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Where and when adolescents are physically active: Neighborhood environment and psychosocial correlates and their interactions

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Abstract

Female adolescents are less active than male peers in certain contexts including the neighborhood. Adolescents' physical activity can be explained by interactions between environmental and psychosocial factors, but few studies have tested such interactions in relation to context-specific behaviors. This study tested interactions between neighborhood environmental and psychosocial factors in relation to adolescents' context-specific physical activity. Data were collected in 2009–11 from 910 adolescents and a parent/guardian residing in the Baltimore/Seattle regions. Measures included adolescent-reported neighborhood leisure-time physical activity (LTPA) and non-neighborhood LTPA, accelerometer-based non-school moderate-to vigorous-physical activity (MVPA), psychosocial factors, and objective and parent-perceived neighborhood environmental factors. Gender-stratified mixed effects linear models tested associations of 6 environmental and 4 psychosocial factors and their interactions in relation to each physical activity outcome. The psychosocial factors had consistent associations with the physical activity outcomes but the environmental correlates were context-specific. Decisional balance (weighing of pros and cons of

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physical activity) moderated the association between recreation facility density and neighborhood LTPA among females, with a negative association only among those with high decisional balance (pros outweighed cons). Decisional balance also moderated associations of neighborhood walkability with non-school MVPA among females and non-neighborhood LTPA among males, with positive associations among only those with high decisional balance. Results support context-specific ecological models of physical activity. Targeting environmental factors that may promote opportunities for physical activity in specific contexts as well as adolescent decision-making may help promote their physical activity in those contexts, potentially leading to increased overall physical activity.

Keywords

Ecological model; built environment; exercise; effect modification; recreation; walkability

Introduction

Childhood/adolescent obesity rates over the past four decades have risen as rates of physical activity have declined, especially in areas such as active transportation (walking/bicycling), school-based physical education, and outdoor play.[1] Youth who engage in physical activity gain numerous health benefits[2–4] and are more likely to be physically active as adults[4]. National guidelines recommend youth engage in at least 60 minutes of physical activity daily, with most of that activity being of moderate-to vigorous-intensity.[5] Based on national surveys, only 27% of adolescents meet these recommendations, with the prevalence for males (36%) being double that of females (17%).[6] This difference may be explained partially by the higher sports participation among male adolescents.[6] Female adolescents are also less active than males in specific contexts like their neighborhood and near their school.[7] Studies based on ecological models suggest that individual (e.g., socio-demographic), psychosocial, and environmental correlates of adolescents' physical activity may be gender-specific.[8–11] For example, males with higher peer social support and females with fewer barriers for physical activity are more active than their peers with less social support or more barriers, respectively.[9,10] In another study, accelerometer-assessed moderate-to vigorous- physical activity (MVPA) among female adolescents was related to several objectively-measured environmental factors including neighborhood walkability and proximity to recreational centers, but significant environmental correlates for males' MVPA were not found.[9] Although ecological models posit that factors at multiple levels (e.g., environment and psychosocial) interact with one another to influence behavior,[8] few studies have examined such interactions in relation to adolescents' physical activity within specific time and location contexts. Specifying the context in which physical activity takes place may help improve the predictive capacity of relevant correlates, and interactions among them.[12]

Although some consistent psychosocial (e.g., self-efficacy) and environmental (e.g., good access to recreation facilities) correlates of adolescents' physical activity have been identified,[13] other potential correlates have had mixed results. For example, at the psychosocial-level, fewer perceived barriers (cons) and greater perceived benefits (pros) have been linked to higher physical activity in adolescents in some studies but others report null associations.[13–15] The mixed findings for some of these correlates may be partly due to differences in measurement assessment of the outcome or exposure (e.g., objective vs. perceived) across studies.[16] In addition, because most environment measures are specific to a certain setting such as the neighborhood and physical activity measures are typically broader (e.g., overall walking), this lack of context-specificity of the behavior may weaken the environment-physical activity associations.[12] The inconsistent associations between environmental factors and physical activity may also be due to differences in population characteristics. For example, one study found moderating effects by self-efficacy (a psychosocial factor) on the association between land use mix and adolescents' self-reported active transportation, with a positive association found among those with lower self-efficacy and negative association in those with higher self-efficacy.[17]

There is some evidence of interactions between environmental and psychosocial factors in relation to adolescents' physical activity.[17–19] One study found interactions between several psychosocial factors (e.g., social support and friend norms) and physical activity resource availability in relation to adolescent MVPA, with stronger positive associations found among those in neighborhoods with high vs. low resource availability.[19] However, an important limitation of previous research is the assumption that most of adolescents' physical activity occurs in the neighborhood. No study that we are aware of has examined environment-psychosocial interactions in relation to context-specific physical activity. Evidence of such interactions may extend our understanding of factors driving adolescents to be more or less active during specific times (e.g., outside of school hours) and locations (e.g., in the neighborhood). For example, if adolescents living within easy access to parks are active in their neighborhoods only when they have high levels of social support, then interventions could be developed to target family/friends to support them to use the neighborhood parks.

In the present analysis, we focused on six neighborhood environmental and four psychosocial factors deemed pertinent to adolescent physical activity.[13] These specific factors were examined in a previous publication[18] on adolescent active travel to/from school using data from the same larger study used in the present analysis. In that publication, the authors found only a few main effects with, and interactions between, psychosocial and environmental factors, in particular those pertinent to active travel (e.g., home/school residential density). Those findings suggest correlates may be both domain- (transport vs. leisure) and context-specific (home/school).

The aims of the present study were to test associations of environmental and psychosocial factors, and their interactions, with adolescents' (a) self-report neighborhood leisure-time physical activity (LTPA), (b) self-report non-neighborhood LTPA, and (c) accelerometer-based non-school MVPA (i.e., beyond school hours). Further, given the evident gender differences in adolescents' physical activity, we examined these aims among males and females separately.

Methods

This cross-sectional study analyzed data from the Teen Environment and Neighborhood (TEAN) study. TEAN was an observational study of the neighborhood environment and physical activity among adolescents (aged 12–16 years) residing in the Baltimore, MD/Washington, DC and the Seattle-King County, Washington metropolitan regions.

Participant recruitment

As described previously,[20] the 2000 Census was used to identify 447 block groups in the Baltimore, MD/Washington, DC and Seattle/King County, WA regions that met study design criteria for household income and walkability. Median household incomes for block groups were deciled and dichotomized by median split to create low- and high-income categories. A walkability score for each block group was estimated using Geographic Information Systems (GIS) measures of residential density, street connectivity, retail floor area ratio, and land use mix.[20] The block group walkability index scores were deciled and dichotomized by the median split to create low- and high-walkability categories. Using these income/walkability categories, the census block groups were grouped into one of the four quadrants: a) low income/low walkability, b) low income/high walkability, c) high income/low walkability, and d) high income/high walkability. A list obtained from a marketing company was used to identify households within each quadrant with adolescents 12–16 years of age. The study team contacted randomly-selected households via phone and mailed the occupants information about the study. Recruitment and measurement occurred across all quadrants simultaneously, but during the school year only. Adolescents were excluded if they had a condition that could affect their physical activity (e.g., physical disability), dietary habits (e.g., eating disorder), or participation (e.g., developmental disability). Out of 2619 eligible households contacted by phone, 36% agreed to enroll in the study. Participation rates were similar across the four neighborhood quadrants. The final sample included 928 adolescents and one of their parents/guardians. Parent informed consent and adolescent assent was obtained in writing and the Institutional Review Boards of the participating institutions approved the study.

Data collection

Data were collected between 2009 and 2011. Participating adolescents wore an accelerometer and completed a survey assessing physical activity, psychosocial factors, perceived neighborhood environment, and socio-demographics. One parent/guardian of each participant completed a separate survey assessing similar variables.

Measures

Table 1 describes the survey and objective measures. In brief, adolescents reported their frequency of *neighborhood leisure-time physical activity (LTPA)*[21] (Cronbach’s alpha=0.81) and *non-neighborhood LTPA*[22] (Cronbach’s alpha=0.80). We averaged the ordinal response categories across the set of items used for each scale. These mean scores can be interpreted as indicators of average frequency, along a continuum from low to high, that participants reported going to places to be active during the week/month. Participants were also mailed an Actigraph accelerometer with detailed instructions on wearing the device for at least 7 days with at least one weekend day. *Non-school moderate-to vigorous-physical activity (MVPA)* was defined as MVPA (≥2296 counts/min)[23] accrued between 3–11 pm on weekdays and all day on weekend days. Neighborhood *walkability* and *recreation facility density* were measured within a 1-km buffer around the participant’s home address.

Adolescents and their parent/guardian completed the same neighborhood environment measures in separate surveys. Preliminary analyses showed stronger correlations between the physical activity outcomes and the parent/guardian-perceived environment scores than the adolescent scores. Thus, we used only the parent/guardian scores, including *safety from traffic, pedestrian safety, safety from crime,* and *neighborhood aesthetics*.[24] A previous study reported ICC's of 0.66 (traffic and pedestrian safety combined), 0.78 (safety from crime), and 0.61 (aesthetics).[24]

Adolescent psychosocial factors included six physical activity-specific measures adapted from previous surveys[18,25] including *social support* (ICC range: 0.68–0.74),[25] *decisional balance*[26] or the weighing of the benefits (pros) and barriers (cons) to being physically active (pros ICC=0.74 and cons ICC=0.86),[25] *self-efficacy* (ICC=0.71),[25] and *parental rules* (ICC=0.68)[18].

Adolescents reported their age, gender, ethnicity, employment/volunteer status, among other factors. Parents reported their highest level of education, marital status, household income, number of vehicles in the household, number of children/adults in the household, and work status. Variables significantly (p<.05) related to the physical activity outcomes were included as covariates in the models.

Analyses

Data from the two regions were pooled for analysis. One male participants' accelerometer data was an outlier and was excluded from the non-school MVPA model. Two female participants' GIS data for recreation facility density were also outliers and were excluded from all analyses.

The final analytical sample included 454 females and 456 males and their parent/guardian, i.e., those with complete data for self-report physical activity, perceived and objective neighborhood environment, and the psychosocial variables. The analytical sample for the accelerometer outcome was reduced because 23 females and 21 males had incomplete or no accelerometer data. Student t-tests or chi-square tests revealed that those excluded from analysis due to missing data did not differ significantly on socio-demographics compared to the analytical sample.

The distribution and skewness of each outcome were examined for normality. Formal tests of normality were not performed given they can be overly sensitive to sample size. In large samples such as the present one, even small deviations from normality could produce significant findings of non-normality. Because all three outcomes had acceptable skewness for robust linear regression (i.e., <1.5, absolute), we analyzed each outcome in its original units.

Mixed-effects linear models assessed the associations of the neighborhood environment and psychosocial factors, and their interactions, with each outcome. All continuous predictors were centered on the gender-specific grand means. All models controlled for walkability/income quadrant, site (King County or Maryland regions), and census block group (random effect). The accelerometer-based non-school MVPA analyses also controlled for the device model and wear time. For all models, we tested for multicollinearity among the independent variables. Results are presented as unstandardized estimates.

To assess the moderating effects of the psychosocial factors, we tested 24 interaction terms (between the six neighborhood environment and four psychosocial variables) separately for each outcome. Interaction terms from the single-interaction models with $p<.10$ were identified and tested in a full model to assess their multiplicative effects. From the full models, we used a backwards elimination approach, removing the least significant interaction terms one at a time until only those with $p<.05$ remained. We did not adjust for multiple hypothesis testing given the reduced power to detect interactions and the exploratory nature of the study. We plotted significant interactions to show the association of the neighborhood environment factor with the physical activity outcome at low (−1 SD) or high (+1 SD) levels of the psychosocial moderator. All analyses were performed in SAS version 9.4 (SAS Institute Inc., Cary, North Carolina).

Results

Participant characteristics

Participants (mean age ± SD= 14.1 ± 1.4 years) were predominantly non-Hispanic Caucasian (66%) and of high socio-economic status, as evidenced by their parent/guardian's high education and household income (Table 2).

Males were significantly more active on all three physical activity outcomes but the neighborhood environment scores were similar for males and females (Table 2). Although similar levels of social support and decisional balance were found among males and females, males had significantly higher self-efficacy and females had significantly more parental rules (Table 2).

Associations of neighborhood environmental and psychosocial factors, and their interactions, with context-specific physical activity

Among female participants, the only significant main effect for the neighborhood environmental factors was parent/guardian-perceived safety from crime, specifically related to non-neighborhood LTPA (B (SE) = 0.08 (0.03), p=0.02) and non-school MVPA (B (SE) = 1.15 (0.56), p=0.04) (Table 3). Regarding psychosocial factors, social support was positively related to both neighborhood LTPA (B (SE)=0.48 (0.06), p<.0001) and non-neighborhood LTPA (B (SE) = 0.33 (0.04), p<.0001). Self-efficacy was also positively related to both non-neighborhood LTPA (B (SE) = 0.09 (0.04), p=0.01) and non-school MVPA (B (SE) = 1.50 (0.59), p=0.01). Parental rules were negatively related to both neighborhood LTPA (B (SE) = −0.05 (0.02), p=0.004) and non-neighborhood LTPA (B (SE) = −0.02 (0.01), p=0.04).

Results from the interaction models for females show that only decisional balance had significant moderating effects, specifically on associations of the objective neighborhood environmental factors with neighborhood LTPA and non-school MVPA (Table 3). For neighborhood LTPA, there was a significant interaction between recreation facility density and decisional balance (B (SE) = −0.03 (0.01), interaction p=0.03). Among females with high decisional balance (pros outweighed cons to being physically active), there was a negative association between recreation facility density and neighborhood LTPA (Figure 1 A). For non-school MVPA, there was a significant interaction between neighborhood walkability and decisional balance (B (SE) = 0.51 (0.25), interaction p=0.04) (Table 3). Walkability was positively related to non-school MVPA only among females with high decisional balance (Figure 1 B). Among females living in a high walkable neighborhood, those with higher levels of decisional balance accrued about 3 more minutes of non-school MVPA daily than those with lower levels, which translated to about 21 additional minutes/ week.

Among males, the only significant main effect for the neighborhood environmental factors was recreation facility density, which related to more non-neighborhood LTPA (B (SE) = 0.02 (0.01), p=0.02) (Table 4). For the psychosocial factors, social support and self-efficacy were positively associated with all three physical activity outcomes. Parental rules were negatively related to neighborhood LTPA (B (SE) = −0.05 (0.02), p=0.005). Results from the interaction models for males show that decisional balance moderated the association between walkability and non-neighborhood LTPA (B (SE) = 0.04 (0.02), interaction p=0.01) (Table 4). The association between walkability and non-neighborhood LTPA was positive among males with higher levels of decisional balance and negative among those with lower levels (Figure 2).

Discussion

We found associations of neighborhood environmental and psychosocial factors, and their interactions, with adolescents' physical activity in specific locations and times, thereby supporting context-specific ecological models of physical activity. The psychosocial factors self-efficacy, social support, and parental rules had consistent associations in the main effects models for all three outcomes. The neighborhood environmental factors showed gender- and context-specificity, with positive associations of parent/guardian-perceived safety from crime with non-neighborhood LTPA and non-school MVPA among females only and between recreation facility density and non-neighborhood LTPA among males only. The interaction models showed that only decisional balance had moderating effects on some of the neighborhood environment-physical activity associations but the moderating effects were not always in the expected direction. There was an *inverse* association between recreation facility density and neighborhood LTPA only among female participants with high decisional balance (reported more pros than cons to being physically active). However, among adolescents with high decisional balance, there was a *positive* association between neighborhood walkability and non-school MVPA in females and non-neighborhood LTPA in males.

From the main effects models, parent/guardian-perceived neighborhood safety from crime was related to higher non-neighborhood LTPA and non-school MVPA among females only. In another study, parents who reported greater perceived risk of harm to their child in the neighborhood (lower safety) were more likely to report constraining behaviors (e.g., forbidding their child to play with friends outdoors in the neighborhood), which related to less self-reported active transportation and accelerometer-based MVPA in the evening among female adolescents.[27] Parents may perceive girls to be at greater risk of harm such as by molestation or assault and, perhaps unintentionally, allow or promote greater risk-taking among boys.[28] Parents with higher perceived neighborhood safety may have had fewer rules in place for where/when their child can be physically active, potentially contributing to females' higher physical activity outside the neighborhood and beyond school hours.

Among males, greater recreation facility density was related to higher non-neighborhood LTPA. In a different study of adolescent's context-specific physical activity, greater recreation facility density was related to higher self-reported outdoor non-school physical activity among males only.[29] Our finding was unexpected given the contextual mismatch between the exposure (recreational facilities in the *neighborhood*) and outcome (*non-neighborhood* LTPA). To our surprise, none of the neighborhood environmental factors were significantly related to neighborhood LTPA. One hypothesis for why we found an association between neighborhood recreation facility density and non-neighborhood LTPA among males may be due to differences in how the "neighborhood" was defined by participants, parents/guardians, and the objective measures. Children/adolescents may perceive smaller spatial neighborhood boundaries than their parents or GIS-based buffers.[30,31] Using consistent neighborhood boundaries may help reduce Type 2 error and improve statistical power to detect significant associations between neighborhood environmental factors and neighborhood-based physical activity.[12,32]

Context-specific physical activity was positively related to social support and self-efficacy but inversely related to parental rules in both males and females. These findings are consistent with other studies on non-context-specific physical activity among adolescents.[9,14,27] In another TEAN publication, none of the four psychosocial factors examined here were significantly related to adolescents' active travel to/from school.[18] It is possible that psychosocial factors are more influential on leisure-time or personal choice physical activity than that accrued from necessity (e.g., walking to school).

The moderating effects by decisional balance reflect an interaction between adolescent decision-making and opportunities for physical activity (e.g., neighborhood environment). Among the few studies examining psychosocial moderators of associations between neighborhood environmental factors and adolescent physical activity,[17,18] none that we are aware of has reported moderating effects by decisional balance. We found that decisional balance moderated the association between recreation facility density and females' neighborhood LTPA, with an unexpected *inverse* association found only among those with high decisional balance (reported more pros than cons to being physically active). A similar unexpected finding was reported in a study that found an inverse association between land use mix (closer proximity to destinations) and active transportation among adolescents with high self-efficacy.[17] Features of the recreation facilities not measured in this study may be explaining this finding. For example, the quality of those facilities may be just as important to adolescents' LTPA as their access/proximity. If adolescents live in neighborhoods where there is good access to recreation facilities but they are run-down or vandalized, then adolescents may avoid using them. Examining access/proximity and quality of recreation facilities in the neighborhood may provide a more comprehensive picture of the role of recreation facilities on neighborhood LTPA. For females with low decisional balance, access to more recreation facilities and therefore more opportunities for physical activity in the neighborhood may help them overcome some barriers to being active.

We also found moderating effects of decisional balance on associations of neighborhood walkability with females' non-school MVPA and males' non-neighborhood LTPA, with positive associations only among those with high decisional balance. More walkable neighborhood environments support active lifestyles, including both choice - (leisure) or necessity- (transportation) driven physical activity.[33] When neighborhoods are more walkable, female adolescents with high decisional balance reported more pros than cons to engaging in physical activity and as such, may have been more motivated to engage in physical activity during after school hours. Females with low decisional balance reported more cons than pros to engaging in physical activity and thus, may have had less motivation to engage in physical activity because their perceived benefits are outweighed by barriers like feeling embarrassed if seen doing physical activity. We did not measure motivation to engage in physical activity and as such, could not test these hypotheses. Another possible explanation is that females with higher decisional balance may have had higher self-efficacy to do physical activity. In preliminary analyses, we found a significant positive correlation between decisional balance and self-efficacy (ρ=.51, p=<.001), thereby providing some support for this hypothesis.

Living in a more walkable neighborhood may also reduce some of the perceived barriers to physical activity among males with low decisional balance and encourage them to be physically active nearby instead of further away. One study found that among adolescents living in activity-supportive neighborhoods (e.g., high access to activity resources), there were stronger positive associations between psychosocial factors and physical activity.[19] In contrast, living in a less walkable neighborhood may contribute to male adolescents' perceived barriers and motivate them to seek physical activity opportunities outside their neighborhood. Males with high decisional balance living in high walkable neighborhoods may also be from high SES households and have parents that model or encourage physical activity and sports beyond the neighborhood. Sports participation among adolescents is more common in higher-income families than those of lower income.[34] We did not control for household income or parent education/employment because they were not significantly correlated with any of the physical activity outcomes. Thus, neighborhood walkability may be related to non-neighborhood LTPA among males through socio-economic and parental influences not measured in our study.

Strengths and limitations

Strengths of this study include using both perceived and objective measures of the environment and physical activity. Nonetheless, future studies could improve measuring context-specific physical activity by using simultaneous global positioning systems with accelerometer monitoring.[35] The sample size was large enough to conduct gender-stratified analyses. In addition, data were collected from participants living in two different US regions and from neighborhoods selected to be diverse in both SES and built environments.

Limitations of the study include potential variations in perceived and objective neighborhood boundary definitions, which may introduce Type 2 error and weaken associations between neighborhood environmental factors and neighborhood-based physical activity. The cross-sectional nature of the study did not allow for causal inferences. Also, because no other study that we are aware of has tested interactions across levels of the ecological model in relation to context-specific physical activity among adolescents, our analyses were exploratory. As such, we did not adjust for multiple hypothesis testing and until additional studies are conducted, the results should be interpreted with caution.

Conclusions

This research supports the application of ecological models for examining the plurality of potential influences on adolescents' physical activity across multiple time/location contexts. The main effects results indicate that both psychosocial and environmental factors have relevance for context-specific physical activity among adolescents. Findings for the interactions suggest that the combination of neighborhood environmental opportunities and decision-making by adolescents are related to their physical activity behaviors. Multilevel interventions targeting both psychosocial and environmental factors are needed to help promote adolescents' physical activity in specific contexts, which may potentially lead to increased overall physical activity.

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Highlights

- Findings support context-specific ecological models of physical activity (PA).
- We report environment by decisional balance (pros and cons of PA) interactions.
- Decisional balance moderates recreation facility density-neighborhood PA relation.
- Decisional balance moderates association of walkability with non-school PA.
- Decisional balance moderates association of walkability with non-neighborhood PA.

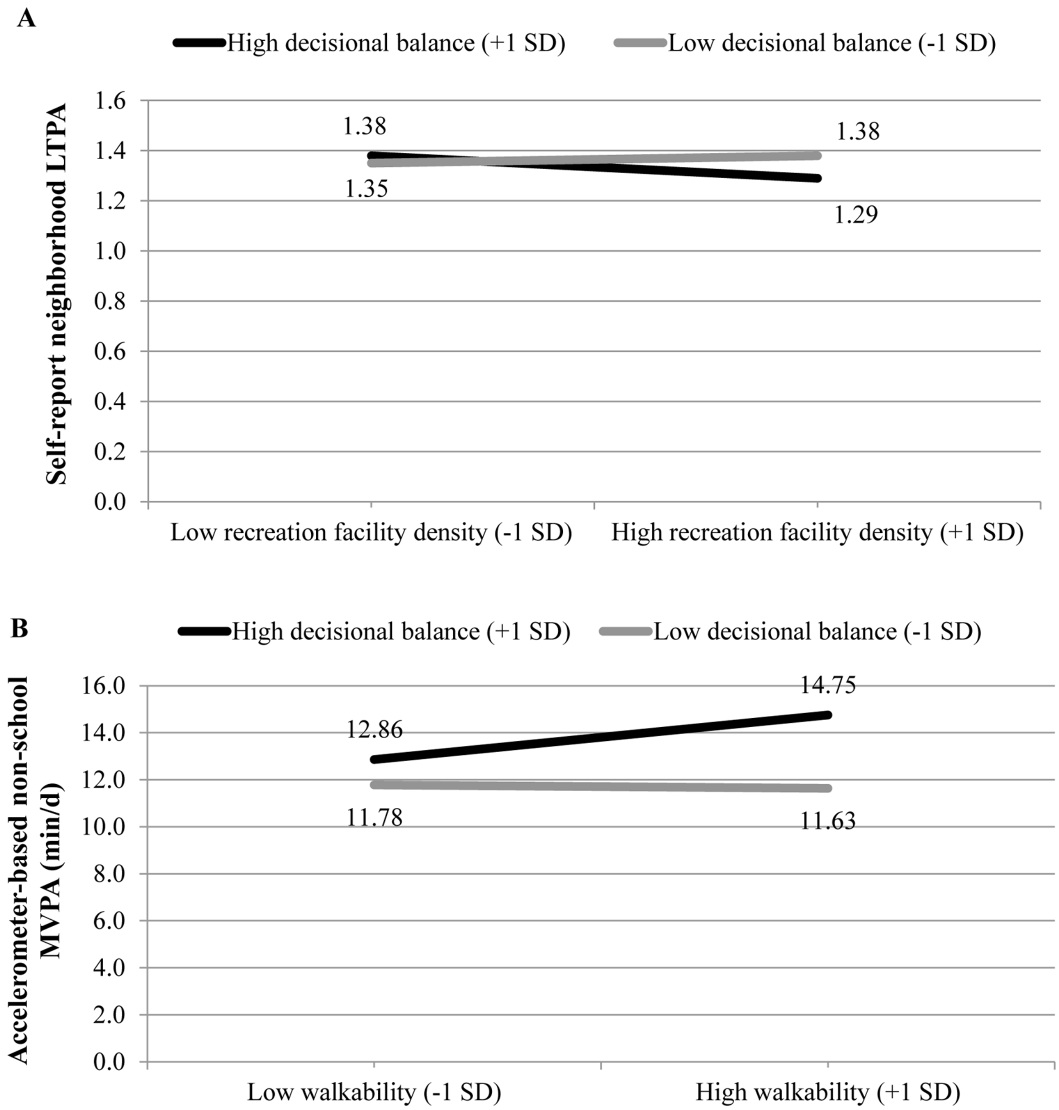

Figure 1.

Significant interactions between psychosocial and neighborhood environmental factors in relation to **(A)** self-report neighborhood leisure-time physical activity (LTPA) and **(B)** accelerometer-based non-school moderate-to vigorous-physical activity (MVPA) among *female* participants. Baltimore, MD/Washington, DC and Seattle-King County, Washington, 2009–11.

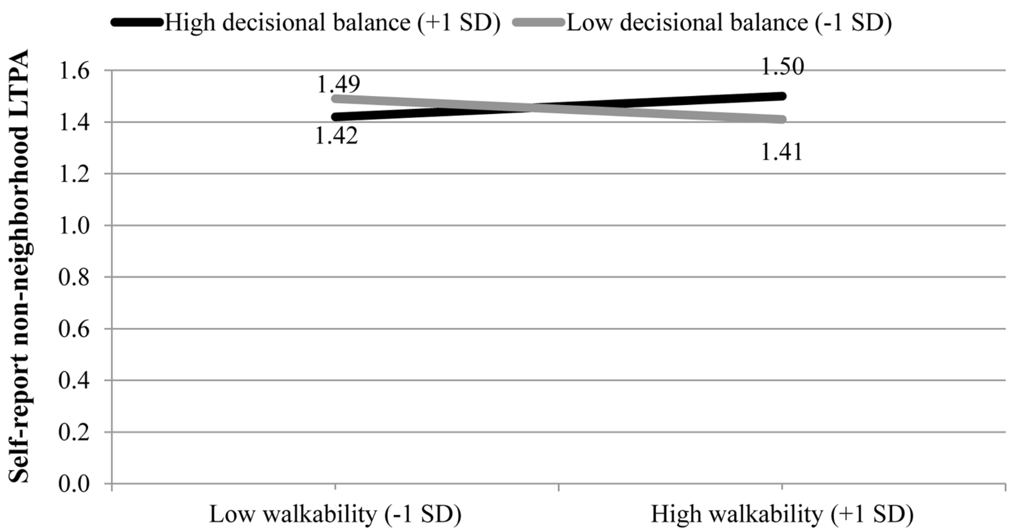

Figure 2.

Significant interaction between psychosocial and neighborhood environmental factors in relation to self-report non-neighborhood leisure-time physical activity (LTPA) among *male* participants. Baltimore, MD/Washington, DC and Seattle-King County, Washington, 2009–11.

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Table 1

Teen Environment and Neighborhood (TEAN) study measures. Baltimore, MD/Washington, DC and Seattle-King County, Washington, 2009–11.

Measure	Description/sample items	Response options	Scoring
Physical activity			
Neighborhood leisure-time physical activity (LTPA)	Frequency of LTPA in 5 specific locations outside the home in the neighborhood, (e.g., nearby park/open space). Only 5 most relevant items used from original questionnaire.	0= 'never,' 1= 'once a month or less,' 2= 'once every other week,' 3= 'once a week,' 4= '2 or 3 times/week,' 5= '4 or more times/ week'	Mean score.
Non-neighborhood LTPA	Frequency of LTPA in 15 specific locations outside the neighborhood such as indoor recreation/exercise facility, trails, and indoor swimming pool. Items adapted from original scale to ask about use instead of distance/ proximity to location.	0= 'never,' 1= 'once a month or less,' 2= 'once every other week,' 3= 'once a week,' 4= '2 or 3 times/week,' 5= '4 or more times/ week'	Mean score.
Non-school moderate-to vigorous-physical activity (MVPA)	Models: Actigraph 7164 (90% of sample), GT1M (7%), or GT3X (3%). Epoch: 30 seconds. Non-wear time: 30 minutes of consecutive zero-count values. Valid wear time: ≥10 hours/day on ≥5 valid days, including at least 1 weekend day. Non-school time: between 3–11 pm on weekdays and all day on weekend days. Cut points: Evenson MVPA (≥ 2296 counts per minute). Data processing software: MeterPlus.	N/A	Mean daily non-school MVPA minutes.
Objective neighborhood environment			
Walkability	For each study region, standardized scores were computed for 4 GIS-based urban form measures within a 1-km network buffer around participant's home: residential density, land use mix, intersection density, and retail floor area ratio (retail building square footage divided by retail land square footage).	N/A	Weighted sum of z-scores for the four normalized environmental measures.
Recreation facility density	Count of parks and private recreation facilities within the 1-km network buffer around participant's home.	N/A	Total number of parks/ recreation facilities.
Parent/guardian -perceived neighborhood environment			
Safety from traffic	3 items, e.g., "the speed of traffic on most streets is usually low (30 mph or less)."	1= 'strongly disagree' to 4= 'strongly agree'	Mean score after reverse-coding 2 negative statements.
Pedestrian safety	3 items, e.g., "streets have good lighting at night."	1= 'strongly disagree' to 4= 'strongly agree'	Mean score.
Safety from crime	1 item, "there is a high crime rate."	1= 'strongly disagree' to 4= 'strongly agree'	Reverse-coded score.
Neighborhood aesthetics	4 items, e.g., "there are many interesting things for my child to look at while walking."	1= 'strongly disagree' to 4= 'strongly agree'	Mean score.

Measure	Description/sample items	Response options	Scoring
Adolescent psychosocial factors			
Social support	Frequency of instrumental and encouragement social support for physical activity from adults in the household (3 items) and siblings/friends (2 items).	0= ‘never’ to 4= ‘very often’	Mean score.
Decisional balance	5 items asked about the benefits of physical activity (pros) such as “physical activity would help me stay fit” and 5 items were about the negative aspects (cons) such as “physical activity takes time away from being with my friends.”	1= ‘strongly disagree’ to 4= ‘strongly agree’	Mean score of the pros items minus mean score of the cons items.
Self-efficacy	6 items asked how sure respondents were that they could do physical activity in given situations (e.g., “when you feel sad or stressed”), in the past year.	1= ‘I’m sure I can’t’ to 5= ‘I’m sure I can’	Mean score.
Parental rules	14 yes/no parental rules such as “stay close to or within sight of your home/parent” and “come in before dark.”	Yes/No	Sum of the number of ‘yes’ responses.

Table 2

Characteristics of TEAN study sample, stratified by gender (N=910). Baltimore, MD/Washington, DC and Seattle-King County, Washington, 2009–11.

	Females	Males
Characteristic	**n=454**	**n=456**
Adolescent socio-demographics		
Age in years, mean (SD)	14.2 (1.4)	14.0 (1.4)
Non-Hispanic Caucasian, n (%)	301 (67.2)	300 (65.8)
Works/volunteers outside home, n (%)	151 (33.3)	130 (28.5)
Parent/guardian socio-demographics		
Completed college education or higher, n (%)	344 (76.4)	339 (74.3)
Married/living as married, n (%)	373 (82.9)	389 (85.3)
Employed, n (%)	331 (73.7)	352 (77.2)
Annual household income, n (%) [a]		
< $60,000	85 (19.6)	96 (22.0)
$60,000–$90,000	111 (25.6)	99 (22.7)
≥ $90,000	238 (54.8)	242 (55.4)
Children in household, mean (SD)	2.1 (1.2)	2.0 (1.0)
Vehicle access, mean (SD) [b]	1.1 (0.4)	1.1 (0.4)
Adolescent physical activity		
Self-report neighborhood LTPA score, mean (SD) **	1.4 (1.2)	2.0 (1.3)
Self-report non-neighborhood LTPA score, mean (SD) **	1.2 (0.7)	1.4 (0.8)
Accelerometer-based non-school MVPA (min/day), mean (SD) **	16.1 (10.2)	23.5 (13.6)
Valid number of hours/day, mean (SD) *	6.4 (1.2)	6.6 (1.1)
Objective neighborhood environment		
Walkability index, mean (SD)	0.02 (2.6)	−0.2 (2.7)
Recreation facility density, mean (SD)	4.5 (5.1)	4.2 (4.9)
Parent/guardian-perceived neighborhood environment		
Traffic safety, mean (SD)	2.6 (0.6)	2.6 (0.6)
Safety from crime, mean (SD)	3.1 (0.9)	3.1 (0.9)
Pedestrian safety, mean (SD)	2.8 (0.6)	2.8 (0.7)
Neighborhood aesthetics, mean (SD)	3.1 (0.6)	3.1 (0.6)
Adolescent psychosocial factors		
Social support, mean (SD)	2.1 (0.9)	2.1 (0.9)
Decisional balance, mean (SD)	2.1 (0.7)	2.0 (0.7)
Self-efficacy, mean (SD) *	3.5 (1.0)	3.6 (1.0)
Parental rules, mean (SD) **	9.2 (3.0)	8.2 (3.1)

Notes: LTPA= leisure-time physical activity, MVPA= moderate-to vigorous-physical activity, SD= standard deviation, TEAN= Teen Environment and Neighborhood

*Gender differences significant at p<.05.

[**] Gender differences significant at p<.0001.

[a] Missing n=20 in female sample and n=19 in male sample.

[b] Number of vehicles per licensed driver in household.

Table 3

Associations of objective and perceived neighborhood environment and psychosocial factors, and their interactions, with context-specific physical activity among *female* participants.[a] Baltimore, MD/Washington, DC and Seattle-King County, Washington, 2009–11.

	Self-report neighborhood LTPA (n=454)		Self-report non-neighborhood LTPA (n=454)		Accelerometer-based non-school MVPA (n=431)	
	B (SE)	***p***	**B (SE)**	***p***	**B (SE)**	***p***
Objective neighborhood environment						
Walkability index	0.01 (0.03)	.74	0.01 (0.02)	.49	0.44 (0.27)	.10
Recreation facility density	−0.02 (0.01)	.19	−0.01 (0.01)	.21	−0.09 (0.13)	.47
Parent/guardian-perceived neighborhood environment						
Traffic safety	−0.02 (0.09)	.80	−0.03 (0.05)	.56	−0.24 (0.86)	.78
Safety from crime	0.09 (0.06)	.16	0.08 (0.03)	.02	1.15 (0.56)	.04
Pedestrian safety	0.06 (0.08)	.45	−0.07 (0.05)	.18	−0.80 (0.80)	.31
Neighborhood aesthetics	−0.08 (0.09)	.35	0.05 (0.05)	.21	1.09 (0.82)	.18
Adolescent psychosocial factors						
Social support	0.48 (0.06)	<.0001	0.33 (0.04)	<.0001	1.14 (0.61)	.06
Decisional balance	−0.02 (0.08)	.85	−0.01 (0.05)	.91	1.05 (0.76)	.17
Self-efficacy	0.11 (0.06)	.09	0.09 (0.04)	.01	1.50 (0.59)	.01
Parental rules	−0.05 (0.02)	.004	−0.02 (0.01)	.04	−0.26 (0.17)	.13
Significant interactions						
Recreation facility density X decisional balance	−0.03 (0.01)	.03	-	-	-	-
Walkability index X decisional balance	-	-	-	-	0.51 (0.25)	.04

Notes: LTPA= leisure-time physical activity, MVPA = moderate-to vigorous-physical activity, SE = standard error

[a]All models adjusted for adolescents' age and work/volunteer status, walkability/income quadrant, site (King County or Maryland regions), and census block (random effect). Accelerometer-based model also adjusted for valid wear time and device used. Independent variables are centered on the grand means for the female sample.

Table 4

Associations of objective and perceived neighborhood environment and psychosocial factors, and their interactions, with context-specific physical activity among *male* participants.[a] Baltimore, MD/Washington, DC and Seattle-King County, Washington, 2009–11.

	Self-report neighborhood LTPA (n=456)		Self-report non-neighborhood LTPA (n=456)		Accelerometer-based non-school MVPA (n=435)	
	B (SE)	***p***	**B (SE)**	***p***	**B (SE)**	***p***
Objective neighborhood environment						
Walkability index	0.003 (0.04)	.94	−0.002 (0.02)	.93	−0.02 (0.39)	.95
Recreation facility density	0.01 (0.02)	.50	0.02 (0.01)	.02	0.12 (0.18)	.50
Parent/guardian-perceived neighborhood environment						
Traffic safety	0.17 (0.11)	.12	0.03 (0.06)	.58	0.95 (1.21)	.43
Safety from crime	−0.11 (0.07)	.11	−0.02 (0.04)	.69	−0.80 (0.77)	.30
Pedestrian safety	−0.0001 (0.09)	.99	0.05 (0.05)	.33	0.67 (0.98)	.50
Neighborhood aesthetics	0.02 (0.09)	.80	0.06 (0.05)	.26	0.43 (1.05)	.68
Adolescent psychosocial factors						
Social support	0.42 (0.07)	<.0001	0.32 (0.04)	<.0001	2.39 (0.85)	.005
Decisional balance	0.03 (0.09)	.72	0.003 (0.05)	.96	−0.65 (0.94)	.49
Self-efficacy	0.23 (0.07)	.0005	0.19 (0.04)	<.0001	2.95 (0.74)	<.0001
Parental rules	−0.05 (0.02)	.005	−0.01 (0.01)	.23	−0.40 (0.22)	.07
Significant interaction						
Walkability index X decisional balance	-	-	0.04 (0.02)	.01	-	-

Notes: LTPA= leisure-time physical activity, SE = standard error

[a]Adjusted for adolescents' age and work/volunteer status, walkability/income quadrant, site (King County or Maryland regions), and census block (random effect). Independent variables are centered on the grand means for the male sample.