

Relationship of objective street quality attributes with youth physical activity: findings from the Healthy Communities Study

A. T. Kaczynski^{1,2} , G. M. Besenyi³, S. Child⁴, S. Morgan Hughey⁵ , N. Colabianchi⁶, K. L. McIver⁷, M. Dowda⁷, R. R. Pate⁷  and on behalf of the Healthy Communities Study Team

¹Department of Health Promotion, Education, and Behavior, Arnold School of Public Health, University of South Carolina, Columbia, SC, USA; ²Prevention Research Center, Arnold School of Public Health, University of South Carolina, Columbia, SC, USA; ³Department of Kinesiology, College of Human Ecology, Kansas State University, Manhattan, KS, USA; ⁴Department of Sociology, University of California, Berkeley, Berkeley, CA, USA; ⁵Department of Health and Human Performance, College of Charleston, Charleston, SC, USA; ⁶School of Kinesiology, University of Michigan, Ann Arbor, MI, USA; ⁷Department of Exercise Science, Arnold School of Public Health, University of South Carolina, Columbia, SC, USA

Address for correspondence: A Kaczynski, Department of Health Promotion, Education, and Behavior, Arnold School of Public Health, University of South Carolina, 915 Greene Street, Columbia, SC 29208, USA. E-mail: atkaczyn@mailbox.sc.edu

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Summary

Background: Residential environments may significantly influence youth physical activity (PA). However, few studies have examined detailed street quality attributes via observational audits in relation to context-specific PA among youth.

Objectives: The objective of this study was to explore whether the overall quality of street environments, as well as specific attributes, was associated with neighbourhood-based and street-based PA within a national sample of youth in the Healthy Communities Study.

Methods: Data were collected from 4616 youth from 130 communities across the USA. Youth PA in the neighbourhood and on the participant's street was captured using 7-d recall interviews. Windshield survey observational audits documented five street quality variables: burned, boarded up or abandoned residential units, litter, overall condition of residences, street type and presence of sidewalks in good condition.

Results: Youth with no litter on their street reported significantly lower neighbourhood-based PA and youth living on a side street, cul-de-sac, dead-end or one-way street reported greater neighbourhood-based PA. No significant associations were detected for the overall street quality index or with street-based PA.

Conclusions: Specific street quality attributes may be associated with youth PA. Further research and collaboration between diverse disciplines and agencies should focus on understanding and improving street quality to promote youth PA and health.

Keywords: Built environment, neighbourhood, physical activity, youth.

Introduction

Youth physical activity (PA) has important implications for health outcomes in childhood (1), as well as the maintenance of PA and health into adulthood (2). However, PA levels of children and adolescents remain low and constitute a significant public health concern (3,4). Environmental contexts, including neighbourhood factors such as safety (e.g. crime rates, traffic volume and speed), walkability (e.g. well-maintained sidewalks and nearby destinations) and disorder (e.g. abandoned buildings and litter), have been extensively related to

PA rates among youth (5,6). Likewise, parent or child perceptions of neighbourhood aesthetics, active play areas and accessibility are often strongly associated with children's PA (7,8).

The current paper attempts to address several gaps in the extant literature on neighbourhood street environments and youth PA. First, we examined key street quality attributes hypothesized to be associated with leisure time and transportation-related neighbourhood-based and street-based youth PA. Residential streets are particularly salient options for youth PA given parents' concerns about safety, mobility and territorial

range (9,10) and as avenues to other nearby opportunities. Some researchers have studied broader neighbourhood factors such as street connectivity, building density or land use mix (6), while less research has considered the quality of street environments (11).

Second, this study employs objective street audits conducted via 'windshield surveys' to measure the presence or absence of five specific street quality variables as well as a total summary index. Windshield surveys involve direct observation to assess neighbourhood characteristics and conditions and have been used in previous studies examining features associated with other health behaviours among youth (12). Much of the prior research on neighbourhood attributes and youth PA has relied on parent or child perceptions or macro-level metrics derived from geographic information systems (GIS) (6). In contrast, one study that incorporated pedestrian environment audits found that objectively measured street-level characteristics (i.e. the presence of pedestrian amenities and low traffic volume) were positively associated with youth PA in Mexico (11).

Finally, this study integrates these unique features within a large, national sample of US youth to examine two specific location-based PA outcomes. Other national studies have investigated neighbourhood characteristics related to youth PA with mixed results (13,14) and typically examined broad factors (i.e. GIS-derived measures) rather than quality characteristics pertinent to street-based youth PA. Additionally, measures of youth PA often encompass any activity occurring before or after school hours, without regard for location (10,14). Thus, these studies may misattribute neighbourhood characteristics associated with youth PA by including PA acquired through other sources (i.e. organized sports), rather than leisure time or transportation activities occurring specifically within the neighbourhood.

The purpose of this study was to employ the rich and unique data from the Healthy Communities Study (HCS) (15) to better understand relationships between residential street quality and youth PA. Specifically, we examined whether the overall quality of street environments, as well as specific variables, was associated with each of neighbourhood-based and street-based youth PA.

Methods

Study design and sampling

The HCS is a large-scale, observational study of 130 US communities exploring associations between community programmes and policies designed to promote health behaviours and obesity-related child outcomes such as body mass index, nutrition and PA (15,16). As described elsewhere (17), within each

community, one or more census tracts were randomly selected; then, the public high school (9th–12th grade) closest to the centroid of the tract was identified to represent the selected community, and two elementary (kindergarten through 5th grade) and two middle schools (6th–8th grade) within the high school's catchment area (as defined by the local school district) were identified and used for participant recruitment. Using a stratified random selection process, children in kindergarten through 8th grade and their parents were recruited via an informational letter sent home from the school (17). Parents provided written informed consent for their child's participation, and the study was approved by the Battelle Memorial Institute Institutional Review Board.

Data collection

Data collection for the HCS took place year-round from November 2013 to July 2015 as communities were recruited. Trained field data collectors conducted in-home interviews with participating families. Self-reported sections of the interview were completed independently with parental or guardian assistance as needed for youth ages 9–15 years, while the self-administered section was completed by the parent or guardian for children ages 4–8 years. Coinciding with the household interviews, trained staff also conducted observational windshield audits by driving a vehicle down the participant's street segment and documenting specific quality attributes (described further in the next section).

Measures

Physical activity

Child PA data were captured using the 7-d Physical Activity Behaviour Recall as part of the household interview (18). Respondents indicated whether or not the child had participated in 15 different activities during the past week, the days on which he or she did the activity and the average intensity of the activity (light, moderate, hard and very hard). As well, participants who indicated activity on the previous day were asked to respond to additional items about the type of activity, the duration of the activity (minutes), location of the activity (e.g. school, home and street) and any co-participants. To better understand the relationship between street environments and context-specific PA, an overall *neighbourhood-based PA index* was created by summing the frequency (times per week) of seven of the 15 activity types that were not related to time at school (pick up sports – i.e. non-organized/non-structured

play, non-school sports, physically active games, outdoor/adventure activities, walk/bike to school, walk/bike to store/friend's house and walk/bike for fun/exercise). Additionally, among those who reported any neighbourhood PA activities on the previous day, a *street-based PA* variable assessed whether any of this activity occurred on the child's street. This latter variable was dichotomized as 'any street-based PA' vs. 'no street-based PA' based on the distribution of episodes for youth in the sample.

Street quality

Quality variables for each participating household's street segment were documented through direct observation windshield surveys using five items from the Neighbourhood Attribute Inventory (19). A participant's street segment was defined as the road segment from intersection to intersection that bordered the home address not to exceed 0.5 miles, and each segment was audited by a single data collection staff member trained and certified to a gold standard (at least 80% reliability compared with trainer ratings of street segment photos during training and throughout the study). The five selected Neighbourhood Attribute Inventory items comprised measures of physical disorder as well as environmental variables related to PA with high to acceptable reliability (20). Specifically, these included (i) the presence (0) or absence (1) of any burned, boarded up or abandoned residential units, (ii) the presence and amount of litter measured using a 3-point scale and dichotomized as some/moderate/a lot (0) or none (1), (iii) the overall quality and condition of residential units captured using a 5-point scale and dichotomized as fair/poor/mixed (0) or excellent/good (1), (iv) the type of street dichotomized as a major or moderately busy thoroughfare (0) or a side street/cul-de-sac/dead end/one-way (1) and (v) sidewalks that were absent or available but in poor condition (0) vs. the presence of sidewalks that were in good condition (1). Scores for all items were summed to provide an overall quality score (0–5) for each child's street segment.

Analyses

Descriptive statistics were used to explore characteristics of the study sample and key exposure and outcome variables. Multilevel linear regression models examined the influence of both the total street quality score and each street quality variable on the youth neighbourhood PA index, and multilevel logistic regression examined relationships between the same exposure variables and the likelihood of youth

engaging in PA specifically on their street. All analyses were performed in SAS 9.4 and were adjusted for selected sociodemographic correlates of youth PA (gender, age, race, ethnicity and parent level of education), with community of residence treated as a random variable.

Results

In total, the HCS included youth from 130 communities (mean = 39.5, range = 6–83 per community). The analysis for the neighbourhood PA index dependent variable included 4415 participants with complete data for all variables (deletions for missing variables from the full sample of 5138 youth in the HCS included 180 for PA, 75 for parental education, 46 for ethnicity and 417 for one or more windshield survey variables). The analysis for the street-based PA dependent variable included 2724 participants given that this variable was calculated only for youth who reported participating in PA the previous day. As shown in Table 1, of the youth in the current sample ($n = 4.415$), 50.8% were female, and the mean age was 9.3 years ($SD = 2.7$). Just over half were non-Hispanic (55.1%) and White (58.5%).

The average neighbourhood-based PA index was 9.57 episodes in the past week ($SD = 7.20$, range = 0–46). Of those youth who reported engaging in PA on the previous day, 24.6% had at least one episode of street-based PA (Table 1). The mean total street quality score (range = 0–5) was 2.84 ($SD = 1.26$), and the five individual street quality variables ranged from 86.9% of youth having an absence of burned, boarded up or abandoned units to only 27.5% having sidewalks that were present and in good condition (Table 1).

Based on multilevel linear regression analyses, youth who had no litter present on their street reported significantly lower neighbourhood-based PA compared with youth living on streets where litter was observed ($b = -0.51$, $p = 0.04$). In addition, youth had significantly greater neighbourhood-based PA when they lived on a side street, cul-de-sac, dead-end or one-way street compared with youth who lived on a major or moderately busy thoroughfare ($b = 0.60$, $p = 0.03$; Table 2). No significant associations were detected between reported neighbourhood-based PA and presence and condition of sidewalks, condition of residential units, presence of burned, boarded up or abandoned units or the total street quality score. The multilevel logistic regression analyses showed no significant associations between street-based PA on the previous day and the five individual street quality variables or the total street quality score.

Table 1 Participant and street characteristics

Participant characteristic	N	% or mean (SD)
Gender		
Male	2173	49.2
Female	2242	50.8
Age	4415	9.3 (2.7)
Ethnicity		
Not Hispanic	2434	55.1
Hispanic	1981	44.9
Race		
White	2584	58.5
African-American	848	19.2
Mixed race	198	4.5
Unknown	583	13.2
Other	202	4.6
Body mass index	4250	19.95 (5.37)
Neighbourhood-based PA index	4415	9.6 (7.2)
Street-based PA		
Yes	703	24.6
No	2158	75.4
Street quality attributes		
Burned, boarded up, abandoned units		
Absent	3836	86.9
Present	579	13.1
Litter		
None	1486	33.7
Some/moderate/a lot	2929	66.3
Condition of residential units		
Excellent/good	2461	55.7%
Fair/poor/mixed	1954	44.3%
Street type		
Side street/cul-de-sac/ dead-end/one-way	3558	80.6
Major or moderately busy thoroughfare	857	19.4
Sidewalks		
Present and in good condition	1215	27.5
Absent or in poor condition	3200	72.5
Total street quality summary score (0–5)	4415	2.8 (1.3)

PA, physical activity.

Discussion

This study examined the relationship between street quality attributes and youth PA. Data from the HCS provided a unique opportunity to assess the association of two context-specific youth PA outcomes with objective street quality measures in a national sample. Namely, we assessed five specific street

quality characteristics, as well as a total summary index, in relation to both neighbourhood-based and street-based PA among youth ages 9–15. The ability of this study to examine objectively measured street quality through the use of windshield surveys in a large and diverse sample is an important contribution to the literature on youth PA, which has previously largely relied on broader scale measures collected through GIS or self-reported (i.e. parent-reported) data in limited geographic areas.

One counterintuitive result of our study was that youth living on streets with no litter reported lower neighbourhood-based PA. Few prior studies have isolated the association between specific elements of neighbourhood quality and youth PA, instead relying on composite metrics of objective or parent-reported safety (21). The positive relationship between litter and PA observed in this study might be explained by factors such as mixed land use, increased pedestrian traffic or more population and playmates nearby, which may facilitate greater PA among youth through diverse mechanisms (6,11) but may also result in increased litter and other minor neighbourhood quality issues.

We also found that living on a side street, cul-de-sac, dead-end or one-way street was related to greater levels of neighbourhood PA. This is consistent with other past research showing that such street designs promote outdoor play and PA among youth (22); however, it also contrasts somewhat with most research on adults that has reported positive associations between intersection density (usually characterized by grid-like street patterns devoid of cul-de-sacs) and PA (23). One solution that combines both types of street layouts is the fused grid, which incorporates cul-de-sacs, side streets and connecting green spaces and trails within cells bounded by higher traffic arterial and commercial roads plotted in a grid-like manner (24). The fused grid planning model has received limited attention in relationship to either youth or adult PA but deserves greater consideration to balance the active transportation and recreation pursuits of adults and youth alike (24).

Several other street quality variables were unrelated to either neighbourhood-based or street-based PA. It is possible that youth of certain ages are more likely to engage in play in residential yards or local green spaces such that the quality of street environments matters less for PA. Indeed, one study of 10- to 14-year-old boys in Houston found that few of the audited street characteristics within 400 m of home were associated with objectively measured moderate-to-vigorous PA and instead

Table 2 Association of street quality attributes with neighbourhood PA and street-based PA

Street quality attribute	Neighbourhood PA index (<i>n</i> = 4415)		Street-based PA (yes) (<i>n</i> = 2724)	
	<i>b</i>	<i>p</i>	OR	95% CI
Burned, boarded up or abandoned units (absent)	−0.13	0.68	1.00	(0.75, 1.33)
Litter (none)	−0.51	0.04	0.83	(0.67, 1.03)
Condition of residential units (excellent/good)	−0.20	0.42	1.01	(0.82, 1.23)
Street type (side street/cul-de-sac/dead-end/one-way)	0.60	0.03	1.24	(0.97, 1.58)
Sidewalks (present and in good condition)	0.04	0.89	1.10	(0.89, 1.36)
Total street quality score	−0.05	0.65	1.01	(0.93, 1.10)

CI, confidence interval; OR = odds ratio; PA, physical activity. Significant findings ($p < .05$) are indicated in bold text.

suggested that other factors not examined, such as parks and recreation facilities, may be more strongly related to adolescent PA (25). As well, the PA recall instrument was designed to capture activities that could be affected by community interventions (consistent with the purpose of the HCS) and therefore potentially did not include all relevant activities for youth in this age group, including some that may have been related to street quality.

Finally, we found a lack of associations between the total street quality measure and either neighbourhood-based or street-based PA. Interestingly, elements within this composite metric, such as sidewalks, residential condition or the presence of burned, boarded up or abandoned units, may not have significantly impacted the PA of youth in this study. Other factors within the proximal road environment, such as lighting, topography, crosswalks, traffic control measures (e.g. speed bumps and speed limits), surveillance and shade trees, potentially warrant examination as part of a youth-focused street quality index in future (21).

Limitations

Several limitations should be noted. First, this analysis is one component of the broader HCS and employed a cross-sectional study design, which limits the ability to infer causation between street quality indicators and neighbourhood-based and street-based youth PA behaviour. In addition, the PA measures used as the dependent variables in these analyses were self-reported by adults (for younger children) or youth (for older children) (18). Self-reported measures are potentially influenced by recall and social desirability bias. However, this measure was carefully developed for this particular study, followed a strict data collection protocol with trained research staff and allowed researchers to examine location-based PA in a large

population of children across 130 communities (18). Likewise, the street-based PA variable used for the second research question only focused on the prior day and only included youth who had participated in any PA on the previous day, resulting in a smaller sample size for this particular analysis. The reduction in sample size may have contributed lower power to detect statistically significant findings for the litter and street type variables, as they approached statistical significance in relationship to street-based PA but did not meet the $p < 0.05$ threshold. Results may also have varied depending on whether the previous day was on a weekend or weekday, although Sunday data collection was uncommon, and the season in which data collection occurred. Finally, the direct observation windshield surveys were limited to five key neighbourhood variables hypothesized to influence youth PA levels and were conducted by a single data collection staff member.

Future research

This study contributes to knowledge of environmental factors that may influence youth PA. However, there are several opportunities for future research that could improve understanding of neighbourhood-based and street-based youth PA. For example, incorporating sociodemographic characteristics of broader neighbourhoods, such as poverty levels and racial segregation, may be valuable as these may play a role in youth PA via the real and perceived availability and suitability of neighbourhood resources (5,6,26). Likewise, examining interactions between sociodemographic (e.g. race and gender) or interpersonal (e.g. social support and safety) variables and street attributes may illuminate additional dynamics in the association between residential quality and youth PA. Additionally, previous studies have found that both parent and child perceptions of

environmental factors, including access to PA opportunities, may influence and even predict youth PA (7,27), suggesting that perceived environments may be just as important as objective measures when exploring neighbourhood effects. As well, a growing body of literature points to the important role that social environments, such as parental support, neighbourhood social cohesion and youth peer relationships, play in youth PA (5). For instance, as youth are often aware of and heed neighbourhood boundaries (i.e. parks, schools and busy streets) set forth by their parents (27), future research could examine how parental perceptions and decisions regarding children's outdoor autonomy may impact PA and obesity outcomes (7,28). Not only have parents expressed concern for 'stranger danger' during child outdoor activity, the social pressure of constant child supervision has increased, resulting in parents being fearful of judgement or legal action for allowing children outdoors without adult supervision (29). Furthermore, both objective and perceived indicators of crime and safety are also predominant elements of neighbourhood social contexts that should be considered in future studies (5,10). Similarly, related measures of neighbourhood quality such as broken windows may help in explaining parent and child attitudes towards street-based PA (5). Finally, investigating the potential moderating effects that individual and community-level factors (e.g. psychosocial, income and alternative PA opportunities) have on youth behaviours could improve our understanding of and ability to promote neighbourhood PA and subsequently obesity prevention among youth (30).

In summary, using data from over 4000 youth across 130 communities, this study found that specific street quality attributes, such as the presence of litter and living on side streets, cul-de-sacs or less busy roads, were associated with higher levels of neighbourhood-based PA. Such evidence suggests that the design and quality of streets and neighbourhoods may play an important role in facilitating children's PA. Collaboration between local government officials in sectors such as public health, community development and transportation and planning regarding the physical infrastructure and aesthetic maintenance of street and neighbourhood features could have a positive influence on the PA and health of children and families nationwide.

Conflict of interest statement

No conflict of interest was declared.

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Author contributions

A. K. conceived of the manuscript and led all aspects of analysis and writing. G. B., S. C. and S. M. H. contributed to analysis and writing. N. C. and K. M. contributed to research design and data collection. M. D. led all analyses, and R. P. led all aspects of the study design and implementation. All authors were involved in writing the paper and had final approval of the submitted and published versions.

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