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Interactions of Psychosocial Factors with Built Environments in Explaining Adolescents' Active Transportation

Xiaobo Wang[a], Terry L. Conway[b], Kelli L. Cain[b], Lawrence D. Frank[c], Brian E. Saelens[d], Carrie Geremia[b], Jacqueline Kerr[e], Karen Glanz[f], Jordan A. Carlson[g], James F. Sallis[b]

a Department of Physical Education, Zhengzhou University of Light Industry, Zhengzhou, Henan, 450002, China. wangxb193@zzuli.edu.cn. Tel: +86 15803715988

b University of California, San Diego, 9500 Gilman Dr., La Jolla, CA 92093 United States

c Schools of Population and Public Health and Community and Regional Planning, University of British Columbia, Vancouver, BC, Canada.

d University of Washington Department of Pediatrics and Seattle Children's Hospital Research Institute, P.O. Box 5371, Seattle, WA 98145, USA.

e Department of Family Medicine and Public Health, University of California, San Diego, 9500 Gilman Drive # 0811, La Jolla, CA, 92093, USA.

f University of Pennsylvania Perelman School of Medicine and School of Nursing, 423 Guardian Drive, Philadelphia, PA 19104, United States.

g Children's Mercy Hospital, Center for Children's Healthy Lifestyles and Nutrition, 610 E. 22nd St., Kansas City, MO 64108, United States

Corresponding author:

Xiaobo Wang, Department of Physical Education, Zhengzhou University of Light Industry, Zhengzhou, Henan, 450002, China. wangxb193@zzuli.edu.cn.

Tel: +86 15803715988

Abstract

The present study examined independent and interacting associations of psychosocial and neighborhood built environment variables with adolescents' reported active transportation. Moderating effects of adolescent sex were explored. Mixed-effects regression models were conducted on data from the Teen Environment and Neighborhood observational study (N=928) in the Seattle, WA and Baltimore regions 2009-2011. Frequency index of active transportation to neighborhood destinations (dependent variable) and 7 psychosocial measures were reported by adolescents. Built environment measures included home walkability and count of nearby parks and recreation facilities using GIS procedures and streetscape quality from environmental audits. Results indicated all 3 environmental variables and 3 psychosocial variables (self-efficacy, social support from peers, and enjoyment of physical activity) had significant positive main effects with active transportation ($Ps < 0.05$). Three of 21 two-way interactions were significant in explaining active transportation ($Ps < 0.1$): self-efficacy X GIS-based walkability index, barriers to activity in neighborhood X MAPS streetscape scores, and self-efficacy X GIS-based counts of parks and recreation facilities. In each two-way interaction the highest active transportation was found among adolescents with the combination of activity-supportive built environment and positive psychosocial characteristics. Three-way interactions with sex indicated similar associations for girls and boys, with one exception. Results provided modest support for the ecological model principle of interactions across levels, highlight the importance of both built environment and psychosocial factors in shaping adolescents' active transportation, demonstrated the possibility of sex-specific findings, and suggested strategies for improving adolescents' active transportation may be most effective when targeting multiple levels of influence.

Keywords Ecological models, moderators, walkability, parks

Introduction

Increasing emphasis has been placed on achieving national objectives for improving physical activity of adolescents to prevent chronic diseases and promote health (U.S. Department of Health and Human Services, 2010). Recommendations for children and adolescents are to do 60 minutes or more of daily physical activity (U.S. Department of Health and Human Services, 2008). However, only 27 percent of U.S. children and adolescents (ages 12-15) met the recommendations based on self-report (CDC, 2015), and only 8 percent of U.S. adolescents (ages 12-19) achieved the guidelines based on accelerometers (Troiano et al., 2008).

Active transportation has been identified as an important target for increasing children and adolescents' total physical activity (Larouche et al., 2014; Cooper et al., 2005; Davison et al., 2008; Southward et al.,2012; Carver et al., 2014; Schoeppe et al., 2015; Carlson et al., 2015; Denstel et al., 2015). Active transportation has numerous health benefits such as greater fitness (Cooper et al., 2008; Lubans et al., 2011), lower BMI (Østergaard et al., 2012; Heelan et al., 2005; Tudor-Locke et al., 2003), lower adiposity (Rosenberg et al., 2006; Sarmiento et al., 2015), and diabetes prevention (Saunders et al., 2013).It also has many economic, social, and ecological co-benefits (Badland et al., 2011; Mackett et al., 2011).

Ecological models are widely used conceptual frameworks for health promotion, can integrate multiple models and theories, and can serve as meta-models to inform studies and interventions on health behaviors (Sallis & Owen, 2015). Unlike behavioral models and theories target individuals, ecological models of physical activity emphasize factors at multiple levels, such as intrapersonal, interpersonal, social, environmental and policy levels, influence behavior (Sallis et al., 2006; Sallis & Owen, 2015). Central tenets of ecological models are that influences from multiple levels can interact and exert synergistic effects on behaviors, and multilevel interventions should be most effective in changing behavior (Hovell et al., 2002; Sallis & Owen, 2015; Stokols et al., 1996). Thus, evaluating how factors from different levels (i.e. environmental and psychosocial) interact could provide evidence to guide effective approaches for multi-level interventions to increase physical activity.

For physical activity, few published studies with adults (Carlson et al., 2012; Ding et al., 2012; Rhodes et al., 2006; Kaczynski et al., 2012; Van Dyck et al., 2009), one study with adolecents (De Meester et al., 2013) and one study with children; (D'Haese et al., 2016)) have reported on interactions between psychosocial variables and built environments, but the patterns of interactions varied across studies. Literature on correlates of physical activity indicated built environment variables were less consistently related to youth PA than adult PA (Bauman et al., 2012), so perhaps examining multi-level interactions is more important for youth because different subgroups may respond differently to the same built environments. Present analyses added to the scant literature on interactions across multiple levels of correlates by focusing on active transportation as the outcome. Built environment variables have tended to be more consistently related to active transportation than other physical activity outcomes (Ding et al., 2011), so active transportation may be a more sensitive outcome for evaluating cross-level interactions of correlates. Because of the substantial sex differences in physical activity (CDC, 2015; Troiano et al., 2008), sex as a third-level moderator should be explored.

The aim of the present study was to examine the independent and interacting associations of psychosocial and built environment variables with adolescents' active transportation. Based on an ecological model of physical activity (Sallis et al., 2006; Sallis & Owen, 2015), the present study had three hypotheses: (1) psychosocial and built environmental factors will both contribute to explaining adolescents' active transportation, (2) adolescents' active transportation will be explained by the interactions of psychosocial and built environmental variables; and (3) sex of the adolescent is likely to further moderate some of the interactions with built environment.

Methods

Study Design

The present study used data from the Teen Environment and Neighborhood (TEAN) observational study (Sallis et al., under review, 2016; Carlson, et al., 2014). Data collection was conducted in the King County-Seattle, WA and Baltimore-Washington, DC regions 2009--2011. These areas were chosen based on (1) detailed land uses of each parcel and completeness of GIS databases, (2) consistency in land use data across the metropolitan area (i.e., across jurisdictions), and (3) variability in built environment walkability across neighborhoods within the metropolitan area.

A cross-sectional 2x2 design was used to select census block groups of lower versus higher median household income (based on Census 2000 data) and higher versus lower walkability (GIS-based measures of built environments), similar to prior studies (Frank et al., 2010; King et al., 2011).

Participants

Participants were 928 adolescents (ages 12-16) and one of their parents. They were selected from 447 census block groups representing high or low walkability and high or low income. A total of 2619 eligible households were contacted by phone, and the recruitment rate was 36% of those who were contacted and eligible. These adolescent-parent pairs returned both adolescent and parent surveys to assess demographics, health behaviors, perceived neighborhood environments, and psychosocial characteristics (available at http://sallis.ucsd.edu/measure_tean.html).

Measures

Key measures analyzed in the present study were described in Table 1. Active transportation (dependent outcome) and psychosocial measures (independent variables) were constructed from survey items self-reported by adolescent participants.

Built environment measures were neighborhood walkability and count of nearby parks and recreation facilities using GIS procedures and streetscape quality from environmental audits using the validated MAPS (Microscale Audit of Pedestrian Streetscapes). For each variable, Table 1 includes a description of the construct, sample items, number of items, response scale, and description of the score used in analyses. Almost all measures have documented psychometric properties or have been used in previous studies.

Active transportation was the dependent outcome variable in the present study. It was an index computed by summing the sample-based z-scores of (a) frequency of active transportation to 10 non-school destinations, such as shops and parks, and (b) frequency of active transportation to/from school scale (6 items). The combined measure is an indicator of overall frequency of active transportation, most of which is likely to occur in the neighborhood. The active transportation to school scale has evidence of test-retest reliability (Joe et al., 2012), but the active transportation to non-school destinations scale has not been evaluated previously. For present analyses, a constant of +10 was added to the summed z-scores so that all index values were positive. This was done solely to avoid interaction graphs with "negative activity" values on the y-axis. Adding a constant has no impact on interpretation of results, and all model statistics (other than for the intercept and y-axis in plots of interaction effects) are identical when a constant is added to z-scores.

Seven psychosocial variables were measured in the TEAN study, and they are among the most consistently related to adolescent physical activity (Sallis et al., 2000). Most of the variables are consistent with social cognitive theory, and most measures of the selected psychosocial constructs have evidence of reliability and validity, as shown in Table 1. The variables were self-efficacy, decisional balance for physical activity, barriers to activity in neighborhood, social support from peers and family, enjoyment of physical activity, and athletic ability.

[Insert Table 1 here.]

Covariates

Variables adjusted for in the statistical models included individual-level demographics and study design factors related to participant recruitment (e.g., living in the Baltimore versus Seattle regions and a neighborhood quadrant code reflecting high/low walkability and high/low neighborhood income). Adolescent-reported demographics included: adolescents' age, sex, race/ethnicity (recoded to white/non-Hispanic or non-white), having a driver's license, job, and being home-schooled (all except age coded as yes or no, 1 or 0), and calculated BMI z-score based on adolescent self-report of weight and height (using CDC age and gender standards) (Kuczmarski et al., 2002). Parent-reported household covariates included parent's marital status (recoded as married or living with a partner versus other), highest education of an adult in the household, annual household income, and ratio of vehicles per licensed driver in the household.

Data Analysis

Mixed-effects regression models were fitted using the MIXED procedure in SPSS 21.0 to account for participant clustering within census block groups. Three models were tested, one for each built environment measure. Each full model included all demographic and study design covariates, all 7 psychosocial measures, all 2-way interactions between the psychosocial measures and 1 of the 3 built environment measure being examined in the model, and all 3-way interactions adding sex to each of the 2-way interactions being tested in each model. Then backwards stepwise elimination procedures were used to eliminate non-significant ($p > .10$) interaction terms to produce the reduced models tabled in the Results section. The dependent variable for all models was the Active Transportation Index score. The main effects for all 7 psychosocial measures were retained across the 3 models tested, but only one built environment variable was included in each model. All demographics and study design factors also were retained across all models to provide consistent covariate adjustments. All predictors included in models were mean-centered.

To illustrate the patterns indicated by significant interactions, graphs of the associations between the built environment measure and the Active Transportation index were plotted at +1 standard deviation and -1 standard deviation values of the moderator variable in the interaction term.

Results

Participant Characteristics

Participants were adolescents with an average age of 14.1±1.4 years; 50.4% were girls; 66.3% were non-Hispanic white. Roughly half were recruited from the Baltimore/Maryland region (n =485) and half from Seattle/King County, WA (n= 443). About 5.9% of adolescents had a driver's license, 4.2% were home-schooled, and 31.0% reported working/volunteering at a job outside the home. Parents reported 83.4% were married or living with a partner, the highest education in the household was a college degree for 74%, and there were an average of 1.1±0.4 motor vehicles per licensed driver. Descriptive statistics of independent variables and physical activity outcomes are presented in Table 2.

[Insert Table 2 here.]

Validity Analysis of Active Transportation Index

Because the active transportation index was new, we conducted additional analyses to explore its association with an objective measure of active trips. GPS monitoring data were available for most participants in the TEAN study, and a previous paper reported the computation of time in various travel modes, including walking and bicycling (Carlson et al., 2015). A Pearson correlation was computed between GPS-defined minutes of walking and bicycling trips and the self-reported active transportation index used in present analysis, based on the 691 adolescents in the TEAN study with at least three days of GPS monitoring. The correlation was $r=0.334$, $p<.01$. This correlation is similar to validity results for other adolescent self-reports of physical activity (Ainsworth et al., 2015), supporting the validity of the active transportation outcome measure.

Main Effects

All three objective built environment measures had significant main effects in the direction of more activity-supportive built environments associated with more active transportation. Three of the seven psychosocial measures also had consistent significant main effects across the three models, all in a positive direction, with higher active transportation associated with higher self-efficacy, social support from peers, and enjoyment of PA.

Built environment X Psychosocial variable interactions

Three of 21 2-way interactions were significant ($p<.10$); one in each of the 3 models (Table 3). The interactions were: self-efficacy X Walkability Index, barriers to activity in the neighborhood X MAPS Active Travel Score, and self-efficacy X Parks and Recreation Facilities.

There were no significant 3-way interactions with sex for the walkability index or Parks and Recreation Facilities GIS measures with any of the psychosocial measures. There was one 3-way interaction in the MAPS Active Travel Score model: Sex X MAPS active travel X Athletic Ability. This 3-way interaction reflected a significant ($p=.054$) interaction between MAPS Active Travel Score X Athletic Ability for boys (i.e., boys perceiving higher athletic ability had a stronger association between MAPS streetscape scores and active transportation than boys perceiving lower athletic ability) but a non-significant interaction for girls ($p=.754$).

[Insert Table 3 here.]

Line graphs plotted at "higher" (+1 standard deviation) and "lower" (-1 standard deviation) above and below the mean of the psychosocial measure indicate the patterns of association for each significant interaction (see Figure 1 to 5).

[Insert Figure 1 to 5 here.]

Discussion

The present study examined the independent and interacting associations of psychosocial and built environment variables with adolescents' reported active transportation. Results showed all three built environment and three psychosocial variables (self-efficacy, social support from peers, and enjoyment of physical activity) had significant independent main effects with active transportation.

As for three objective built environment measures, the present study found higher scores on each of walkability, MAPS Active Travel Score, and number of public parks and private recreation facilities was related to higher levels of adolescents' active transport. These findings are generally consistent with evidence from the adult (Bauman et al., 2012; Heath et al., 2006; Gebel et al., 2007; Saelens et al., 2008) and youth literature (Ding et al., 2011). The walkability main effect suggests the overall design of neighborhoods is important for adolescent active transportation, and the MAPS association indicates an apparent role of the design of streetscape features, such as sidewalks and street crossings. The association of proximity of recreation facilities with adolescent active transport was less expected, but could be explained by recreation facilities being common destinations of adolescents (Grow et al., 2008). In addition, recreation facilities were among the destinations included in the active transport index.

The present study also found 3 psychosocial measures had significant independent associations with active transportation. All these effects were in the expected positive direction, with higher frequency of active transportation associated with higher self-efficacy, social support from peers, and enjoyment of PA, consistent with previous studies (e.g., Ghekiere et al., 2016). Perhaps these three psychosocial variables are more relevant to active transportation than the others, though psychosocial variables have generally been conceptualized as correlates of leisure-time physical activity. Social support from peers for being more active could stimulate adolescents to travel to nearby destinations to be active with friends. Self-efficacy for, and enjoyment of, physical activity could be positive beliefs that generalize across physical activity for leisure and transport purposes. On the other hand, parental support could include driving adolescents to places where they can be active. Decision balance may be more relevant to choice-based leisure-time physical activity than to active transportation, which is often a necessity.

The third findings of present study is three of 21 2-way interactions were significant and these interactions showed a similar synergistic pattern in which the built environment seems to have stronger facilitating effects on active transportation among adolescents who had favorable psychosocial characteristics, namely higher self-efficacy for physical activity and lower perceived neighborhood barriers. This finding provided limited support for the ecological model principle of interactions cross levels of influence (Sallis & Owen, 2015). The pattern of interactions suggest improving environments could be expected to be most helpful to those who have higher self-efficacy for physical activity and fewer perceived neighborhood barriers. The implication is that multi-level interventions that enhance both self-efficacy and improve built environment to be more supportive of active transportation may have even better outcomes than either approach separately. The small number of significant interactions does not support a broad conclusion that built environment and psychosocial variables often work together to facilitate adolescent active transport, but the main effects indicate the independent relevance of both levels of influence and support the promise of multi-level interventions.

Perceived neighborhood barriers to physical activity was the only variable with a two-way interaction with the built environment (MAPS score) but not a significant main effect with active transport. It appears the effect of an objectively-supportive environment is amplified when the neighborhood is perceived as activity-supportive; that is, with fewer barriers. The interaction of perceived barriers with the MAPS score suggests that deficiencies in the pedestrian environment (e.g., sidewalk presence and quality) and safety of street crossings could be perceived as barriers.

Findings of the present study had similarities and differences with previous studies of the interactions of built environments and psychosocial variables, though the studies used different physical activity outcomes. De Meester et al. (2013) reported walkability had stronger association with adolescents' total physical activity when psychosocial characteristics (i.e., perceived barriers and benefits) were less favorable. This pattern was found only in the lower-income subgroup. A different pattern was found in the present study, with stronger built environment associations when psychosocial characteristics (i.e., self-efficacy, barriers) were favorable. The additive pattern in the present study was similar to that in the study of older adults' walking for transportation by Carlson and colleagues (2012). In the Carlson et al. (2012) study there was also an interaction of walkability with social support, but the present analysis found no interactive effects of social support. The study of younger adults by Ding and colleagues (2012) found no significant interactions for transport walking, though there were interactions between built environment and psychosocial attributes in explaining leisure walking. The study of children's total physical activity by D'Haese et al. (2016) did not find a consistent pattern of interactions. The different patterns of findings across studies could possibly be explained by the different age groups, outcomes, and psychosocial factors explored.

The present study made an important contribution by examining 3-way interactions with sex of the adolescent. Because only 1 of 21 3-way interactions was significant, the main conclusion is that both independent and interactive associations of environmental and psychosocial variables with adolescents' active travel are similar for girls and boys. The one significant 3-way interaction indicated a significant 2-way interaction between MAPS Active Travel Score and Athletic Ability for boys but a non-significant interaction for girls. A possible interpretation is that boys with high perceived athletic ability were motivated to take advantage of safe and attractive streetscapes to go places to play sports or be active. Perhaps girls were restricted by their parents from traveling on their own even when streets were safe and girls were motivated to go play sports.

Limitations

The present study was cross-sectional in design and can only support inferences about associations with adolescents' active transportation. The small number of interactions could be related to use of a novel active transportation index, and may be influenced by the limitations manifested from self-report methodology, especially in adolescents. Although active transportation was self-reported, there was evidence to support the validity of the reports. Though Global Positioning Data (GPS) were collected in this study, they were only available for a subset of participants, so they were not used as the outcome. Psychosocial variables are usually designed to explain leisure-time physical activity, so they may not be well suited to active transportation, which is often less subject to choice and motivation. Some of the psychosocial variables were based on single items, which limited statistical power. Development of psychosocial variables tailored to active transportation outcomes of adolescents is recommended. Present analyses were based on a conceptualization that psychosocial variables could moderate built environment effects. Another possibility is that psychosocial variables could be mediators of the relation of built environments and active transportation, raising the possibility of intervening on psychosocial mediators to enhance the use of built environments.

Conclusions

All three objective built environment variables and 3 of 7 psychosocial variables were significantly related to the frequency of adolescents' active travel, supporting population-wide importance of these variables. There were only three significant 2-way interactions of psychosocial attributes and built environment explaining adolescents’ active transportation. The pattern of interaction effects was similar across all 3 interactions, indicating adolescents with the most frequent active travel had most activity-supportive built environments and more favorable psychosocial attributes. The exploration of three-way interactions involving sex of the adolescents indicated similar associations for girls and boys, with one exception. Findings based on the main effects and interactions indicated that to maximize active transportation in adolescents, both favorable built environments and psychosocial resources are needed. The few significant interactions provided modest support for the ecological model principle of interactions across levels. However, the interactions, in combination with the several main effects, highlight the importance of both built environment and psychosocial attributes in facilitating or hindering adolescents' active transportation. An implication of the overall findings is that to increase adolescents' active transportation, interventions are most likely to be effective when they combine the complementary strengths of physical environment interventions, with expected long-term effects in large populations (Sallis & Owen, 2015) and psychosocial interventions, with strong short-term effects on individuals (Spence et al., 2003). This hypothesis could be tested by evaluating whether built environments moderate effects of psychosocial interventions with adolescents, especially those designed to build self-efficacy.

Conflict of interest

Dr. Sallis discloses financial relationships with SPARK programs of School Specialty Inc, Santech Inc, and Nike Inc.
All other authors declare that there are no conflicts of interests.

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Table 1 Description of Measures in the present study

Variable Name	Description/ sample items	Number of items; response options	Subscale score used in analyses	Psychometric properties or prior evidence (reference)
Active Transportation (Dependent Variable-Outcome)				
Active transport index	An index was computed by summing the z-scores for two scales: Active transportation (non-school) + Active transportation to/from school (see below),	Z-scores of the two active transportation scales were summed to form the index measure.	A constant of 10 was added to the summed z-scores so that all index values were positive.	(see separate scales below)
Active transport, non-school	Typical frequency of walking or bicycling to/from 9 locations (e.g., recreation facility, friend's house, park, food outlet) or skateboarding to various places.	10 items;0=never, 1=≤ once/ month, 2=once every other week, 3=once/ week, 4=2-3 times/ week, 5= 4+ times/ week.	Mean of 10 items to represent the average frequency of active transportation to various non-school locations.	N/A; developed by investigators
Active transport, to/from school	Days per week they traveled to or from school using active modes (walking, bicycling, or skateboarding).	6 items (3 going to school and 3 from school); days per week used each active mode of transport (range per mode = 0-5 days)	Responses across the 6 items were summed to equal the total number of active trips per week to and from school.	Test-retest ICCs=.51 -.84, and percent agreement=73%-95% (Timperio et al., 2006; Joe et al., 2012)
Psychosocial variables (Independent Variables)				
Self-efficacy for physical activity	Adolescents were asked to report their "confidence" they could do physical activity in 6 situations, including when stressed or sad, even if I have to get up early, and when it is either raining or hot outside.	6 items. 5-point response scale ranged from "I know I can't" (1) to "I know I can" (5).	Mean of 6 items.	α=.76, test-retest ICC = .71 (Norman et al., 2005).
Decisional balance for physical activity	Example items for pros (benefits): parents would be happy, I would be more fit. Example items for cons (barriers): take time away from friends, I would need too much help from parents.	A 5-item pros scale and a 5-item cons scale. The 4-point response scale ranged from strongly disagree (1) to strongly agree (4).	Means for pros and cons computed separately; decision balance equals mean of pros minus cons.	Pros:α=.81; test–retest ICC=.74 Cons:α=.53; test–retest ICC=.86(Norman et al., 2005).

Barriers to activity in your neighborhood	A 9-item scale assessed barriers to activity in their neighborhood. Items included no choice of activities, no other teens there, afraid because of crime.	Items were rated on a 4-point scale ranging from strongly disagree (1) to strongly agree (4).	Mean of 9 items.	Test-retest ICCs= .35 - .73; percent agreement range for items = 44% - 81% (Forman et al., 2008)
Social support for physical activity (2 scales)	Separate scales for parents and peer covered instrumental and encouragement types of social support (e.g., encourages me to do physical activity, does physical activity with me).	5 items rated separately for parent (3 items) and peer support (2 items). A five-point response scale ranged from 0 "never" to 4 "very often".	Means for parent and peer separately.	Family support α=.79 test-retest ICC = 74. Peer support α=.60 test-retest ICC = .68 (Norman et al., 2005).
Enjoyment of physical activity	1 item assessed adolescents' enjoyment of physical activity.	Responses on a 5-point scale ranged from "strongly disagree" (0) to "strongly agree." (4)	Item response	Test-retest ICC=.43 (Norman et al., 2005)
Athletic ability	1 item assessed adolescents' perceived athletic ability.	Responses on a 5-point scale ranged from "much lower" (1) to "much higher" (5) than others of same sex and age.	Item response	N/A; developed by investigators
Objective Built Environment variables (Independent Variables)				
Walkability index based on GIS measures	Index was computed for a 1-km street network buffer around each participant's home and school	Index components included: 1) net residential density, housing units per residential acre; 2) land use mix, distribution of floor space for residential, entertainment and retail uses; 3) Retail FAR (floor-to-land area ratio for retail uses); 4) intersection density, intersections per square km	Each component standardized by region. Walkability Index = [(z-intersection density) + (z-net residential density) + (z-retail floor area ratio) + (z-land use mix)]	N/A (Saelens et al., 2012; Frank et al., 2010)
Park and private recreation facilities. based on GIS data and	Number of public parks and recreation facilities within or intersected by a 1 km street network buffer around each participant's home.	Public parks and private recreation facilities were enumerated and geocoded. GIS was used to compute variables.	Number of parks and private recreation facilities in or intersecting each participant's buffer were summed.	N/A (Adams et al., 2015)

procedures				
Microscale audit of pedestrian streetscapes (MAPS). Direct observation	Trained observers coded details of streetscapes. Four sections of MAPS : (1) route, evaluated characteristics for a 0.25 mile route from participant's home towards non-residential destinations; (2) street segments, assessed sidewalks, slope, buffers between street and sidewalk, bicycle facilities, building aesthetics; (3) crossings, assessed crosswalk markings, width of crossings, curbs, crossing signals, and pedestrian protection; (4) cul-de-sacs, included size and amenities (available for download at http://sallis.ucsd.edu/measure_maps.html).	120 items were coded as dichotomous (no/yes) or trichotomous variables (0, 1, 2+). Subscales were constructed as described in Millstein et al., 2013; the MAPS Active Transport scale is described in Cain et al., 2016.	A grand score was calculated by subtracting the overall negative valence score from the overall positive valence score. 10 positive subscales: commercial-shops and restaurants/entertainment, residential mix,institutional/services-profession al services, religious, and schools, government services, parking structures, recreational land use-public and private. Negative subscale: adverse land uses.	MAPS items and subscales had very good inter-rater reliability (Millstein, 2013), and were significantly related to active transport in four age groups (Cain et al. 2014 and Cain et al. 2016)

Table 2 Descriptive Statistics of variables. Data were collected in the Seattle, WA and Baltimore regions of the United States,

	N	Minimum	Maximum	Mean	Std. Deviation
Physical Activity Outcome					
Active transportation index	926	8.0	16.6	10.0	1.58
Psychosocial Measures					
Self-efficacy	926	1	5	3.53	1.00
Decisional balance	926	-1	3	2.01	0.78
Barriers to activity in your neighborhood	925	1	4	1.75	0.58
Social support from adults in household	926	0	4	2.26	0.99
Social support from peer	926	0	4	1.84	1.17
Athletic ability	923	1	5	3.42	1.03
Enjoyment of PA	926	1	5	4.27	0.98
Built Environment Measures					

Walkability index (GIS)	928	-5.69	23.43	-0.03	2.85
MAPS active travel score	878	1.50	38.65	13.53	6.83
GIS-based counts of parks + recreation Facilities	928	0.00	66.00	4.46	5.60

2009-2011.

Table 3: Associations of objective built environment attributes, psychosocial variables, and built environment × psychosocial interactions with the Active Transportation Index. Data were collected in the Seattle, WA and Baltimore regions of the United States, 2009-2011.

	Built Environment Models											
	Walkability Index (1 km buffer)				MAPS Active Travel Score				GIS counts of Parks+Recreation Facilities (1 km buffer)			
		CI $_{95\%}$				CI $_{95\%}$				CI $_{95\%}$		
Psychosocial Moderators	**B**	**Lower Bound**	**Upper Bound**	**P-value**	**B**	**Lower Bound**	**Upper Bound**	**P-value**	**B**	**Lower Bound**	**Upper Bound**	**P-value**
Intercept	8.471	7.797	9.145	0.000	8.471	7.792	9.149	<0.001	8.397	7.720	9.074	0.000
Self-efficacy	0.126	-0.001	0.252	**0.051**	0.143	0.016	0.270	**0.027**	0.132	0.005	0.258	**0.041**
Decisional balance	-0.129	-0.284	0.025	0.100	-0.125	-.280	.029	.113	-0.121	-0.275	0.034	0.125
Barriers to activity in neighborhood	-0.181	-0.354	-0.008	**0.040**	-0.165	-.339	.008	.062	-0.148	-0.321	0.025	0.093
Social support from adults in household	-0.085	-0.200	0.030	0.148	-0.088	-.204	.028	.135	-0.076	-0.192	0.039	0.194
Social support from peers	0.231	0.141	0.321	**<0.001**	0.243	.154	.333	**<0.001**	0.227	0.137	0.317	**<0.001**
Athletic Ability	-0.022	-0.139	0.095	0.707	-0.032	-.150	.086	.592	-0.032	-0.150	0.085	0.589
Enjoyment of physical activity	0.145	0.012	0.277	**0.032**	0.135	.001	.268	**.048**	0.139	0.006	0.272	**0.041**
Walkability index	0.100	0.057	0.143	**<0.001**	--	--	--	--	--	--	--	--
MAPS active travel score	--	--	--	--	0.024	0.009	0.040	**0.002**	--	--	--	--
GIS-based counts of parks+recreation facilities	--	--	--	--	--	--	--	--	0.043	0.023	0.062	**<0.001**
					Interactions							

Self-efficacy X Walkability index	0.035	0.003	0.067	**0.034**	--	--	--	--	--	--	--	--
Barriers to activity in neighborhood X MAPS active travel score	--	--	--	--	-0.020	-0.042	0.002	**0.079**	--	--	--	--
Self-efficacy X GIS-based counts of parks+recreation facilities	--	--	--	--	--	--	--	--	0.016	0.000	0.031	**0.052**
Gender X MAPS active travel X Athletic Ability	--	--	--	--	0.028	0.001	0.055	**0.044**	--	--	--	--

All models controlled for study design factors and demographic characteristics (see covariates and data analysis sections in Methods). All predictors included in models were mean-centered.

Fig. 1 Plotting significant Walkability Index X Self Efficacy interaction on active transportation

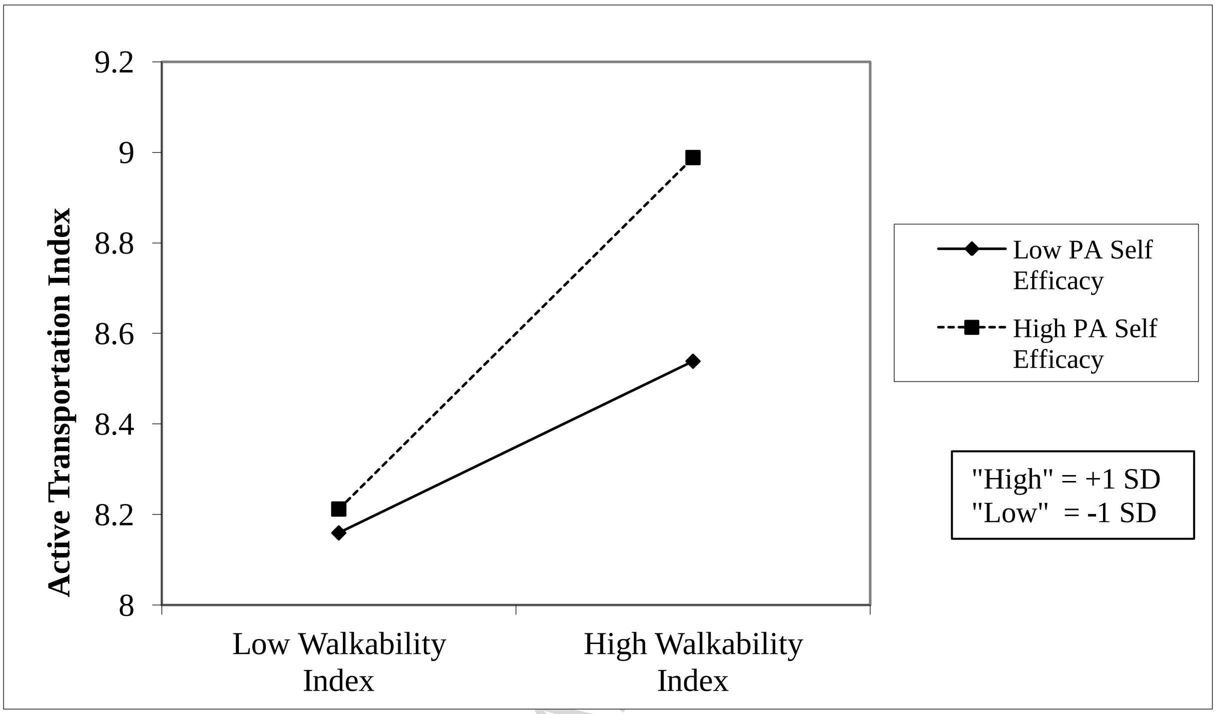


Fig. 2 Plotting significant Parks & Recreation Facilities X Self Efficacy interaction on active transportation

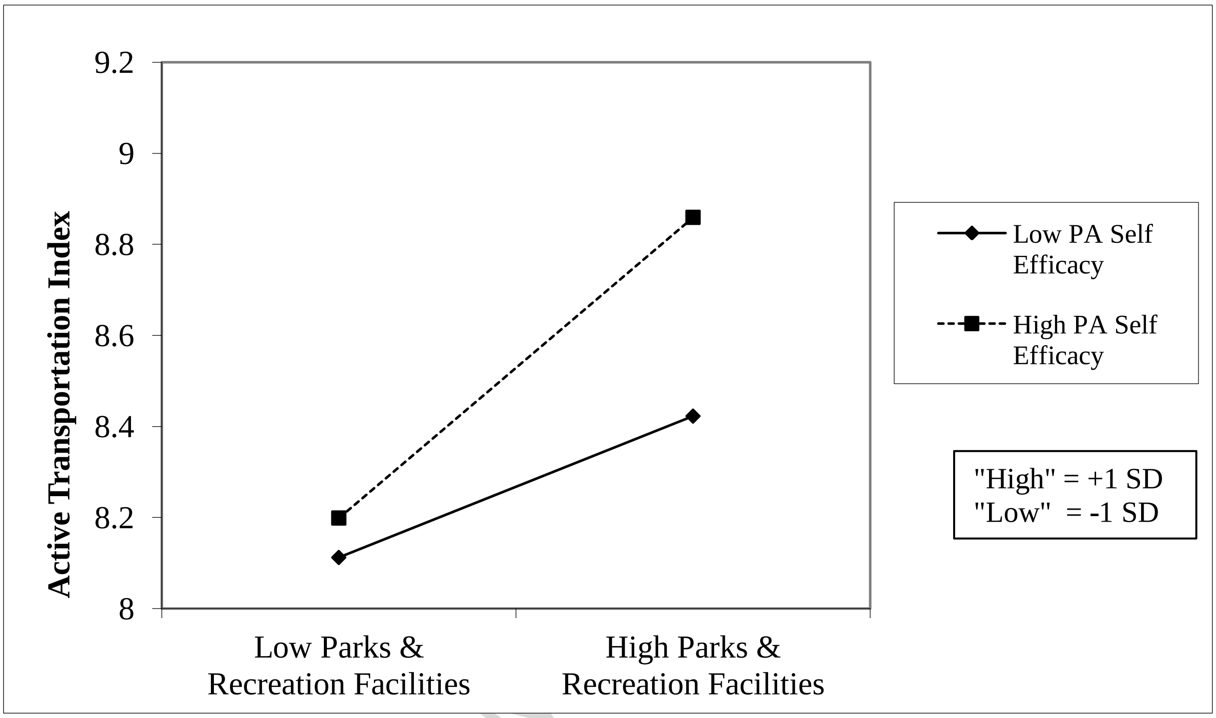


Fig. 3 Plotting significant MAPS Active Travel Score X Barriers to Physical Activity in the Neighborhood interaction on active transportation

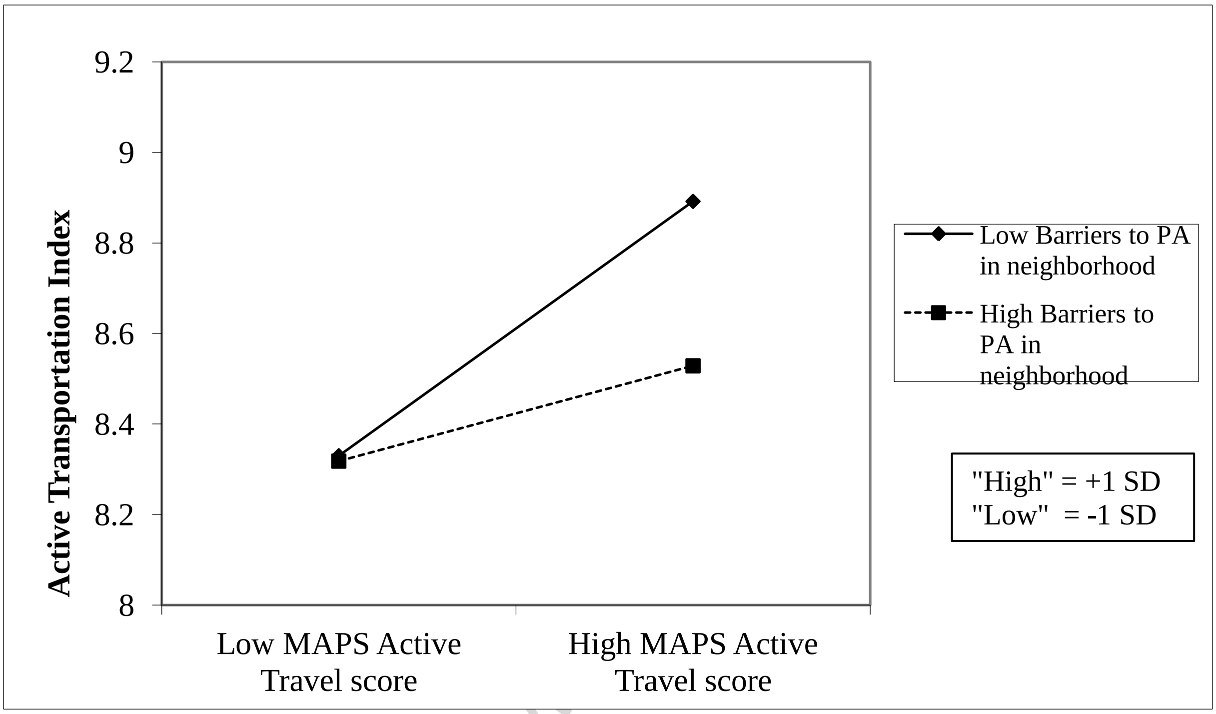


Fig. 4 Plotting significant MAPS Active Travel Score X Perceived Athletic Ability interaction on active transportation-- Boys Only

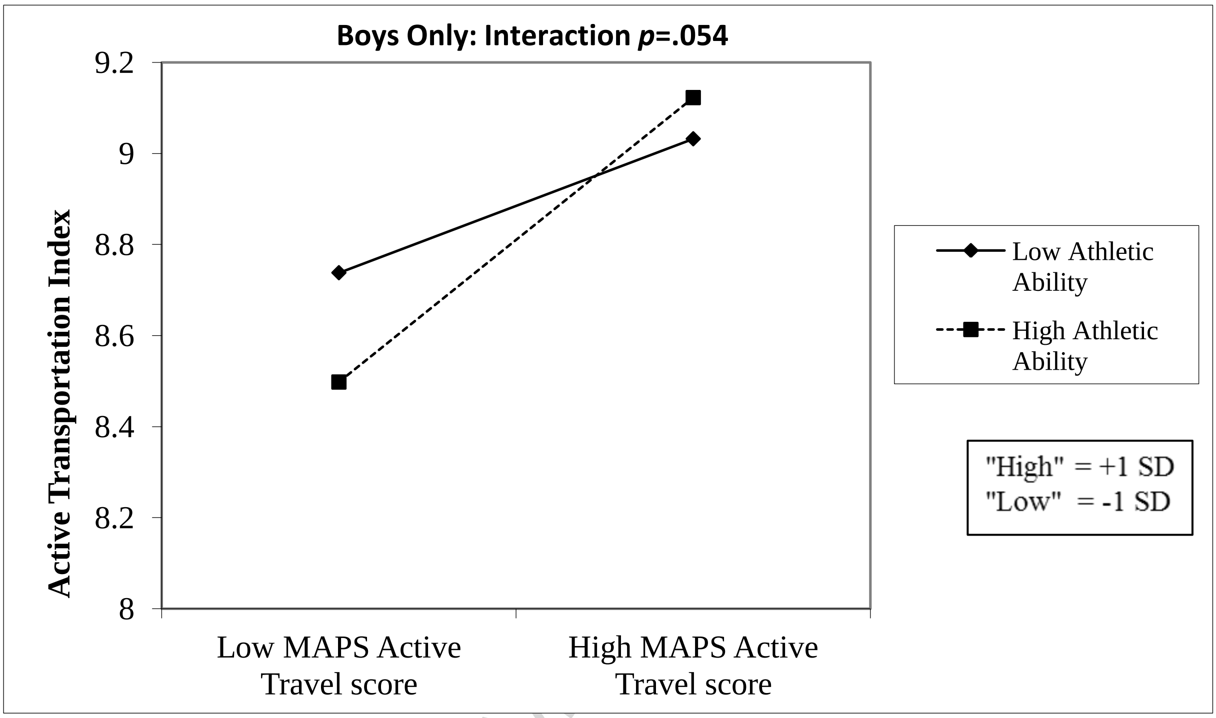
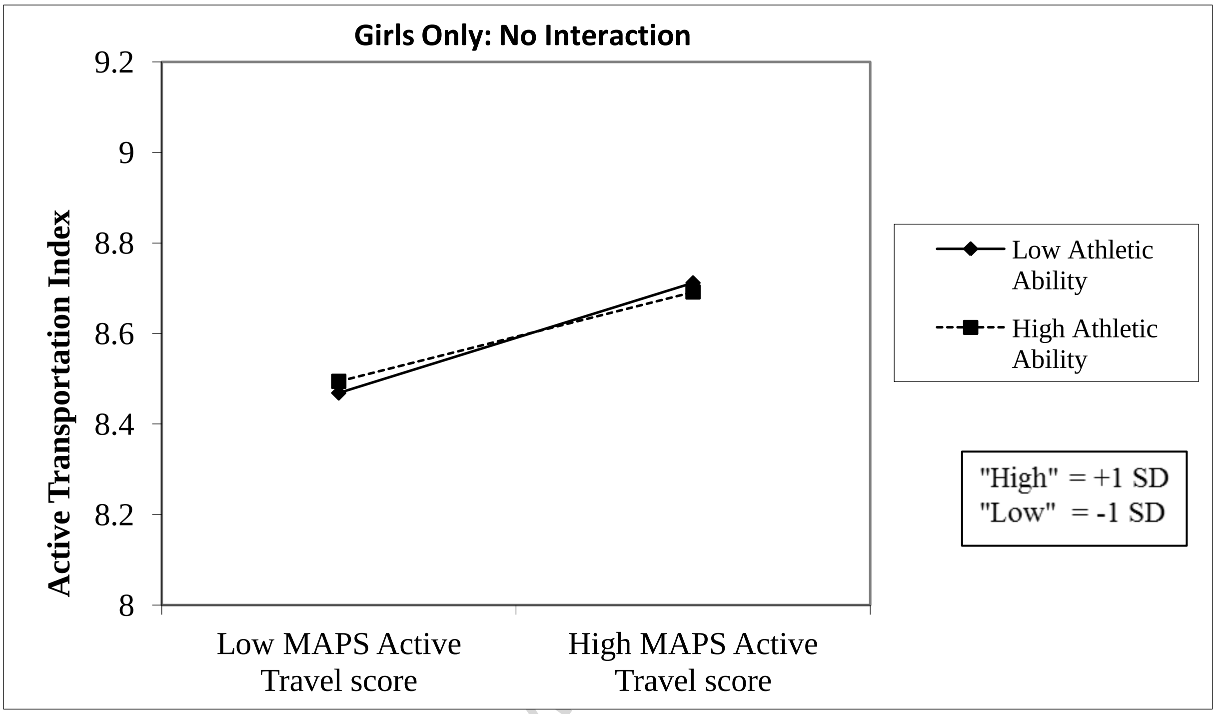


Fig. 5 Plotting significant MAPS Active Travel Score X Perceived Athletic Ability interaction on active transportation-- Girls Only



Highlights:

- Three of 21 2-way interactions were significant in explaining active transportation.
- Youth were most active when environment and psychosocial variables were favorable.
- Results suggest interventions that change environments and people are most promising.