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Authors
Bejarano, Carolina M
Carlson, Jordan A
Cushing, Christopher C
et al.

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Neighborhood built environment associations with adolescents' location-specific sedentary and screen time

Carolina M. Bejarano, MA[a], **Jordan A. Carlson, PhD**[b,*], **Christopher C. Cushing, Ph.D.**[c], **Jacqueline Kerr, PhD**[d], **Brian E. Saelens, PhD**[e], **Lawrence D Frank, PhD**[f], **Karen Glanz, MPH, PhD**[g], **Kelli L. Cain, MA**[d], **Terry L. Conway, PhD**[d], and **James F. Sallis, PhD**[d]

[a]Clinical Child Psychology Program, University of Kansas, 1000 Sunnyside Avenue, Lawrence, Kansas

[b]Center for Children's Healthy Lifestyles and Nutrition, Children's Mercy Hospital, Kansas City, Missouri

[c]Clinical Child Psychology Program & Schiefelbusch Institute for Life Span Studies, University of Kansas, 1000 Sunnyside Avenue, Lawrence, Kansas

[d]Department of Family Medicine and Public Health, University of California San Diego, San Diego, California

[e]Department of Pediatrics, University of Washington & Children's Hospital and Regional Medical Center, Seattle, Washington

[f]School of Community and Regional Planning, University of British Columbia, Vancouver, British Columbia, Canada

[g]Perelman School of Medicine and School of Nursing, University of Pennsylvania, Philadelphia, Pennsylvania

Introduction

Sedentary time, screen time in particular, appears to have potential as a significant intervention target for obesity prevention and improved cardiometabolic health in youth. Although evidence is mixed regarding the health consequences of objectively measured sedentary time in youth (Carson et al., 2014; Cliff et al., 2016; Saunders et al., 2013; Tremblay et al., 2011, van Ekris et al., 2016), there is a large literature linking TV and screen time with greater risk of youth obesity (Tremblay et al., 2011). Furthermore, there are more consistent associations between greater objective sedentary time and numerous poor health outcomes in adults (Owen et al., 2010; Proper et al., 2011), and adolescence is a key developmental period where health-related habits are established and can be carried into

*Corresponding author. Jordan A. Carlson, Center for Children's Healthy Lifestyles and Nutrition, Children's Mercy Kansas City, 610 E. 22nd Street, Kansas City, MO 64113, Tel.: 816-234-9240. jacarlson@cmh.edu.

adulthood (Telama, 2009). A next step in this research is to better understand the determinants of sedentary time to inform effective interventions.

Ecological models posit that health behaviors are influenced by individual-, interpersonal-, and environmental-level factors (Sallis et al., 2015). Neighborhood attributes, specifically land use mix and residential density, have shown promise as environmental-level factors that are related to physical activity in adolescents (Ding et al, 2011), but less is known about how neighborhood environments relate to youth's sedentary time. Although there appears to be a clear link between neighborhood environments and walking in adults (Owen et al., 2007) and youth (Carlson et al., 2015), a small increase in walking time likely has little impact on offsetting total sedentary time because a very large proportion of the day is spent being sedentary. The home setting is where a large proportion of sedentary time occurs and is supported (e.g., by couches, TVs, computers; Maitland et al., 2013). A more substantial way neighborhood environments may impact sedentary time could be by creating appeal for youth to spend time outside their home where they may be more likely to engage in non-sedentary activity. However, this hypothesis has been seldom investigated (Chastin et al., 2016).

Few studies have examined neighborhood environments in relation to objectively measured sedentary time in youth, and findings have generally been null (McDonald et al., 2012; Timperio et al., 2017; Veitch et al., 2011) or mixed (Hinckson et al., 2017). One study found that better objective sidewalk quality was related to less total sedentary time in youth (Jago et al., 2006). Hinckson et al. (2017) found that favorable perceived, but not objective, neighborhood environment attributes were associated with less total sedentary time in adolescents. Timperio and colleagues studied typologies (i.e., seven objectively measured neighborhood attributes that yielded four distinct clusters) of children's neighborhood environments and found no significant differences in objectively measured sedentary time between typologies (2017). However, having a neighborhood profile indicative of little mixed use development, few playgrounds, low street connectivity, and low traffic was related to greater television viewing in 5 to 6 year olds, while having greater mixed land use and many playgrounds was associated with less TV viewing three years later (Timperio et al., 2017).

Due to the lack of comprehensive and consistent findings, further research is necessary to clarify the potential impact of the neighborhood environment on sedentary time in youth. There has been more research examining these relationships in adults, and a recent review paper found mixed associations between the neighborhood environment and sedentary time (Koohsari et al., 2015). There were consistent findings of lower sedentary time for residents of urban versus rural and suburban areas, but mixed findings regarding the associations of walkability, crime, streetscapes, and aesthetics with sedentary time.

It is notable that previous studies, both in adults and youth, have been limited by examining total sedentary time without regard to where the sedentary time occurs (e.g., within the home, in the home neighborhood, at school, at work, or elsewhere). For example, studies examining residential neighborhood environments have not isolated the sedentary time spent in one's home neighborhood. Authors of studies involving youth and adults have suggested that future research focusing on context-specific sedentary time would provide more clarity regarding how environment is related to sedentary behavior (Hinckson et al., 2017; Compernolle et al., 2017).

Present Study

The objective of the present study was to investigate relations of neighborhood environment attributes to objectively measured total sedentary time, home sedentary time, home neighborhood sedentary time, and time spent at home, and self-reported TV time and total screen time in adolescents. We hypothesized that adolescents living in a more favorable neighborhood environment for physical activity (Ding et al., 2011) would spend less time at home, in total sedentary time, watching TV, and engaging in total screen time as compared to those living in a less activity-supportive neighborhood environment. We also hypothesized that those living in a more favorable neighborhood environment would spend less time being sedentary when in their neighborhood and at home.

The present study addressed limitations of past studies by including both perceived and objective measurements of the neighborhood environment, as well as investigating both self-reported and objective measures of sedentary time. Following recommendations for research in this area (Hinckson et al., 2017), the present study provided more precision in the dependent variables by using the combination of global positioning systems (GPS) and accelerometer data to examine the places where sedentary time occurred.

Methods

Participants and Procedures

Participants were 524 adolescents who participated in the Teen Environment and Neighborhood (TEAN) observational study of neighborhood environments and physical activity. This study was conducted in the Baltimore, Maryland-Washington, DC and Seattle-King County, Washington metropolitan areas in the United States. Adolescents and one parent/guardian per adolescent were selected from census block groups representing high or low walkability and high or low income. Four block group types were created based on median splits of GIS-based measures of walkability (Frank et al., 2010) and census-based household income (2 X 2 matrix defined by high/low walkability X high/low household income) as described previously (Sallis et al., 2018). Participants were recruited through contacting households with adolescents ages 12-16, via mail and telephone, identified by a list purchased from a marketing company. Participants were screened and considered ineligible for the study if they had a physical disability that affected their physical activity, any conditions that affected their dietary habits, and any developmental disability that would limit their ability to participate. Parents and adolescents provided informed consent and assent, respectively. All procedures were approved by the Institutional Review Board of the sponsoring university. Participants were mailed an accelerometer and Global Positioning System (GPS) tracker with instructions to wear the devices during all waking hours for seven days, except during water activities. Participants had the option of completing study surveys online or on paper sent through the postal mail. Of the 928 participants from the full sample, 130 were not given a GPS device and 152 did not wear the provided accelerometer and GPS tracker together for ≥1 valid school day and ≥1 valid non-school day; these participants were excluded from present analyses. Participants who attended homeschool, did not provide their school address, or had geocoding errors were also excluded (n = 122). Therefore, the analytic sample for the present study was 524 participants.

Measures

Demographic information and anthropometrics—Adolescents completed a survey to report their age, gender, and race/ethnicity. Parents completed a survey to report on their highest level of education, marital status, and number of vehicles per licensed driver in the household. The parent of each participant measured and reported their child’s height and weight based on detailed instructions provided by the research team. BMI percentiles were calculated using the Centers for Disease Control and Prevention growth charts (CDC 2000).

Perceived neighborhood environment—Parents completed a subset of the Neighborhood Environment Walkability Scale for Youth (NEWS-Y), which assessed various aspects of the perceived neighborhood environment around their home. The subscales that were examined in the present study were land use mix-access (2 items; e.g., parking is difficult near shopping), street connectivity (2 items; e.g., many different routes to get from place to place), walking facilities (3 items; e.g., sidewalks on most of streets), neighborhood aesthetics (4 items; nice things to look at), traffic safety (3 items; traffic makes it unpleasant to walk), pedestrian safety (3 items; crosswalks on busy streets), and crime safety (5 items; high crime rate). As compared to the original NEWS-Y, the “pedestrian and automobile traffic safety” scale was split into separate scales to investigate traffic and pedestrian safety separately. Parents could indicate responses on a scale ranging from 1-4, with items averaged within each subscale and higher numbers representing greater walkability or safety (some items were reverse scored). Test-retest ICCs for NEWS-Y subscales have ranged from .61 to .78 in prior work (Rosenberg et al., 2009).

Objective neighborhood environment—Objective measures of the built environment were derived from data from the county tax assessor, regional land use at the parcel level, and street networks. These data were integrated into GIS to derive built environment features within .5 km street network buffers around each participant's home. Based on recommendations from past research, this study examined neighborhoods using a smaller buffer size than sometimes used in physical activity studies, but that may be more appropriate for detecting the hypothesized effects, particularly in youth (McDonald et al., 2012). Using methods described in a previous study (Frank et al., 2010; Saelens et al., 2012), the variables of residential density (housing units per residential parcel), street connectivity (intersections per square km), retail floor area ratio (building square ft per parcel square ft, with higher values reflecting more pedestrian-oriented design), mixed land use (includes residential, retail, food and entertainment, and office land use types; 0 = single use and 1 = even distribution across the 5 uses), cul-de-sac density (number of cul-de-sacs per square km), and number of parks were calculated.

Screen time—Adolescents reported on time spent watching television, videos, or DVDs (one item) during a typical school day but not during school hours, which made up the TV time dependent variable. Response options included None, 15 minutes, 30 minutes, 1 hour, 2 hours, 3 hours, and 4 or more hours per day. Reported time spent watching television was combined with reported time engaged in sedentary computer or video games and reported time using the internet or electronic media for leisure, to create the total screen time dependent variable (sum of three items). Past studies using similar measures for time spent watching television have found good test-retest reliability and construct validity based on associations with home sedentary environment and psychosocial variables (Norman et al., 2005).

Objectively measured sedentary time and physical activity—Participants wore the accelerometer (ActiGraph models 7164, GT1M & GT3X, Pensacola, FL) on their right hip. Data from the accelerometers were downloaded and converted to minutes engaged in sedentary time using a cut point of ≤ 100 counts per minute (Evenson et al., 2008; Treuth et al., 2004) applied to 30-second epochs. The Evenson cut point applied to 30-second epochs was used for calculating moderate-intensity physical activity (MVPA), which was used as a covariate (Evenson et al., 2008; Physical Activity Guidelines for Americans, 2008). Non-wear periods were considered >60 consecutive epochs (30 minutes) with count = 0, and such periods were excluded from analyses. A minimum of 8 hours of wear time per day was necessary for inclusion, which is considered an acceptable threshold for wear time in youth (Mattocks et al., 2008). Days with >960 minutes (16 hours) of daily accelerometer wear time were excluded because the participant could have worn the device while sleeping, which could have profound impacts on their estimated sedentary time.

GPS-assessed locations—Latitude and longitude data were collected at 30-second epochs from the GPS tracker. Participants who met the accelerometer wear criteria and also had >8 hours of daily GPS signal were included. The GPS and accelerometer data were merged using the Personal Activity and Location Measurement System Version 4 (PALMS; Center for Wireless and Population Health). The devices were time synchronized during initialization and linked in PALMS with a time stamp. Details of the spatial analysis methods have been previously presented (Carlson et al., 2016). In brief, each participant's home and school address was geocoded and integrated into ArcGIS (ESRI, Inc., Redlands, CA). Exposure to the home neighborhood was defined in two different ways. A 50-m-radius circular buffer around the point resulting from geocoding the home address was used to define the 'at-home' location. A 1-km street network buffer around the home address, excluding the 'at-home' buffer and when applicable excluding the participant's school (15 meter buffer around the school parcel), was used to define the 'home neighborhood' location. Total time (while the devices were worn) and sedentary time were calculated specific to the at-home and home neighborhood locations, as well as overall (across all locations). These calculations involved filters for spending at least 60 minutes per day at home for total sedentary time and home sedentary time, spending at least 60 minutes per day at or in the home neighborhood for home neighborhood sedentary time, and spending at least 15 minutes per day at home for the time spent at home variable. These procedures were meant to exclude days when participants had minimal exposure to their home neighborhood environment by spending little time at home, which would also result in abnormally large or small proportions of time in the at-home and home neighborhood locations being sedentary.

Data Analysis

Independent variables were those calculated from the NEWS-Y scales and GIS measures of the neighborhood built environment. All independent variables were computed as sample-specific z-scores to standardize across various scales. Dependent variables were minutes per day of TV time, total screen time, total sedentary time, home sedentary time, home neighborhood sedentary time, and time spent at home. Index scores were calculated for the perceived and objective neighborhood environment, respectively. The indices were calculated by taking an average of the component variable z scores (7 for the perceived index and 5 for the objective index). The objective index excluded cul-de-sac density as its effects appeared to be distinct from the other objectively measured variables. As preliminary data analysis, Pearson correlations were run between time spent at home and each of the sedentary time dependent variables. Next, mixed effects models were run in SPSS Version 24 to account for the nested data structure, with census block group included as a random effect. Each independent variable was entered into a separate model, and each model was adjusted for location-specific wear time; participant characteristics of gender, age, race/ethnicity, and BMI percentile; city, neighborhood income, vehicle access, and parent education and marital status (90 models total for 15 independent variables × 6 dependent variables). Models were also adjusted for MVPA, with the exception of the models investigating time spent at home. Participant level data files were used for the analyses.

Results

Descriptive Results

The sample size for the study was 524 adolescents (*Mean* age = 14.13, 50.6% female, 70.1% White, non-Hispanic) after excluding participants as described in the procedures. Table 1 provides demographic information and Table 2 provides means and standard deviations of the study variables. Associations were examined between time spent at home with TV time ($r = .02$), total screen time ($r = .05$), total sedentary time ($r = .09$), home sedentary time ($r = .98$), and home neighborhood sedentary time ($r = .61$). Of the days of data included, 54% were school days ($n = 1,581$) and 46% were non-school days ($n = 1,858$). The mean number of school days per participant was 3.5, $SD = 1.5$, and the mean number of non-school days per participant was 3.0, $SD = 1.6$.

Perceived Neighborhood Environment

See Table 3 for results of the mixed models. Perceived neighborhood environment variables of land use mix-access, and walking facilities were significantly negatively associated with home neighborhood sedentary time. A one standard deviation increase in land use mix-access was associated with 9.83 fewer minutes of home neighborhood sedentary time, while a one standard deviation increase in walking facilities was associated with 16.31 fewer minutes of home neighborhood sedentary time. Significant negative associations also emerged between perceived neighborhood aesthetics and the dependent variables of daily TV time, daily total screen time, and time spent at home. An increase of one standard deviation in neighborhood aesthetics was associated with 9.77 fewer minutes of daily TV time, 17.94 fewer minutes of daily total screen time, and 15.7 fewer minutes per day of time spent at home.

Crime safety was marginally associated with total screen time (p = .053), such that parents who perceived greater crime safety had adolescents who spent fewer minutes in daily total screen time. A one standard deviation increase in perceived crime safety was associated with 12.82 fewer minutes of daily total screen time.

The perceived neighborhood index score was associated with less TV time, less total screen time, and less home neighborhood sedentary time. A one standard deviation increase in overall perceptions of activity-supportiveness of the neighborhood environment was associated with watching 13.60 fewer minutes of TV per day, engaging in 28.15 fewer minutes of total screen time per day, and spending 29.09 fewer minutes per day in home neighborhood sedentary time.

Objective Neighborhood Environment

Results pertaining to the objective neighborhood environment variables indicated that street connectivity was positively associated with total sedentary time and negatively associated with home neighborhood sedentary time, such that a one standard deviation increase in street connectivity (i.e., more intersections), was associated with 6.53 more minutes per day of total sedentary time and 10.90 fewer minutes per day of home neighborhood sedentary time. Mixed use was positively associated with home sedentary time, with a one standard deviation increase in the mixed use score being associated with 2.84 more minutes per day of home sedentary time. Mixed use was marginally associated with total sedentary time (p = .050), such that a one standard deviation increase in mixed use was associated with 4.61 more minutes per day of total sedentary time.

Cul-de-sac density was significantly negatively associated with total sedentary time, with a one standard deviation increase in cul-de-sac density relating to 5.25 fewer minutes per day of total sedentary time. Cul-de-sac density was also significantly negatively associated with home sedentary time, indicating that a one standard deviation increase in cul-de-sac density was associated with 3.19 fewer minutes per day of sedentary time at home.

The objective neighborhood environment index was significantly positively associated with total sedentary time and home sedentary time. A one standard deviation increase in the objective neighborhood environment index was associated with 9.11 more minutes per day of total sedentary time and 4.90 more minutes per day of sedentary time at home.

Discussion

A physical activity-supportive perceived neighborhood environment was related to less TV time, total screen time, and sedentary time in the home neighborhood, but not total sedentary time. Findings were more mixed with regards to the objective neighborhood environment, with mixed use and the neighborhood environment index being positively related to total and home sedentary time, cul-de-sac density being negatively related to total and home sedentary time, and street connectivity being negatively related to home neighborhood sedentary time but positively related to total sedentary time. The findings pertaining to perceived neighborhood aesthetics supported the primary hypothesis that favorable neighborhood environments for physical activity would be related to less time spent at home, and also less total sedentary time. However, overall there was limited support for this hypothesis. Findings for perceived aesthetics, perceived crime, the perceived neighborhood environment index, and cul-de-sacs density provided partial support for the hypothesis that neighborhood environments related to greater amounts of physical activity (Ding et al, 2011) would also relate to less sedentary time for youth, but cul-de-sac density was the only *objective* environment attribute related to total sedentary time in the expected direction.

The Perceived Neighborhood Environment and Sedentary Time

Better perceived aesthetics was related to less TV and total screen time. However, associations with TV and total screen time were strongest for the perceived neighborhood environment index, showing the importance of the combination of environment attributes. When parents have positive perceptions of attractive neighborhood environments, they may be more comfortable with their adolescent spending more time out of the home and away from non-portable electronic entertainment. Though the same associations were not found with the accelerometer measures of sedentary time, TV time and total screen time are important sedentary behaviors as they have been more consistently associated with health markers in youth (Tremblay et al., 2011), and are often targets for interventions.

Examining time spent at home as a dependent variable was one unique contribution of the present study. The significant association between neighborhood aesthetics and time spent at home provided some support for our primary hypothesis. The finding suggested that adolescents may be more likely to leave their home, and perhaps spend time outside, if their neighborhood is more aesthetically pleasing (e.g., trees along the streets, many beautiful natural sights). This pattern is consistent with previous findings that children engaged in significantly less total screen time when parents perceived their neighborhood as having access to good quality parks, playgrounds, and sidewalks (Carson et al., 2010). Thus, improving neighborhood aesthetics may be an important way to support adolescents to spend less time at home and being sedentary in front of a screen. Indeed, more time away from home may lead to less opportunity to engage in sedentary time, especially TV and total screen time in the home, and previous research shows that time at home is mostly inactive for adolescents (Carlson et al., 2016). Although the present study found small-to-no correlation between time spent at home and TV and total screen time, these activities were not measured with specificity to the home. The correlation between time spent at home and total sedentary time was larger and meaningful, but still small.

Although the association between greater perceived crime safety and less total screen time approached statistical significance, perceived safety was not associated with time at home. Other (albeit few) studies of associations between perceived neighborhood safety and total screen time have had null findings (Carson et al., 2010), so more research is needed in this area before drawing conclusions.

Although the perceived environment variables were not related to total or home sedentary time, two perceived environment variables (land use mix-access and walking facilities) were associated with less home neighborhood sedentary time, as was the perceived neighborhood environment index. These findings are likely at least partly explained by the neighborhood environment supporting more walking and less vehicle time, which is discussed more below in regards to objectively measured street connectivity.

The Objective Neighborhood Environment and Sedentary Time

Several associations between the objective neighborhood environment attributes and total and home sedentary time were in the unexpected direction, particularly for mixed land use, street connectivity, and the overall neighborhood environment index, indicating that these attributes may be related to both more sedentary time and more physical activity among adolescents (Ding et al, 2011). While mixed land use near the home provides destinations to walk to, sedentary time may be more likely than physical activity to occur inside these destinations. However, mixed land use was not associated with home neighborhood sedentary time, so the potential impact of mixed land use mix on sedentary time may be more complex. There could be moderating effects of other variables, such as aesthetics and perceived safety, that should be explored. The potential impact of street connectivity on sedentary time also appears complex. The negative (expected) association between street connectivity and home neighborhood sedentary time is likely at least partly explained by transportation mode. As shown previously in this sample, greater street connectivity was related to more walking and less vehicle time (Carlson et al., 2015). However, the drivers of the positive association between street connectivity and *total* sedentary time are less clear. Although street connectivity was not related to time spent at home, it is possible that connected streets with heavy traffic deter youth from spending time outdoors.

Previous evidence has shown that cul-de-sacs can be a setting for children's leisure-time physical activity (Ding et al, 2011), although findings in adolescents have been somewhat mixed regarding associations between cul-de-sacs and physical activity (Carver et al., 2008). The present finding that cul-de-sacs were associated with less total and home sedentary time fits with the notion that cul-de-sacs provide a safe place for activity (both light and moderate-to-vigorous), potentially due to less traffic and greater perceived safety (Veitch et al., 2006). Thus, cul-de-sac density was the one objective environment attribute investigated in this paper that appears to support both increased total physical activity and reduced total sedentary time.

Integration of Findings

In the present study, the discrepant findings using perceived versus objective environment measures are notable. Perceived environment features positively correlated with physical activity in youth tended to be negatively correlated with sedentary time, as expected. The effect sizes were meaningful, with 14 to 29 fewer minutes of daily sedentary time per one standard deviation increase in the perceived neighborhood environment index. In contrast, with objective environment variables there were sometimes associations with sedentary time in the opposite direction of what was expected based on previous associations with physical activity. However, the effect sizes appeared to be much smaller for the objective environmental variables than perceived environment variables, with 5 to 9 more minutes per day of sedentary time per one standard deviation increase in the objective neighborhood environment index. The few studies that have examined associations between objectively measured neighborhood environments and sedentary time in youth have generally had null findings when sedentary time was measured objectively (Hinckson et al., 2017; McDonald et al., 2012; Timperio et al., 2017; Veitch et al., 2011), but some associations in expected directions have been observed for TV and total screen time (Veitch et al., 2011; Timperio et al., 2017). However, few past studies examined both perceived and objectively measured neighborhood environments in relation to sedentary time in youth (Hinckson et al., 2017; Jago et al., 2006; Veitch et al., 2011), so it is difficult to determine whether differential findings with perceived and objective environment measures generalize across studies. Some studies showing associations between neighborhood environments and sedentary time or TV/total screen time did not appear to adjust for MVPA (Hinckson et al., 2017; Jago et al., 2006; McDonald et al., 2012, Timperio et al., 2017; Veitch et al., 2011), so prior findings may simply show that an increase in MVPA offsets sedentary time, but not necessarily that neighborhood environments can decrease sedentary time over and above their influence on MVPA (i.e., increase light activity). An exception appears to be in regards to the impact of the neighborhood environment on transportation-related sedentary time, with previous studies finding negative associations between objectively measured neighborhood walkability and adolescents' time spent in a vehicle (Carlson et al., 2015). The discrepancy in findings between perceived and objective neighborhood environments, and between objective sedentary time and TV/total screen time, suggests a complex and unclear role of the neighborhood environment on sedentary time in youth. Taking into account current findings about sedentary time and past findings about MVPA, it is possible that some aspects of the neighborhood environment, such as mixed land use, may support both more sedentary time and more MVPA (and perhaps less light intensity activity that is between sedentary and MVPA), so more work is needed to gain more insight into these associations.

Strengths, Limitations, and Future Directions

Strengths of the present study included the large sample of adolescents from two geographic regions in the US, and equal selection from census block groups representing high or low walkability and high or low income. This strategy maximized variation in walkability and minimized income as a potential confounder of the results. This study examined both perceived and objective environment variables and a wider range of sedentary time measures than prior studies. The use of GPS to define location-specific wear time, and the use of accelerometers to provide objective measurement of sedentary time were also a particular strengths of the study that added information beyond previous work in this area.

Findings of the present study must be considered in light of some limitations. The cross-sectional design of the study does not allow for causal inferences. Perceived neighborhood environments were assessed through parent report, and it is possible that adolescents' perceptions of their neighborhood environment may reveal different associations. Given potential error in the GPS and the home buffer used some sedentary time classified as occurring in the neighborhood may have actually occurred at home. Future studies should use newer GPS devices that measure signal strength to support identification of indoor vs. outdoor time (Lam et al., 2013). The use of hip-worn accelerometer cut points for the purposes of this study is potentially limited because they do not specifically differentiate sitting from standing behavior (Mitchell et al., 2017). However, these methods have good validity for accurately assessing an individual's volume of sedentary time in minutes

(Evenson et al., 2008; Trost et al., 2011; Carlson et al., 2019), as was done in the present study. Lastly, the decision to exclude the school location from the neighborhood buffer was made in efforts to isolate the potential effects of the neighborhood environment on sedentary behavior from those that are dictated by being at school. However, there remains a possible limitation that participants spent time at school on the weekends, for example using a playground or field, that would not be captured.

In future research it may be important to focus on consistency of measurement across studies. For example, we found it useful to compare our findings of the perceived neighborhood environment to those of Hinckson et al. (2017), as they also used the NEWS-Y. Consistency of measurement methods may allow for more rapid development of consensus regarding results across multiple studies. Future research may also be improved by measuring domain- and/or location-specific sedentary behaviors, such as total screen time, riding in a car, or sitting at a restaurant, that could inform more targeted behavior- and setting-specific interventions to decrease sedentary time. Sedentary time could also be delineated by whether it occurs in a destination (and which type of destination) or during transportation, because the environments within specific destinations are likely important over and above the neighborhood environment. Future studies could examine whether there are differences in associations between the neighborhood environment and sedentary time across demographic subgroups (e.g., SES, gender, race/ethnicity), and whether these associations differ in relation to the home environment and/or other personal attributes (e.g., enjoyment of sedentary time).

Conclusions

The present study found that having more favorable perceived neighborhood aesthetics was associated with less TV and total screen time, partly by supporting adolescents to spend less time at home. Cul-de-sacs were also related to less total sedentary time, suggesting their potential role in supporting both light and moderate-to-vigorous physical activity among youth. However, mixed land use and the objective neighborhood environment index, which are commonly associated with greater physical activity were associated with more sedentary time in the present study, so they may support both increased physical activity and increased sedentary time. Other environments, such as the home and school environment, and availability of screen-based opportunities (Wiecha et al., 2001), may be more important targets for reducing sedentary time in youth. The apparent complexity of this research area makes it a good fit for studies that examine true multi-level ecological models (Sallis et al., 2015) by including variables at individual, social, and multiple environmental levels and investigating interactions among levels.

Acknowledgments

Conflicts Of Interest

This study was funded by NIH grant HL083454. The authors have no conflicts of interest to disclose.

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Highlights

- Neighborhood environment associations with sedentary time differed between perceived and objective measures
- Perceived neighborhood aesthetics and an overall perceived index were related to less screen time
- Objective mixed land use and an overall objective index were related to more total sedentary time
- Cul-de-sac density was related to less home sedentary time and total sedentary time

Table 1.

Demographic Information

	Mean (SD) or n (%)
Site	
Baltimore/MD	253 (48.3%)
Seattle/King County	271 (51.7%)
Age	14.13 (1.44)
Gender	
Boys	259 (49.4%)
Girls	265 (50.6%)
Ethnicity	
White, Non-Hispanic	366 (70.1%)
Non-White or Hispanic	156 (29.9%)
Walkability of neighborhood	
High Walkability	240 (45.8%)
Low Walkability	284 (54.2%)
Income level of neighborhood	
High Income	264 (50.4%)
Low Income	260 (49.6%)
Vehicle Access	1.09 (.40)
Parental Education	
Some college or less	183 (35.1%)
College degree or more	338 (64.9%)
Parent Marital Status	
Married or living with partner	437 (83.7%)
Not married or living with partner	85 (16.3%)
Youth BMI Percentile	64.17 (26.44)
Youth BMI z-score	.47 (.96)

Note. n = 524. Vehicle access indicates ratio of drivable motor vehicles to licensed drivers in the household. BMI = Body Mass Index. Ethnicity (n = 2), parental education (n = 3), and parental marital status (n = 2) was not reported for some participants.

Table 2.

Descriptive characteristics for study variables

	Mean (SD)
Sedentary and wear time	
Total wear time (minutes/day)	778.32 (69.08)
Time at home (minutes/day)[a]	310.73 (157.27)
Time in home neighborhood (minutes/day)	362.08 (152.26)
Total sedentary time (minutes/day)[b]	511.05 (70.29)
Home sedentary time (minutes/day)[b]	219.61 (99.81)
Home neighborhood sedentary time (minutes/day)[c]	238.99 (106.24)
TV time (minutes/day)	84.50 (70.81)
Total screen time (minutes/day)	206.68 (150.93)
Perceived neighborhood environment around home	
Land use mix-access (1-4)	2.45 (.57)
Street connectivity (1-4)	2.76 (.62)
Walking facilities (1-4)	2.62 (.89)
Neighborhood aesthetics (1-4)	3.10 (.63)
Traffic safety (1-4)	2.51 (.56)
Pedestrian safety (1-4)	2.82 (.64)
Crime safety (1-4)	3.04 (.69)
Objective neighborhood environment around home	
Residential density (housing units/ parcel)	6.15 (11.17)
Street connectivity (intersections/sq km)	91.05 (30.60)
Retail floor area ratio (building:parcel sq ft)	.11 (.22)
Mixed use (0=single 1=mixed)	.08 (.14)
Cul-de-sac density (cul-de-sacs/sq km)	18.55 (18.64)
Number parks (parks/sq km)	.49 (.77)

Note. n = 524

[a]Filter required participants to have spent at least 15 minutes at home.

[b]Filter required participants to have spent at least 60 minutes at home.

[c]Filter required that participants to have spent at least 60 minutes at home or in the home neighborhood

Table 3.

Relations of neighborhood environment attributes to TV, screen, total and location-specific sedentary time, and time spent at home in youth

	TV time (minutes/day)[a] *n* = 524		Total screen time (minutes/day)[a] *n* = 524		Total sedentary time minutes/day)[a] *n* = 397		Home sedentary time (minutes/day)[a] *n* = 397		Home neighborhood sedentary time (minutes/day)[a] *n* = 509		Time at home (minutes/day)[b] *n* = 397	
	B (95% CI)	***p***	**B (95% CI)**	***p***	**B (95% CI)**	***p***	**B (95% CI)**	***p***	**B (95% CI)**	***p***	**B (95% CI)**	***p***
Perceived neighborhood environment around home												
Land use mix-access (z score)	−1.67 (−7.62, 4.28)	.582	−7.20 (−19.83, 5.44)	.264	2.14 (−2.39 6.68)	.354	.03 (−2.38, 2.44)	.982	**−9.83 (−17.74, −1.92)**	**.015**	−5.80 (−20.91, 9.31)	.451
Street connectivity (z score)	1.13 (−4.67, 6.93)	.383	6.29 (−6.06, 18.65)	.317	1.57 (−2.81, 5.94)	.482	−1.11 (−3.45, 1.23)	.352	−2.38 (−10.38, 5.62)	.559	10.23 (−4.42, 24.88)	.171
Walking facilities (z score)	−2.41 (−8.45, 3.63)	.433	−8.30 (−21.07, 4.46)	.202	2.02 (−2.66, 6.71)	.396	1.47 (−1.01 3.96)	.245	**−16.31 (−24.23, −8.39**	**.000**	15.26 (−.24, 30.76)	.0.54
Neighborhood aesthetics (z score)	**−9.77 (−15.71, −3.82)**	**.001**	**−17.94 (−30.65, −5.23)**	**.006**	2.56 (−2.14, 7.26)	.285	−1.40 (−3.91, 1.11)	.274	.17 (−8.07, 8.40)	.968	**−15.70 (−30.97, −.43)**	**.044**
Traffic safety (z score)	−3.58 (−9.35, 2.18)	.223	−6.84 (−19.15, 5.46)	.275	−1.57 (−6.01, 2.87)	.489	.29 (−2.08, 2.66)	.810	−6.12 (−13.99, 1.74)	.127	−3.38 (−17.99, 11.22)	.649
Pedestrian safety (z score)	.99 (−4.90, 6.89)	.741	4.95 (−7.59, 17.50)	.438	1.28 (−3.25, 5.81)	.579	−.01 (−2.42, 2.40)	.991	−6.26 (−14.23, 1.71)	.123	.03 (−15.07, 15.14)	.997
Crime safety (z score)	−4.63 (−10.74, 1.48)	.137	−12.82 (−25.81, .17)	.053	−1.24 (−5.86 3.39)	.600	−.70 (−3.16, 1.75)	.573	−1.28 (−9.53, 6.98)	.761	−1.27 (−16.73, 14.19)	.872
Perceived neighborhood environment index (z score)	**−13.60 (−26.67, −.53)**	**.041**	**−28.15 (−55.96, −.35)**	**.047**	4.71 (−5.45, 14.87)	.363	−1.03 (−6.42, 4.35)	.707	**−29.09 (−46.59, −11.60)**	**.001**	−.83 (−34.47, 32.82)	.962
Objective neighborhood environment around home												
Residential density (z score)	.58 (−5.32, 6.48)	.063	4.36 (−8.19, 16.89	.495	1.63 (−2.35, 5.61	.420	1.18 (−.94, 3.30)	.273	−3.45 (−11.32, 4.42)	.390	1.20 (−12.46, 14.86)	.863
Street connectivity (intersection	−5.23 (−11.38, .91)	.067	4.27 (−8.74, 17.29)	.519	**6.53 (1.71, 11.25)**	**.008**	2.42 (−.16, 5.00)	.066	**−10.90 (−19.04, −2.76)**	**.009**	6.21 (−9.92, 22.34)	.449

	TV time (minutes/day)[a] *n* = 524		Total screen time (minutes/day)[a] *n* = 524		Total sedentary time minutes/day)[a] *n* = 397		Home sedentary time (minutes/day) [a] *n* = 397		Home neighborhood sedentary time (minutes/day)[a] *n* = 509		Time at home (minutes/day)[b] *n* = 397	
	B (95% CI)	***p***	**B (95% CI)**	***p***	**B (95% CI)**	***p***	**B (95% CI)**	***p***	**B (95% CI)**	***p***	**B (95% CI)**	***p***
density) (z score)												
Retail floor area ratio (z score)	2.83 (−3.22, 8.89)	.358	2.98 (−9.86, 15.83)	.648	3.21 (−1.07, 7.48)	.141	1.73 (.−.54, 3.99)	.136	−5.15 (−13.21, 2.91)	.210	−3.73 (−18.32, 10.86)	.615
Mixed use (z score)	−1.25 (−7.35, 4.84)	.686	−4.46 (−17.36, 8.44)	.142	**4.61 (−.00, .72)**	**.050**	**2.84 (.39, 5.28)**	**.023**	3.15 (−4.99, 11.29)	.447	−1.63 (−17.26, 13.98)	.838
Number parks (z score)	−5.51 (−11.45, .42)	.069	−.37 (−12.98, 12.24)	.955	.53 (−3.98, 5.05)	.816	.53 (−1.87, 2.93)	.664	5.76 (−2.14, 13.66)	.153	−12.60 (−27.35, 2.16)	.094
Cul-de-sac density (z score)	−1.99 (−8.27, 4.28)	.532	−5.44 (−18.68, 7.81)	.420	**−5.25 (−9.84, −.66)**	**.025**	**−3.19 (−5.63, −.76)**	**.010**	−6.43 (−14.77, 1.91)	.131	6.87 (−8.62 22.37)	.383
Objective neighborhood environment index (z score)	−5.07 (−15.52, 5.38)	.341	4.10 (−17.99, 26.19)	.716	**9.11 (1.59, 16.62)**	**.018**	**4.90 (.91, 8.89)**	**.016**	−6.28 (−20.25, 7.69)	.378	−6.75 (−32.38, 18.88)	.605

Note.

[a] Adjusted for participant MVPA (total or location-specific), location-specific wear time, gender, age, race/ethnicity, and BMI percentile, city, neighborhood income, vehicle access, and parent education and marital status.

[b] Adjusted for location-specific wear time, gender, age, race/ethnicity, and BMI percentile, city, neighborhood income, vehicle access, and parent education and marital status.

Perceived index = average of 7 perceived variables; Objective index = average of objective variables, excluding cul-de-sac density.