Published in final edited form as:

Health Place. 2015 July ; 34: 164–170. doi:10.1016/j.healthplace.2015.05.006.

Patterns of neighborhood environment attributes in relation to children's physical activity

Jonathan M. Kurka^a, Marc A. Adams^{a,*}, Michael Todd^b, Trina Colburn^c, James F Sallis^d, Kelli L. Cain^d, Karen Glanz^e, Lawrence D. Frank^f, and Brian E. Saelens^c

^aExercise and Wellness Program, School of Nutrition and Health Promotion, Arizona State University, USA

^bCollege of Nursing and Health Innovation, Arizona State University, USA

^cCenter for Child Health, Behavior, and Development, Seattle Children's Research Institute, USA

^dDepartment of Family and Preventive Medicine, University of California San Diego School of Medicine, USA

^eDepartment of Epidemiology and Biostatistics, Perelman School of Medicine, Department of Biobehavioral Health Sciences, School of Nursing, University of Pennsylvania, Philadelphia, USA

^fSchools of Population and Public Health and Community and Regional Planning, University of British Columbia, USA

^gDepartment of Pediatrics, School of Medicine, University of Washington, USA

Abstract

Characterizing neighborhood environments in relation to physical activity is complex. Latent profiles of parents' perceptions of neighborhood characteristics were examined in relation to accelerometer-measured moderate-to-vigorous physical activity (MVPA) among 678 children (ages 6-12) in two US regions. Neighborhood environment profiles derived from walkability, transit access, aesthetics, crime and traffic safety, pedestrian infrastructure, and recreation/park access were created for each region. The San Diego County profile lowest on walkability and recreation/park access was associated with an average of 13 fewer minutes/day of children's out-of-school MVPA compared to profiles higher on walkability and recreation/park access. Seattle/King County profiles did not differ on children's MVPA. Neighborhood environment profiles were associated with children's MVPA in one region, but results were inconsistent across regions.

Keywords

built environment; accelerometer; exercise; latent profile analysis

*Corresponding Author: Marc A. Adams, Exercise and Wellness Program, School of Nutrition and Health Promotion, Arizona State University, 500N, third Street (Mail Code 3020), Phoenix, AZ 85004, USA.

CONFLICTS OF INTEREST

None to report.

INTRODUCTION

Regular physical activity reduces risk for developing adverse health outcomes and improves cardiovascular, muscular, and metabolic health. For children, the Physical Activity Guidelines for Americans recommends acquiring 60 or more minutes of aerobic physical activity per day, most of which should be moderate-to-vigorous intensity (MVPA) (“Physical Activity Guidelines for Americans,” 2008) to realize health-enhancing benefits. Long et al. (2013) reported that children 6 to 11 years old on average exceeded daily recommendations with the largest proportion of MVPA time occurring outside of school hours (Long et al., 2013), though the proportion meeting guidelines dropped dramatically during adolescence (Troiano et al., 2008). Thus, increased emphasis on identifying promising strategies for increasing youth out-of-school MVPA is warranted.

Ecological models propose that features of built environments influence physical activity and may be especially important for out-of-school physical activity (Saelens et al., 2003). Research supports the important role of neighborhood environments in children’s physical activity (Bauman et al., 2012; Kneeshaw-Price et al., 2013). A central tenet of ecological models is that multiple factors within and across levels of influence should explain physical activity better than a single factor (Sallis et al., 2009). This principle provides a rationale for simultaneously considering multiple factors when explaining MVPA. Limitations arise when analyzing individual attributes separately, as an individual’s residential environment is composed of combinations of physical and social neighborhood features, many of which co-occur. For children, individual features such as recreation facility access, traffic safety, crime safety, and access to public transportation have been associated with children’s physical activity in multiple studies while other features, such as street connectivity, residential density, and greater land-use mix have yielded mixed findings (Ding et al., 2011).

Unique combinations of neighborhood features may be associated with MVPA in different ways (Adams et al., 2011). For example, one neighborhood may exhibit high land-use mix and high street connectivity and good access to transit and parks while another neighborhood within the same urban area may exhibit a different combination of features. Examining combinations of neighborhood features in relation to MVPA may account for more variation in prediction models, thereby strengthening results. The difficulty lies in how best to account for the numerous combinations and complex patterns of built environment features. Different a priori (e.g. indices) and data-driven (e.g. factor analysis) approaches have merits. For example, Tappe et al. explored relationships between perceived built environment features and objective MVPA using a backwards stepwise regression approach. Though this approach considered multiple aspects of built environment features on physical activity while controlling for the other features, the combination of individual features could not be ascertained (Tappe et al., 2013).

The use of latent profile analysis (LPA) to examine built environment features is a relatively new data-driven approach that recognizes the natural co-occurrence of features and seeks to consider this co-occurring impact on outcomes. LPA has shown promise identifying complex patterns of built environment features among adults and older adults with resultant

profiles associated with MVPA in these populations (Adams et al., 2012; Adams et al., 2013).

Parent reports of neighborhood characteristics, such as neighborhood safety and proximity to parks, have been associated with greater levels of children's physical activity (Rosenberg et al., 2009). Parents may limit their child's outdoor activity due to negatively perceived access to recreation facilities or poor safety features and crime (Brownson et al., 2009). Therefore, parents' perceived built environment features may be an important measure when examining children's out-of-school MVPA, as combinations of built environment features may be revealed that are not evident in objectively measured neighborhood features.

The first purpose of the present analysis was to explore whether latent profile analysis could derive unique combinations among 11 perceived neighborhood environment features using a validated self-report measure of the built environment. Second, we explored whether objectively measured children's total and out-of-school MVPA differed across derived latent profiles. We expected that combinations of built environment features would result in unique patterns, termed profiles, and that children in physical activity-supportive neighborhood profiles would have more total and out-of-school MVPA. The present analysis was conducted separately in two U.S. metropolitan regions to examine the consistency in profile derivation and relation to children's MVPA.

METHODS

Design and Sampling

This secondary analysis used baseline data from the Neighborhood Impact on Kids Study (NIK), including parent surveys, objectively measured physical activity, and measured anthropometrics of participating children. NIK is a longitudinal cohort study in Seattle/King County, WA and San Diego County, CA examining neighborhood environment characteristics in relation to child and parent overweight and obesity, with baseline measures (2007) and follow-up measures collected two years apart (Saelens et al., 2012). Neighborhood selection and participant recruitment details have been published previously (Frank et al., 2012). To maximize within-neighborhood homogeneity of environmental features neighborhoods were defined as census block groups rather than census tracts. Objective data were used to calculate walkability (Frank et al., 2012), park proximity and quality, grocery store availability, and fast food restaurant concentration. Block groups were then categorized by median split into "good" and "poor" physical activity environments and good and poor nutrition environments. These categories were used to build a 2X2 matrix of eligible block groups, with the four cells referred to as quadrants. Households with children aged 6-11 years from the identified block groups were selected using probability sampling within each quadrant and contacted by phone. Eligible children were able to engage in MVPA, did not have underlying medical conditions associated with obesity, and were not involved in medical treatment that had a substantive impact on growth. Excluded children had a chronic illness known to affect growth, < 10th percentile BMI for age and gender, an eating disturbance indicative of substantial eating disorder psychopathology, a medically prescribed dietary regimen, or a psychiatric problem that would interfere with participation (Saelens et al., 2012). Only one child per household was eligible to participate. After

screening for eligibility, 944 families agreed to participate. Among these families, 757 consented and had a measurement visit. Institutional review boards at Seattle Children's Hospital, San Diego State University, Emory University, and Arizona State University approved this study and present analyses.

Measures

Perceived Neighborhood Environment—The present study used an adapted version of the original Neighborhood Environment Walkability Scale (NEWS) that combined NEWS and NEWS-Youth subscales, both reliable and valid surveys of physical activity-related neighborhood environment constructs (Saelens et al., 2003; Rosenberg et al., 2009; Adams et al., 2009). The child's parent or guardian completed the surveys for the neighborhood where the child lived a majority of the time. The subscales included residential density (6 items), land use mix-diversity (14 items), land use mix-access (6 items), street connectivity (3 items), pedestrian facilities (3 items), aesthetics (4 items), traffic safety (4 items), and crime safety (7 items). In addition, an 11-item scale measured recreation facility/park access, and one item measured public transit access. Residential density items were rated on a 5-point scale from "none" to "all," with the scale computed as the sum of item responses weighted by values approximating density of households per unit area relative to a single-family detached residence. Land use mix-diversity, transit access, and parks and recreation facility access items were rated on a 5-point scale (i.e., 1-5 min, 6-10 min, 11-20 min, 21-30 min, 31+ min), with item responses representing walking time to stores, transit stops, recreation facilities, etc. in the participant's neighborhood. Each of these scale scores was computed as the mean of constituent item responses. Items in the remaining scales were all rated on a 4-point scale from "strongly disagree" to "strongly agree," with scale scores computed as the means of item responses. Data were recoded as needed so that higher values were expected to be associated with more physical activity. All subscales have previously shown moderate to good test-retest reliability (NEWS: $r = 0.58-0.80$, NEWS-Y: $r = .56-.87$) (Saelens et al., 2003; Rosenberg et al., 2009). The NEWS and NEWS-Youth with standardized subscale scoring procedures are available from <http://sallis.ucsd.edu>.

Moderate to Vigorous Physical Activity (MVPA)—Moderate-to-vigorous physical activity (MVPA) was measured objectively with the ActiGraph (GT1M) accelerometer (Pensacola, FL). Project staff in-person instruction to parents and children on how to have children properly wear the device. Children were asked to wear the accelerometer for 7 days for at least 10 hours per day during waking hours except during water-based activities, such as showering or swimming. Children were asked to re-wear the accelerometer if fewer than 6 valid days were recorded. Physical activity counts were captured in 30-sec epochs, and non-wear time was defined as > 40 epochs (i.e., 20 minutes) of consecutive zero counts. Wear-time was converted into activity intensity using age-specific cut points with MVPA defined as 3 or more METs (Freedson et al., 2005). A day with 10 or more hours of accelerometer wear time was treated as a valid measurement day.

Parents were instructed to keep track of their children's location using daily place logs. The place logs tracked time and place (e.g., name and address) of where their child went throughout the day for each of the days the accelerometer was to be worn. Children's time-

stamped accelerometer data and self-reported place logs were matched to derive children's location-specific MVPA (e.g., school, home, convenience store). Details regarding place log and accelerometer integration methods have been published previously (Kneeshaw-Price et al., 2013).

In-school MVPA minutes/day was calculated by summing all MVPA time accrued at the school location on valid wearing days only. Out-of-school MVPA minutes/day was calculated by subtracting in-school MVPA time from total MVPA time on valid wearing days only. Average daily and average daily out-of-school MVPA were calculated by dividing accrued MVPA by the number of valid days respectively. A total of 674 children had valid MVPA data in San Diego County (valid days $M = 6.5 \pm 1.41$; $n = 308$) and Seattle/King County (valid days $M = 6.7 \pm 1.13$; $n = 366$) regions.

Anthropometries—Children had their weight measured using a digital scale during an office visit (Detecto 750) or an in-home visit (Detecto DR400C) by a trained research assistant. Weight was measured a minimum of three times until three consecutive readings were 0.1 kg different, with the average of those values recorded. Height was measured using a stadiometer during an office visit (235 Heightronic Digital Stadiometer) or an in-home visit (portable Seca 214). The measurement was taken multiple times to the nearest 0.1 cm until a minimum of three consecutive measures were within 0.5 cm of each other, with the average of those values recorded. Child overweight/obesity was defined as BMI 85th percentile for age and gender using CDC 2000 growth charts (Kuczmarski et al., 2000).

Child and Parent Characteristics—Demographic characteristics of the sampled families were gathered by parent survey. Final sample demographics included parent gender and age (years), annual household income (11 levels ranging from <\$10,000 to >\$100,000), parent education (seven levels ranging from < 7th grade to graduate degree), parent body mass index (BMI; kg/m^2), number of people in household, number of vehicles per household, number of drivers per household, marital and cohabitation status (married or living with partner vs. widowed/divorced/separated or single/never married). Additionally, children's gender and age, race/ethnicity (non-Hispanic white versus non-white or Hispanic), were reported by parents.

Data Analysis

Latent profile analysis (LPA) was performed using the 11 parent-reported neighborhood environment variables in Mplus v7.11 (Los Angeles, CA). LPA, a special case of latent class analysis using *continuous indicators*, statistically derives mutually exclusive subsample profiles that maximize between-profile variance and minimize within-profile variance based on model fit criteria (AIC, BIC, log-likelihood) (Collins, 2010). LPA allows for subgroups (profiles) within a population to be identified from their response patterns and classifies individuals into profiles based on probabilities. Latent profiles were examined sequentially starting with 2-profile models using data from Seattle/King County and San Diego County separately. Previous studies have shown that the number of profiles can differ by region, justifying stratification by region (Adams et al., 2011). Analyses continued until either

model identification or convergence could not be achieved. Each participant was subsequently assigned to a single profile based on the highest estimated profile probability.

A multilevel ANCOVA model was estimated for child out-of-school MVPA using assigned profile membership as the predictor variable while controlling for the fixed effects of child gender, age and race/ethnicity, marital status and household income, parent education, number of people living in the household and number of cars per legal driver in household, time at current address, accelerometer wear time, and study design quadrants using SAS v9.3 (Cary, NC; Proc Mixed). Block group in which the child lived was specified as a random effect to account for the nested sampling design. A separate multilevel ANCOVA model was estimated for each region. Post-hoc analyses of odds of children being overweight/obese (yes=1, no=0) across profiles were tested using generalized linear mixed models (SAS, Proc Glimmix) with binary distribution separately for each region, with the same covariates as above except accelerometer wear time was not included.

RESULTS

Out of 757 families, a total of 83 children had missing MVPA data at baseline or moved prior to follow-up. The excluded San Diego subsample (n=56) was 53.6% female with an average age of 8.9 ± 1.6 ($M \pm SD$). The excluded Seattle/King County subsample (n=26) was 46.2% female with an average age of 8.7 ± 1.5 . No demographic or personal characteristics were significantly different between included and excluded samples except race/ethnicity in both San Diego County (32.1% vs. 17.2% nonwhite) and Seattle/King County (23.1% vs. 16.7% nonwhite). A total of 674 participants with survey responses and at least one valid day of baseline MVPA were included in the LPA.

LPA 2-, 3-, and 4-profile models were identified for both regions. For the Seattle/King County region, model fit estimates indicated better fit for the 4-profile solution (AIC=10458.78, BIC=10685.14) compared to the 3-profile (AIC=10653.01, BIC=10832.54) and 2-profile (AIC=10787.95, BIC=11011.64) solutions, but the 3-profile solution was chosen because the 4th profile had a small sample size (< 5% of sample). The San Diego County 4-profile solution was chosen due to better model fit estimates and interpretability than the 3-profile solution (AIC=9198.44 vs. 9257.03, BIC=9414.78 vs. 9428.62) with sufficient sample size in all four profiles. For San Diego (Figure 1) and Seattle (Figure 2) regions, some profiles were visually similar and subsequently labeled similarly according to their pattern traits. Table 1 and Table 2 provide demographic and characteristic information across profiles for the San Diego and Seattle regions, respectively.

The first profile for San Diego (22.7% of region sample) and Seattle (23.6% of region sample) regions, labeled “Low Walkable, Unsafe, Parks and Recreation Sparse”, was characterized by Z-scores lower than region-specific means on all 11 perceived neighborhood variables. The second profile for San Diego (43.7%) and Seattle (35.2%) regions, labeled as “Moderate Walkable, Transit Access, and Recreation”, was characterized by Z-scores that were within 0.5 standard deviations from region specific means. The 3rd Seattle region profile (40.4%) closely resembled the 3rd San Diego region profile (19.7%), consisting of Z-scores greater than the region mean for all 11 perceived neighborhood

variables. These patterns were labeled “High Walkable, Transit, and Recreation Dense” due to particularly high values for land-use mix diversity, transit access, parks, and recreation facilities. The 4th San Diego region profile (13.6%) was differentiated on very low values of land-use mix diversity, land-use mix access, and transit access, and high values of traffic safety and crime safety; therefore it was labeled “Low Walkable and Transit Access, Safe with Average Recreation Facilities”.

In the San Diego region, the profiles did not differ by total child MVPA. However, the San Diego region children living in the ‘Low Walkable, Unsafe, Parks and Recreation Sparse’ profile had approximately 13 fewer minutes per day of out-of-school MVPA compared to the other three profiles. Children living in the “Moderate Walkable, Transit Access, and Recreation”, “High Walkable, Transit, and Recreation Dense”, and “Low Walkable and Transit Access, Safe with Average Recreation Facilities” profiles were not significantly different from each other in out-of-school MVPA. In the Seattle region, no significant differences were found between profiles for total or out-of-school MVPA (Table 3). Odds of children being overweight/obese were not different across profiles.

DISCUSSION

Children’s out-of-school MVPA minutes per day differed between distinct neighborhood profiles in the San Diego region. Children living in neighborhoods perceived as less walkable and not proximal to transit and recreation spaces engaged in about 13 minutes less daily out-of-school MVPA than children in the other three San Diego profiles. Other profiles were perceived as having better pedestrian facilities and access to recreation facilities and parks that were positively associated with children’s MVPA, although differences among them were nonsignificant. Perceived access to transit was notably lower for this profile which is capturing regional location and likelihood of being in a less central location, translating into more sedentary time spent in cars. The lower amount of out-of-school MVPA in the San Diego region Low Walkable, Transit and Recreational Sparse profile may be explained by the combination of features in this profile that included low values of walkability in combination with extremely low values of parks and recreation facilities in the area, as well as the perception of poor traffic safety and crime safety. These results agree with previous studies that have suggested neighborhoods with nearby parks and play areas with traffic safety relate positively to children’s out-of-school MVPA (Han et al., 2013).

It is notable that almost one-quarter of children in the San Diego sample lived in the least physical activity-supportive neighborhoods, although this may be partially due to the NIK sampling plan. The 13-minute per day difference between the Low Walkable, Transit and Recreational Sparse profile and the other profiles is about half of the physical activity recommended for out-of-school time by the Centers for Disease Control and Prevention (Author, 2011). A possible explanation for children in the San Diego region accruing non-significant differences in total-day MVPA could be due to a substantial proportion of daily MVPA being accrued in school, which is MVPA that is more closely associated with school practices than neighborhood environments (Long et al., 2013). Despite similar neighborhood profiles across regions, the San Diego results were not replicated in the Seattle region, wherein no differences across profiles were observed for children’s total or out-of-school

MVPA. This may be a function of a more even distribution of access and exposure to features that support or hinder neighborhood-based activity (Frank et al., 2012).

Children's independent mobility, or the freedom of children to travel around their own neighborhood or city without adult supervision, may have accounted for the lack of MVPA differences between all Seattle profiles and among the other three San Diego profiles. Heightened parental concerns regarding childhood crime and traffic safety could introduce a barrier to children's total and out-of-school daily MVPA given the perceived nature of the neighborhood measures (Brownson et al., 2009; Stone et al., 2014). It is also possible that children in different types of neighborhoods accrue their physical activity differently, or that residents of some neighborhoods, such as the more affluent, may be better able to compensate for neighborhood environment deficiencies by enrolling their children in organized sports teams or activity classes.

Another explanation for similar MVPA levels across Seattle region profiles is the wetter and colder climate in the Seattle region leading parents to rely more on indoor physical activity opportunities for their children, either at school or in community settings such as dance studios or recreation centers. If children are doing more indoor physical activity, then neighborhood environment characteristics would be expected to be less influential, with the possible exception of availability and proximity of recreation facilities. Clearly, more precipitation is not suppressing children's physical activity in the Seattle region as their average total and out-of-school physical activity was higher than for San Diego region children, so additional studies are needed to identify how parents and children are responding to weather-related challenges.

Few studies have examined the combined effect of multiple, perceived and co-occurring built environment factors, and fewer have done so for children. Norman et al. examined the objective recreation environment in relation to adolescent (11-15 years) MVPA, finding that profiles with higher residential densities and a greater number of recreational facilities and acreage were positively associated with total MVPA (Norman et al., 2010). Mota et al. examined perceived neighborhood environment in relation to physical activity and found access to destinations, recreation facilities, and aesthetics to be important neighborhood attributes for explaining adolescents' (11-18 years) physical activity (Mota et al., 2005). In comparison, present analyses showed the profiles with higher values of perceived pedestrian and recreation facilities and parks were positively associated with out-of-school MVPA in the San Diego region, although differences in the Seattle region were non-significant.

It is noteworthy that parent perceptions of neighborhood environments from these two regions resulted in similar types of profiles, although the analysis of San Diego region data revealed one additional profile. Previous reports of adults' perceptions of neighborhoods features identified similar neighborhood patterns (Adams et al., 2011). Adams et al. identified similarly structured neighborhood patterns for a low walkable, transit and recreation sparse profile and a moderate walkable, transit access, and recreation profile using data from different samples of adults in the Seattle and Baltimore, MD regions. However, high walkable profiles were structured differently compared to present Seattle and San Diego region samples. Land-use mix diversity, transit access, and parks and recreation had

the highest values in a high walkable profile, whereas the high walkable profile reported by Adams et al. (2011) showed highest values of residential density. The present Seattle region results differed in number of profiles from Adams et al. (2011), possibly due to the number of subjects available for analysis. A 4-profile solution was identified for the Seattle region in current analyses, but this solution was ultimately rejected due to a small profile sample size, thus uncertain interpretability of one of the derived profiles. The current analysis also sampled less than a third of Seattle region residents compared to Adams et al. (2011), yet found remarkably similar profile patterns for Seattle region participants. It is possible that identification of region-specific profiles may be partially dependent on sample size and differences in the location of participants within the region.

Other studies have found latent profile analysis to be useful when comparing health- related patterns to other health outcomes. Martinson et al. showed that “Unenriched/Obesogenic” and “Risky Consumer” profiles derived from home environment and social/behavioral surveys were associated with youth BMI (Martinson et al., 2011). In the present data, there were no differences in child overweight/obesity by neighborhood profile within each region, likely due to a lack of statistical power. Previous results from the NIK sample examining body mass showed children in neighborhoods with favorable physical activity and nutrition environments to have a lower proportion of overweight and obesity compared to children living in neighborhoods with unfavorable physical activity and nutrition environments (Saelens et al., 2012). In the current study the proportion of overweight/obese children was lowest (14.3%) in the San Diego region neighborhood characterized as low on walkability and transit access, but high on safety and average park and recreation facilities while the highest proportion of overweight/obesity was in the San Diego profile characterized as low on walkability and transit but unsafe with sparse parks and recreations (37.1%). This contrast suggests perceived safety in addition to parks and recreation facilities might be important considerations for obesity control. In the Seattle region, the proportion of overweight/obesity was 27.6% in the Low Walkable, Unsafe, Parks and Recreation Sparse profile compared to 20.8% in the High Walkable, Transit and Recreation dense profile. In general, this trend of overweight/obesity proportions in relation to physical activity supportive neighborhoods agrees with previous results (Saelens et al., 2012) but after adjusting for differences in demographic and personal characteristics, these large differences in overweight/obesity proportions became statistically non-significant among profiles.

The strength of the present study lies in the detailed characterization of neighborhood attributes, with the addition of transit access, aesthetics, traffic safety, crime safety, and pedestrian and recreation facilities variables to the more commonly used variables that constitute walkability (e.g., residential density, land use mix, street connectivity); and the examination of objectively measured MVPA in children while adjusting for demographics and numerous personal and household characteristics. LPA provides an objective way to document how communities are built and how the co-location of different features relates with different behavioral outcomes. The LPA-based approach made use of more information, a total of 11 neighborhood features, and thus allowed for more nuanced empirically-derived classification of neighborhoods into profiles. Out-of-school MVPA was a conceptually congruent outcome to use for this study of neighborhood environment profiles. Limitations of the study included the reliance on parent-report and thus an

examination of only perceptions of neighborhood environments, a lack of measurement for children's independent mobility, and a relatively high affluence of the sample.

Conclusion

This secondary analysis of the Neighborhood Impact on Kids study examined LPA-derived neighborhood environment profiles in relation to young children's out-of-school MVPA. Neighborhood profiles indicative of areas supportive and unsupportive of children's physical activity based on parent's perceived neighborhood features were uncovered. The addition of transit access, aesthetics, traffic safety, crime safety, pedestrian and recreation facilities to the analysis of neighborhood walkability characteristics provided a multidimensional view of the perceived built and social environment. Walkability is often characterized as either high or low, but variation may still exist within low and high walkable neighborhoods once additional features such as public transportation and safety features are included. Overall, neighborhood patterns derived from perceived features of walkability, transit access, aesthetics, crime and traffic safety, pedestrian infrastructure, recreation facilities and parks can be identified and are associated with children's out-of-school MVPA. The feature combinations provide evidence to inform policy decisions for prioritizing investments in specific features that may be missing in certain locations, or highlight which features parents perceived as problems so neighborhood interventions may improve the community's perception of the surrounding environments through targeted changes. Optimizing a combination of features may be the key to increasing healthenhancing physical activity. Though it may be difficult or expensive to change some of these variables, re- development is a common ongoing process. Evidence on the health impacts of urban design decisions can help affect policies and practices. Data such as these also are relevant for ongoing advocacy efforts to reform zoning policies to encourage more "activity-supportive" designs, such as form-based codes that favor mixed land uses (<http://formbasedcodes.org/>).

ACKNOWLEDGEMENTS

This work was supported by in part by the American Heart Association's Beginning Grant in Aid (#12BGIA9280017), the NIH National Institute of Environmental Health Sciences (ES014240), USDA 2007-55215-17924, and by grants to the Seattle Children's Pediatric Clinical Research Center, which is supported by grants UL1 RR025014, KL2 RR025015, and TL1 RR025016 from the NIH National Center for Research Resources.

REFERENCES

- Adams MA, Ding D, Sallis JF, Bowles HR, Ainsworth BE, Bergman P, Bull FC, Carr H, Craig CL, De Bourdeaudhuij I, Gomez LF, Hagströmer M, Klasson-Heggebø L, Inoue S, Lefevre J, Macfarlane DJ, Matsudo S, Matsudo V, McLean G, Murase N, Sjöström M, Tomten H, Volbekiene V, Bauman A, 2013 Patterns of neighborhood environment attributes related to physical activity across 11 countries: a latent class analysis. *Int. J. Behav. Nutr. Phys. Act.* 10, 34. doi: 10.1186/1479-5868-10-34 [PubMed: 23497187]
- Adams MA, Ryan S, Kerr J, Sallis JF, Patrick K, Frank LD, Norman GJ, 2009 Validation of the Neighborhood Environment Walkability Scale (NEWS) items using geographic information systems. *J. Phys. Act. Health* 6 Suppl 1, S113–123. [PubMed: 19998857]
- Adams MA, Sallis JF, Conway TL, Frank LD, Saelens BE, Kerr J, Cain KL, King AC, 2012 Neighborhood environment profiles for physical activity among older adults. *Am. J. Health Behav.* 36, 757–769. doi:10.5993/AJHB.36.6.4 [PubMed: 23026035]

- Adams MA, Sallis JF, Kerr J, Conway TL, Saelens BE, Frank LD, Norman GJ, Cain KL, 2011 Neighborhood environment profiles related to physical activity and weight status: a latent profile analysis. *Prev. Med.* 52, 326–331. doi:10.1016/j.ypmed.2011.02.020 [PubMed: 21382400]
- Bauman AE, Reis RS, Sallis JF, Wells JC, Loos RJF, Martin BW, 2012 Correlates of physical activity: why are some people physically active and others not? *Lancet* 380, 258–271. doi:10.1016/S0140-6736(12)60735-1 [PubMed: 22818938]
- Brownson RC, Hoehner CM, Day K, Forsyth A, Sallis JF, 2009 Measuring the Built Environment for Physical Activity. *Am. J. Prev. Med.* 36, S99–S123.e12. doi:10.1016/j.amepre.2009.01.005 [PubMed: 19285216]
- Collins LM, 2010 Latent class and latent transition analysis: with applications in the social behavioral, and health sciences, Wiley series in probability and statistics. Wiley, Hoboken, N.J.
- Ding D, Sallis JF, Kerr J, Lee S, Rosenberg DE, 2011 Neighborhood environment and physical activity among youth a review. *Am. J. Prev. Med.* 41, 442–455. doi:10.1016/j.amepre.2011.06.036 [PubMed: 21961474]
- Frank LD, Saelens BE, Chapman J, Sallis JF, Kerr J, Glanz K, Couch SC, Learnihan V, Zhou C, Colburn T, Cain KL, 2012 Objective assessment of obesogenic environments in youth: geographic information system methods and spatial findings from the Neighborhood Impact on Kids study. *Am. J. Prev. Med.* 42, e47–55. doi:10.1016/j.amepre.2012.02.006 [PubMed: 22516503]
- Freedson P, Pober D, Janz KF, 2005 Calibration of accelerometer output for children. *Med. Sci. Sports Exerc.* 37, S523–530. [PubMed: 16294115]
- Han B, Cohen D, McKenzie TL, 2013 Quantifying the contribution of neighborhood parks to physical activity. *Prev. Med.* 57, 483–487. doi:10.1016/j.ypmed.2013.06.021 [PubMed: 23827723]
- Kneeshaw-Price S, Saelens BE, Sallis JF, Glanz K, Frank LD, Kerr J, Hannon PA, Grembowski DE, Chan K CG, Cain KL, 2013 Children's objective physical activity by location: why the neighborhood matters. *Pediatr. Exerc. Sci.* 25, 468–486. [PubMed: 23877357]
- Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, Flegal KM, Guo SS, Wei R, Mei Z, Curtin LR, Roche AF, Johnson CL, 2000 CDC growth charts: United States. *Adv. Data* 1–27.
- Long MW, Sobol AM, Cradock AL, Subramanian SV, Blendon RJ, Gortmaker SL, 2013 School-day and overall physical activity among youth. *Am. J. Prev. Med.* 45, 150–157. doi:10.1016/j.amepre.2013.03.011 [PubMed: 23867021]
- Martinson BC, VazquezBenitez G, Patnode CD, Hearst MO, Sherwood NE, Parker ED, Sirard J, Pasche KE, Lytle L, 2011 Obesogenic family types identified through latent profile analysis. *Ann. Behav. Med. Publ. Soc. Behav. Med.* 42, 210–220. doi:10.1007/s12160-011-9286-9
- Mota J, Almeida M, Santos P, Ribeiro JC, 2005 Perceived Neighborhood Environments and physical activity in adolescents. *Prev. Med.* 41, 834–836. doi:10.1016/j.ypmed.2005.07.012 [PubMed: 16137754]
- Norman GJ, Adams MA, Kerr J, Ryan S, Frank LD, Roesch SC, 2010 A latent profile analysis of neighborhood recreation environments in relation to adolescent physical activity, sedentary time, and obesity. *J. Public Health Manag. Pract. JPHMP* 16, 411–419. doi:10.1097/PHH.0b013e3181c60e92 [PubMed: 20689390]
- Physical Activity Guidelines for Americans, 2008.
- Rosenberg D, Ding D, Sallis JF, Kerr J, Norman GJ, Durant N, Harris SK, Saelens BE, 2009 Neighborhood Environment Walkability Scale for Youth (NEWS-Y): reliability and relationship with physical activity. *Prev. Med.* 49, 213–218. doi:10.1016/j.ypmed.2009.07.011 [PubMed: 19632263]
- Saelens BE, Sallis JF, Black JB, Chen D, 2003 Neighborhood-based differences in physical activity: an environment scale evaluation. *Am. J. Public Health* 93, 1552–1558. [PubMed: 12948979]
- Saelens BE, Sallis JF, Frank LD, Couch SC, Zhou C, Colburn T, Cain KL, Chapman J, Glanz K, 2012 Obesogenic neighborhood environments, child and parent obesity: the Neighborhood Impact on Kids study. *Am. J. Prev. Med.* 42, e57–64. doi:10.1016/j.amepre.2012.02.008 [PubMed: 22516504]
- Sallis JF, Owen N, Fisher EB, 2009 Ecological models of health behavior, in: Glanz K, Rimer BK, Viswanath K (Eds.), *Health Behavior and Health Education: Theory, Research, and Practice*. Jossey-Bass, San Francisco, pp. 465–482.

- Stone MR, Faulkner GE, Mitra R, Buliung RN, 2014 The freedom to explore: examining the influence of independent mobility on weekday, weekend and after-school physical activity behaviour in children living in urban and inner-suburban neighbourhoods of varying socioeconomic status. *Int. J. Behav. Nutr. Phys. Act.* 11, 5. doi:10.1186/1479-5868-11-5 [PubMed: 24450739]
- Tappe KA, Glanz K, Sallis JF, Zhou C, Saelens BE, 2013 Children's physical activity and parents' perception of the neighborhood environment: neighborhood impact on kids study. *Int. J. Behav. Nutr. Phys. Act.* 10, 39. doi:10.1186/1479-5868-10-39 [PubMed: 23531282]

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Figure 1 -

Latent Neighborhood Profiles for the San Diego Region. Interpretation: a Z-score equal to one means that the indicator variable was one standard deviation greater than the mean value of that indicator for the region. LW-U-RS=Low Walkable, Unsafe, Parks and Recreation Sparse. MW-TR=Moderate Walkable, Transit Access, and Recreation. HW-TRD=High Walkable, Transit, and Recreation Dense. LWT-S=Low Walkable and Transit Access, Safe with Average Recreation Facilities.

Figure 2 -

Latent Neighborhood Profiles for the Seattle Region. Interpretation: a Z-score equal to one means that the indicator variable was one standard deviation greater than the mean value of that indicator for the region. LW-U-RS=Low Walkable, Unsafe, Parks and Recreation Sparse. MW-TR=Moderate Walkable, Transit Access, and Recreation. HW-TRD=High Walkable, Transit, and Recreation Dense.

Table 1.**Participant Profile Demographics and Characteristics in San Diego Region**

	Low Walkable, Unsafe, Parks and Recreation Sparse (LW-U-RS)	Moderate Walkable, Transit Access, and Recreation (MW-TR)	High Walkable, Transit and Recreation Dense (HW-TRD)	Low Walkable and Transit Access, Safe with Average Recreation Facilities (LWT-S)
Parent				
n *	70	135	61	42
Sex (% women)	81.4	88.9	91.8	78.6
Age (years)	41.0 (5.2)	41.6 (6.8)	40.9 (6.2)	42.5 (5.4)
Race/Ethnicity (% nonwhite)	7.3	13.0	6.7	14.3
Household Income (\$/year - median)	\$90,000-99,000	\$70,000-79,000	\$70,000-79,000	\$90,000-99,000
Education (% at least college degree)	52.2	57.1	66.1	69.1
Number of Vehicles	2.8 (1.2)	2.4 (1.1)	2.2 (0.9)	2.4 (0.8)
Number of Drivers	2.2 (0.5)	2.1 (0.6)	2.0 (0.5)	2.0 (0.4)
Marital Status (% married or living w/ partner)	97.1	92.5	86.7	90.5
Number of People in Household	4.6 (1.0)	4.6 (1.1)	4.3 (1.1)	4.2 (0.9)
Years at current address	8.2 (4.3)	8.5 (5.6)	7.8 (4.7)	7.9 (4.6)
BMI (kg/m ²)	28.0 (6.4)	26.7 (5.0)	26.8 (6.4)	26.6 (4.7)
Children				
Sex (% female)	45.7	47.4	49.2	61.9
Age (years)	9.3 (1.6)	9.3 (1.7)	9.3 (1.5)	9.3 (1.6)
Race/Ethnicity (% nonwhite)	14.3	20.7	11.5	19.1
Overweight (%)	37.1	27.4	29.5	14.3

Values shown are unadjusted means (standard deviations) unless noted otherwise

Overweight = BMI 85th percentile for age and gender

* Some variables contain missing observations

Table 2.**Participant Profile Demographics and Characteristics in Seattle Region**

	Low Walkable, Unsafe, Parks and Recreation Sparse (LW-U-RS)	Moderate Walkable, Transit Access, and Recreation (MW-TR)	High Walkable, Transit and Recreation Dense (HW-TRD)
Parent			
n *	87	130	149
Sex (% women)	89.7	85.4	83.9
Age (years)	41.3 (5.5)	41.2 (5.3)	42.4 (5.7)
Race/Ethnicity (% nonwhite)	9.4	8.6	8.3
Household Income (\$/year - median)	>\$100,000	>\$100,000	>\$100,000
Education (% at least college degree)	71.8	78.5	77.0
Number of Vehicles	2.7 (1.3)	2.3 (0.8)	2.2 (0.7)
Number of Drivers	2.2 (0.6)	2.1 (0.4)	2.1 (0.4)
Marital Status (% married or living w/partner)	95.4	96.2	96.6
Number of People in Household	4.6 (1.0)	4.5 (0.9)	4.4 (0.9)
How long at current address (years)	7.8 (4.3)	8.0 (4.4)	9.2 (6.0)
BMI (kg/m ²)	27.3 (6.3)	26.9 (6.1)	26.4 (5.5)
Children			
Sex (% female)	55.2	43.9	53.02
Age (years)	9.0 (1.4)	8.8 (1.4)	9.0 (1.60)
Race/Ethnicity (% nonwhite)	13.8	20.0	15.44
Overweight (%)	27.6	25.4	20.81

Values shown are means (standard deviations) unless noted otherwise

Overweight = BMI 85th percentile for age and gender

* Some variables contain missing observations

Table 3.

Adjusted Mean Moderate-to-vigorous Physical Activity (MVPA) of Children of each Neighborhood Profile in San Diego and Seattle Regions

	Low Walkable, Unsafe, Parks and Recreation Sparse	Moderate Walkable, Transit Access, and Recreation	High Walkable, Transit and Recreation Dense	Low Walkable and Transit Access, Safe with Average Recreation Facilities
	(LW-U-RS)	(MW-TR)	(HW-TRD)	(LWT-S)
	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)
<i>San Diego Region</i>				
Total MVPA (min/d)	117.1 (99.9 , 137.2)	124.0 (107.5 , 143.0)	124.5 (108.3 , 146.0)	123.3 (105.4 , 144.3)
Out-of-School MVPA (min/d)	63.1 * (50.0 , 79.7)	75.7 (61.4 , 93.4)	76.2 (61.2 , 95.0)	76.8 (60.9 , 96.8)
<i>Seattle Region</i>				
Total MVPA (min/d)	152.3 (130.2 , 178.1)	142.3 (123.0 , 164.7)	149.9 (128.7 , 174.6)	
Out-of-School MVPA (min/d)	115.4 (92.5 , 144.1)	105.8 (86.0 , 130.1)	108.1 (87.1 , 134.2)	

Valid days 10hrs MVPA wear time

All models adjusted for child gender, race/ethnicity and age, parent marital status, income, and education, number in household, years at current address, number of cars per legal driver in household, high/low walkability/nutrition, and accelerometer wear time

* San Diego Low Walkable, Unsafe, Parks and Recreation Sparse Profile (LW-U-RS) MVPA significantly less than other three San Diego profiles' MVPA ($p < .05$)