model 4, Table 2. In bivariate analyses, economic deprivation (OR = 0.49; 95% CI = 0.36, 0.63), neighborhood danger (OR = 0.41; 95% CI = 0.31, 0.53), and neighborhood disorder (OR = 0.61; 95% CI = 0.41, 0.89) were significantly related to a decreased likelihood of perceiving their neighborhood as being safe. Conversely, high social cohesion was significantly associated with a greater likelihood of reporting their neighborhood as being safe (OR = 1.74; 95% CI = 1.11, 2.72). Results of testing possible mediation relationships are shown in Table 3. The odds of those in socially fragmented neighborhoods reporting physical inactivity were not abated when we included mediators.

DISCUSSION

In this cross-sectional study in Boston, Massachusetts, we found that high social fragmentation was associated with an increased likelihood for physical inactivity among adolescents. However, we found no other neighborhood-level characteristic to be significantly associated with physical inactivity. Neither individual-level perception of neighborhood safety nor self-report social cohesion mediated the relationship between social fragmentation and physical inactivity.

This study adds to the literature because it involves looking at a number of socioeconomic characteristics at the neighborhood level among adolescents. More specifically, we investigated whether the neighborhood-level characteristics of economic deprivation, social fragmentation, social cohesion, social disorder, and neighborhood danger were additive independent factors related to physical inactivity. Social fragmentation was the only neighborhood socioeconomic characteristic to be independently associated with physical inactivity when we controlled for individual-level covariates. Although each of the other socioeconomic neighborhood exposures[13–15,17,21] has previously been shown to be associated with physical activity, we found only social fragmentation to be linked to our outcome. Reasons for the discrepant findings might be attributable to differences in measurement of physical activity and neighborhood

TABLE 2—Multilevel Analyses Investigating the Association Between Individual and Neighborhood-Level Sociodemographic Characteristics and the Likelihood of Participating in No Physical Activity Among Adolescents: Boston Youth Study, 2008

Characteristics	Model 1,[a] OR (95% CI)	Model 2,[b] OR (95% CI)	Model 3,[c] OR (95% CI)	Model 4,[d] OR (95% CI)
Individual characteristics				
Intercept	0.24 (0.18, 0.32)	0.05 (0.02, 0.13)	0.04 (0.02, 0.10)	0.05 (0.02, 0.10)
Gender				
Male (Ref)		1.00	1.00	1.00
Female		3.09 (2.28, 4.18)	3.09 (2.28, 4.18)	3.08 (2.25, 4.20)
Age, y				
14 (Ref)		1.00	1.00	1.00
15		1.64 (0.91, 2.96)	1.70 (0.97, 2.97)	1.69 (0.97, 2.95)
16		1.91 (1.13, 3.23)	1.94 (1.17, 3.21)	1.95 (1.17, 3.23)
17		1.89 (1.00, 3.57)	1.94 (1.06, 3.57)	1.98 (1.07, 3.65)
18		1.92 (1.02, 3.66)	1.97 (1.06, 3.66)	1.95 (1.05, 3.63)
19		2.77 (0.97, 7.96)	2.97 (1.06, 8.32)	2.89 (1.04, 8.05)
Race/ethnicity				
White (Ref)		1.00	1.00	1.00
Black		1.62 (1.02, 2.56)	1.66 (1.04, 2.66)	1.61 (1.00, 2.60)
Asian		2.57 (1.53, 4.33)	2.52 (1.48, 4.32)	2.48 (1.43, 4.28)
Hispanic		1.71 (1.10, 2.66)	1.70 (1.08, 2.67)	1.63 (1.04, 2.55)
Other		1.22 (0.73, 2.06)	1.23 (0.73, 2.09)	1.20 (0.72, 2.03)
Nativity				
US-born (Ref)		1.00	1.00	1.00
Immigrant > 4 y		0.93 (0.71, 1.22)	0.92 (0.71, 1.21)	0.91 (0.70, 1.19)
Immigrant ≤ 4 y		1.34 (0.83, 2.15)	1.31 (0.81, 2.11)	1.28 (0.80, 2.05)
Student perception of neighborhood safety				
Always safe (Ref)				1.00
Sometimes safe				1.08 (0.77, 1.53)
Unsafe				0.92 (0.59, 1.44)
Student-reported social cohesion				
Low (Ref)				1.00
Moderate				0.81 (0.58, 1.12)
High				0.73 (0.46, 1.18)
Neighborhood characteristics				
Economic deprivation				
Low or moderate (Ref)	1.00		1.00	1.00
High	1.16 (0.83, 1.63)		1.10 (0.79, 1.54)	1.08 (0.78, 1.50)
Social fragmentation				
Low or moderate (Ref)	1.00		1.00	1.00
High	1.49 (1.12, 1.97)		1.51 (1.11, 2.05)	1.53 (1.14, 2.05)
Social cohesion				
Low or moderate (Ref)	1.00		1.00	1.00
High	1.15 (0.83, 1.60)		1.22 (0.87, 1.71)	1.26 (0.91, 1.74)

Continued

environment across studies, our use of participation in no physical activity as the outcome instead of participation in physical activity, or, possibly, Boston-specific factors that we are unable to ascertain.

A few studies have investigated the role of social fragmentation on physical activity levels. For example, we observed a significant inverse association between social fragmentation and walking for exercise among adult women in Quebec.[20] Also, school-level social fragmentation has been shown to be associated with physical inactivity among adolescents.[45] However, in the only other study of this relationship among adolescents within their residential

TABLE 2—Continued

Danger				
Low or moderate (Ref)	1.00		1.00	1.00
High	1.01 (0.75, 1.37)		1.04 (0.77, 1.40)	1.00 (0.74, 1.35)
Disorder				
Low or moderate (Ref)	1.00		1.00	1.00
High	1.08 (0.79, 1.49)		1.03 (0.72, 1.47)	1.01 (0.71, 1.44)

Notes. CI = confidence interval; OR = odds ratio. Sample size n = 1364.
[a]Neighborhood-level characteristics included only.
[b]Individual-level characteristics included only.
[c]Neighborhood-level and individual-level characteristics are included.
[d]Neighborhood-level and individual-level characteristics and potential mediators are included.

neighborhood,[13] no significant association between social fragmentation and physical activity levels was observed. The explanation of a significant finding of social fragmentation on physical activity in the current study may be attributable to the differing study population. The BYS involved adolescents from an urban setting mostly comprising adolescents from Black or Hispanic racial/ethnic backgrounds. Social fragmentation, an indicator of residential instability, might be an important predictor of physical activity in diverse urban centers such as Boston.

Although we theorized that the students' social cohesion and perception of neighborhood mediated the relationship between social fragmentation and physical inactivity, we observed no evidence to support this hypothesis. However, it might be more important to assess parental perception of neighborhood safety, rather than the child's perception as was done in this study. Social fragmentation, or the residential stability of a neighborhood, may lead to an environment that feels safer for their parents[46,47] and therefore more conducive for parents to allow their children to participate in outdoor physical activity and active transportation. According to the McMillan Framework, parents are thought to process the characteristics of the environment within the context of their perceptions, beliefs, and attitudes.[48,49] These are then linked directly to the parents' decisions to allow their children to use active transportation or to participate in physical activity.[48,49]

Strengths and Limitations

Strengths of this study include a large, diverse, representative sample of adolescents attending public high schools in Boston; the use of objectively measured neighborhood exposures of social fragmentation, economic deprivation, and danger; and the use of multilevel modeling to account for the clustering of the participants within neighborhoods. We also had the ability to control for several neighborhood-level characteristics.

TABLE 3—Bivariate Analyses of Neighborhood-Level Factors and Physical Inactivity With the Potential Mediators Student-Reported Social Cohesion and Perception of Neighborhood Safety: Boston Youth Study, 2008

Factors	Perception That Neighborhood Is Very Safe, OR (95% CI)	Social Cohesion—High, Self-Report, OR (95% CI)	Physically Inactive, OR (95% CI)
Economic deprivation			
Low or moderate (Ref)	1.00	1.00	1.00
High	0.48 (0.36, 0.63)	0.59 (0.39, 0.89)	1.23 (0.90, 1.69)
Social fragmentation			
Low or moderate (Ref)	1.00	1.00	1.00
High	0.81 (0.52, 1.25)	0.75 (0.50, 1.13)	1.45 (1.13, 1.87)
Social cohesion			
Low or moderate (Ref)	1.00	1.00	1.00
High	1.74 (1.11, 2.72)	2.09 (1.34, 3.26)	0.92 (0.67, 1.26)
Neighborhood danger			
Low or moderate (Ref)	1.00	1.00	1.00
High	0.41 (0.31, 0.53)	0.46 (0.32, 0.67)	1.17 (0.87, 1.56)
Neighborhood disorder			
Low or moderate (Ref)	1.00	1.00	1.00
High	0.61 (0.41, 0.89)	0.46 (0.32, 0.67)	1.00 (0.73, 1.38)
Student perception of neighborhood safety			
Always safe (Ref)			1.00
Sometimes safe			1.25 (0.97, 1.60)
Never safe			1.14 (0.79, 1.65)
Student-reported social cohesion			
Low (Ref)			1.00
Moderate			0.85 (0.64, 1.12)
High			0.74 (0.56, 0.97)

Note. CI = confidence interval; OR = odds ratio.

These findings should be interpreted in light of the limitations of this study. First, we used cross-sectional data; therefore, the study does not inform us about the direction of causation. However, our study hypotheses and directionality have intuitive appeal and are based on previous work. As we only had complete data for 72.6% of the participants, selection bias might be a limitation. As those with missing data were more likely to be male, Black, older, and to have immigrated to the United States within the past 4 years, estimates were more likely to be skewed toward the null. In addition, we relied on self-reports for all of the survey data, including physical activity.

Also, we did not determine the validity of the survey tools used to measure physical activity. Moreover, obtaining the timing of when physical activity was measured—for example, during school hours or while at home—was not possible. Residual confounding might also be a limitation as important individual-level variables such as household income or parental education and neighborhood-level variables such as walkability and access to parks were not asked. Also, the population was not representative of the general US population; thus, we may only generalize these findings to adolescents in Boston. Finally, parental perceptions of social cohesion and safety were not collected from the students' parents, which might influence students' physical activity behavior more than the students' own perceptions.[13]

Conclusions

Our study suggests that neighborhood-level social fragmentation may influence adolescent physical activity behavior, even after we accounted for individual and neighborhood-level differences. Residential neighborhoods may be key areas to implement interventions to decrease physical inactivity. Creating a stable social environment that is supportive may also be needed to facilitate participation in physical activity. Other investigators have observed that as social public housing decreases, the mobility rate increases.[50] Possible interventions may include both decreasing turnover rates through such policies as funding social housing and providing social support for residents and families living in socially fragmented neighborhoods.

Future work that uses natural study designs and longitudinal data may help to determine temporality and further to gain a better understanding of the causal mechanisms. ∎

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Contributors

R. Pabayo developed the research question and conceptual model, conducted the main analyses, and was lead author. B. E. Molnar provided input for the analysis and helped write the article. A. Cradock provided help with the literature review, the conceptual framework, and writing the article. I. Kawachi guided the conceptual framework, helped develop the research question, provided input in the analytical strategy, and helped write the article.

Human Participant Protection

The Office of Human Research Administration at the Harvard School of Public Health approved all procedures for the Boston Youth Survey. We obtained passive informed consent (i.e., students' parents were asked to return a form if they did not want their child to participate) from each participant at the time of survey administration.

References

1. Story M, Neumark-Sztainer D. Promoting healthy eating and physical activity in adolescents. *Adolesc Med.* 1999;10(1):109–123, vi.

2. Hills AP, King NA, Armstrong TP. The contribution of physical activity and sedentary behaviours to the growth and development of children and adolescents: implications for overweight and obesity. *Sports Med.* 2007;37(6):533–545.

3. Physical Activity Guidelines Advisory Committee. *Physical Activity Guidelines Advisory Committee Report, 2008.* Washington, DC: US Department of Health and Human Services, 2008.

4. Troiano RP, Berrigan D, Dodd KW, Masse LC, Tilert T, McDowell M. Physical activity in the United States measured by accelerometer. *Med Sci Sports Exerc.* 2008;40(1):181–188.

5. Eaton DK, Kann L, Kinchen S, et al. Youth Risk Behavior Surveillance—United States, 2011. *MMWR Surveill Summ.* 2012;61(4):1–162.

6. Sallis JF, Prochaska JJ, Taylor WC, Hill JO, Geraci JC. Correlates of physical activity in a national sample of girls and boys in grades 4 through 12. *Health Psychol.* 1999;18(4):410–415.

7. Salmon J, Timperio A, Telford A, Carver A, Crawford D. Association of family environment with children's television viewing and with low level of physical activity. *Obes Res.* 2005;13(11):1939–1951.

8. Alamian A, Paradis G. Correlates of multiple chronic disease behavioral risk factors in Canadian children and adolescents. *Am J Epidemiol.* 2009;170(10):1279–1289.

9. Lämmle L, Worth A, Bos K. Socio-demographic correlates of physical activity and physical fitness in German children and adolescents. *Eur J Public Health.* 2012;22(6):880–884.

10. Richards R, Poulton R, Reeder AI, Williams S. Childhood and contemporaneous correlates of adolescent leisure time physical inactivity: a longitudinal study. *J Adolesc Health.* 2009;44(3):260–267.

11. Siegel SR, Malina RM, Reyes ME, Barahona EE, Cumming SP. Correlates of physical activity and inactivity in urban Mexican youth. *Am J Hum Biol.* 2011;23(5):686–692.

12. Singh GK, Yu SM, Siahpush M, Kogan MD. High levels of physical inactivity and sedentary behaviors among US immigrant children and adolescents. *Arch Pediatr Adolesc Med.* 2008;162(8):756–763.

13. Pabayo R, Belsky J, Gauvin L, Curtis S. Do area characteristics predict change in moderate-to-vigorous physical activity from ages 11 to 15 years? *Soc Sci Med.* 2011;72(3):430–438.

14. Cradock AL, Kawachi I, Colditz GA, Gortmaker SL, Buka SL. Neighborhood social cohesion and youth participation in physical activity in Chicago. *Soc Sci Med.* 2009;68(3):427–435.

15. Molnar BE, Gortmaker SL, Bull FC, Buka SL. Unsafe to play? Neighborhood disorder and lack of safety predict reduced physical activity among urban children and adolescents. *Am J Health Promot.* 2004;18(5):378–386.

16. Carroll-Scott A, Gilstad-Hayden K, Rosenthal L, et al. Disentangling neighborhood contextual associations with child body mass index, diet, and physical activity: the role of built, socioeconomic, and social environments. *Soc Sci Med.* 2013;95:106–114.

17. Boone-Heinonen J, Diez Roux AV, Kiefe CI, Lewis CE, Guilkey DK, Gordon-Larsen P. Neighborhood socioeconomic status predictors of physical activity through young to middle adulthood: the CARDIA study. *Soc Sci Med.* 2011;72(5):641–649.

18. Gordon D. Area-based deprivation measures—a UK perspective. In: Kawachi I, Berkman L, eds.

Neighborhoods and Health. New York, NY: Oxford University Press; 2003: 179–207.

19. Congdon P. The spatial pattern of suicide in the US in relation to deprivation, fragmentation and rurality. *Urban Stud.* 2011;48(10):2101–2122.

20. Pabayo R, Barnett TA, Datta GD, Lambert M, O'Loughlin J, Kawachi I. Area-level social fragmentation and walking for exercise: cross-sectional findings from the Quebec Adipose and Lifestyle Investigation in Youth Study. *Am J Public Health.* 2012;102(9):e30–e37.

21. Millstein RA, Strobel J, Kerr J, et al. Home, school, and neighborhood environment factors and youth physical activity. *Pediatr Exerc Sci.* 2011;23(4):487–503.

22. Berkman L, Kawachi I. *Social Epidemiology.* 1st ed. New York, NY: Oxford University Press; 2000.

23. Sampson RJ, Raudenbush SW. Systematic social observation of public spaces: a new look at disorder in urban neighborhoods. *Am J Sociol.* 1999;105(3): 603–651.

24. Prince SA, Kristjansson EA, Russell K, et al. Relationships between neighborhoods, physical activity, and obesity: a multilevel analysis of a large Canadian city. *Obesity (Silver Spring).* 2012;20(10):2093–2100.

25. Brown HS III, Perez A, Mirchandani GG, Hoelscher DM, Kelder SH. Crime rates and sedentary behavior among 4th grade Texas school children. *Int J Behav Nutr Phys Act.* 2008;5:28.

26. Singh GK, Kogan MD, Siahpush M, van Dyck PC. Prevalence and correlates of state and regional disparities in vigorous physical activity levels among US children and adolescents. *J Phys Act Health.* 2009;6(1):73–87.

27. Evenson KR, Murray DM, Birnbaum AS, Cohen DA. Examination of perceived neighborhood characteristics and transportation on changes in physical activity and sedentary behavior: The Trial of Activity in Adolescent Girls. *Health Place.* 2010;16(5):977–985.

28. Deforche B, Van Dyck D, Verloigne M, De Bourdeaudhuij I. Perceived social and physical environmental correlates of physical activity in older adolescents and the moderating effect of self-efficacy. *Prev Med.* 2010;50(suppl 1):S24–S29.

29. Motl RW, Dishman RK, Saunders RP, Dowda M, Pate RR. Perceptions of physical and social environment variables and self-efficacy as correlates of self-reported physical activity among adolescent girls. *J Pediatr Psychol.* 2007;32(1):6–12.

30. Carver A, Timperio A, Crawford D. Perceptions of neighborhood safety and physical activity among youth: the CLAN study. *J Phys Act Health.* 2008;5(3):430–444.

31. Foster S, Giles-Corti B. The built environment, neighborhood crime and constrained physical activity: an exploration of inconsistent findings. *Prev Med.* 2008; 47(3):241–251.

32. Mota J, Almeida M, Santos P, Ribeiro JC. Perceived neighborhood environments and physical activity in adolescents. *Prev Med.* 2005;41(5-6):834–836.

33. Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity of children and adolescents. *Med Sci Sports Exerc.* 2000;32(5):963–975.

34. Smith P, Polanyi M. Social norms, social behaviours and health: an empirical examination of a model of social capital. *Aust N Z J Public Health.* 2003;27(4):456–463.

35. Islam MK, Merlo J, Kawachi I, Lindstrom M, Gerdtham UG. Social capital and health: does

egalitarianism matter? A literature review. *Int J Equity Health.* 2006;5:3.

36. Cohen DA, Finch BK, Bower A, Sastry N. Collective efficacy and obesity: the potential influence of social factors on health. *Soc Sci Med.* 2006;62(3):769–778.

37. Troped PJ, Wiecha JL, Fragala MS, et al. Reliability and validity of YRBS physical activity items among middle school students. *Med Sci Sports Exerc.* 2007; 39(3):416–425.

38. Sampson RJ, Raudenbush SW, Earls F. Neighborhoods and violent crime: a multilevel study of collective efficacy. *Science.* 1997;277(5328):918–924.

39. Azrael D, Johnson RM, Molnar BE, et al. Creating a youth violence data system for Boston, Massachusetts. *Aust N Z J Criminol.* 2009;42(3):406–421.

40. Rothman EF, Johnson RM, Young R, Weinberg J, Azrael D, Molnar BE. Neighborhood-level factors associated with physical dating violence perpetration: results of a representative survey conducted in Boston, MA. *J Urban Health.* 2011;88(2):201–213.

41. Diez-Roux AV. Multilevel analysis in public health research. *Annu Rev Public Health.* 2000;21:171–192.

42. Raudenbush SW. Comparing personal trajectories and drawing causal inferences from longitudinal data. *Annu Rev Psychol.* 2001;52:501–525.

43. Baron RM, Kenny DA. The moderator–mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *J Pers Soc Psychol.* 1986;51(6):1173–1182.

44. Centers for Disease Control and Prevention. Youth Risk Behavior Surveillance system. Available at: http://www.cdc.gov/HealthyYouth/yrbs/index.htm. Accessed August 15, 2013.

45. Pabayo R, Janosz M, Bissett S, Kawachi I. School social fragmentation, economic deprivation and social cohesion and adolescent physical inactivity: a longitudinal study. *PlosOne.* 2014;9(6):e99154.

46. McCulloch A. An examination of social capital and social disorganisation in neighbourhoods in the British household panel study. *Soc Sci Med.* 2003;56(7): 1425–1438.

47. Khawaja M, Abdulrahim S, Soweid RA, Karam D. Distrust, social fragmentation and adolescents' health in the outer city: Beirut and beyond. *Soc Sci Med.* 2006; 63(5):1304–1315.

48. Sirard JR, Alhassan S, Spencer TR, Robinson TN. Changes in physical activity from walking to school. *J Nutr Educ Behav.* 2008;40(5):324–326.

49. McMillan T. Urban form and a child's trip to school: the current literature and a framework for future research. *J Plann Lit.* 2005;19:440–456.

50. Burrows R. Residential mobility and residualisation in social housing in England. *J Soc Policy.* 1999;28(1): 27–52.