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Places where children are active: a longitudinal examination of children's physical activity

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Abstract

Using two-year longitudinal data, we examined locations where children spent time and were active, whether location patterns were stable, and relationships between spending time in their home neighborhood and moderate to vigorous physical activity (MVPA). At two time points (2007–2009 and 2009–2011), children living in the metropolitans areas of either San Diego, CA or Seattle, WA wore an accelerometer, and parents recorded their child's locations for seven days. Across two years, global average proportion of time spent in each location was stable, but total time and proportion of time in each location spent in MVPA decreased significantly across all locations. Children spent the largest proportion of time in MVPA in their home neighborhood at both time points, although they spent little time in their home neighborhood.

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Conflicts of Interest

The authors declare that there are no conflicts of interest; Dr. James Sallis would like to disclose a financial relationship with SPARK Programs of School Specialty Inc.

Keywords

Children; physical activity; exercise; built environment; neighborhood; correlates; prospective

Introduction

Regular physical activity (PA) provides multiple health benefits in youth, including reducing the risk of obesity, hypertension and diabetes (United States Department of Health and Human Services, 2008). For youth, 60 minutes of moderate to vigorous physical activity (MVPA) each day is recommended (Berkey et al., 2000; United States Department of Health and Human Services, 2008). Few US children achieve this level of PA and there is a marked decline in PA from early to late childhood (Chung et al., 2012; Troiano et al., 2008). Based upon device-based assessment (e.g. accelerometry) children's PA after age 5 declined by 4.2% annually, light activity decreased, and sedentary time increased with advancing age(Cooper et al., 2015). In the US by ages 12–13 only 4% of girls and 7% of boys met recommended levels (Cooper et al., 2015).

Opportunities for children's PA could exist in playgrounds, recreation facilities, their homes and yards, public areas by their homes, others' homes and yards, streets, open spaces, and schools (Grow et al., 2008; Jones et al., 2009; McGrath et al., 2015; Oreskovic et al., 2012; Rainham et al., 2012; Veitch et al., 2009). Some children engage in PA walking or biking to and from school (A. R. Cooper et al., 2010; Rainham et al., 2012). In a study combining accelerometer and GPS data, middle school-aged children obtained 41.6 % of their total MVPA in streets, 33.5% at home (including front and back yards), 10.8% at parks/ playgrounds, and 8.4% at school (Oreskovic et al., 2012). In another study, urban children obtained about 50% of total MVPA commuting, 20% at school, and 10% at home (Rainham et al., 2012). In baseline data from the Neighborhood Impact on Kids (NIK) study (on which the present longitudinal study is based), children aged 6 to 12 obtained 44.6% of daily MVPA at home (including front and back yards), 26.8% at school, 7.2% at other's homes, 4.9% at parks and other recreational facilities with remaining locations each less than 2% of MVPA (Kneeshaw-Price et al., 2013).

Children have been found to be most active while outside in their neighborhood, defined as playing in the street, on sidewalks, or in other non-specific outdoor locations near one's home (AR Cooper et al., 2010; Jones et al., 2009; Oreskovic et al., 2012). One study found that children engaged in 62% of their PA when outdoors within their neighborhood (Jones et al., 2009). Looking at the proportion of time spent in MVPA when in the neighborhood, the baseline NIK study found children spent 42% of their neighborhood-based time engaged in MVPA. This was the highest proportion of active time compared to all other locations, although children spent less than 2% of their time outside in their neighborhood (Kneeshaw-Price et al., 2013). In one study, cross-sectional evidence of a positive association between time spent outdoors and MVPA persisted in longitudinal analyses only on weekends (Cleland et al., 2008), suggesting the outdoor locations where children spent time in MVPA changed differently on weekends versus weekdays over time.

Over the last few generations children have been spending less time outdoors (Gester, 1991; Karsten, 2005; Tandy, 1999). This shift may in part be due to the availability of electronic media in the home and parental restrictions regarding engaging in informal and unsupervised activity outdoors (Karsten, 2005; Tandy, 1999). As children grow older they spend less time outdoors (Cleland et al., 2010; Pagels et al., 2014). One study found that over a 5-year period among initially 10–11 year old children, time spent outdoors decreased by 31% in girls and by 19% in boys (Cleland et al., 2010). Considering that children are more active outdoors, the decreased time spent outdoors could be contributing to children's low level of PA. Thus, the locations where children spend their time matters for their PA.

We examined two-year longitudinal data which allowed for assessment of location and MVPA-by-location patterns over time. We investigated where children spent their time, where they were active, the stability of places where they spent their time and activity levels in those locations over time, and relationships between time spent in the neighborhood and PA over time. To follow-up baseline findings of high MVPA levels while outside in the neighborhood, we were interested in ascertaining whether children who spent time outdoors in their home neighborhood at baseline would be more active two years later compared to children who were not active in their neighborhood at baseline.

Methods

Sample

Participants were part of the NIK study, which was an observational cohort study of children initially aged 6–12 that has been described in detail (Frank et al., 2012; Saelens et al., 2012). Briefly, the NIK study examined individual, family and neighborhood factors that explained PA, nutrition, and weight status. Households were randomly selected to differ on PA and nutrition environment within neighborhoods in San Diego County and Seattle/King County. Recruitment occurred via mail and phone contact. Families were eligible if children were ages 6–12 at baseline, lived with a parent/caregiver at least 5 days a week in the selected neighborhood, and were able to engage in MVPA. Data were collected at time 1 (T1) (Sept. 2007 – Jan. 2009) and two years later (T2) (Sept. 2009 – Feb. 2011). For the present analysis, at T1 682 children and at T2 602 children had both complete accelerometer and "place log" data. Demographic data were missing on 18 children resulting in a sample size for this study of 584 children with complete data from T1 and T2. Study was approved by the institutional review boards and informed consent was obtained.

Measures

Physical Activity—A GT1M Actigraph accelerometer was used to measure MVPA. Participants were instructed to wear the accelerometer for 7 days at each time point. If fewer than seven days were recorded, participants were asked to wear the meter for additional days. All recorded days were included. Thus, some cases have more than 7 valid days. Valid days were defined as at least 10 valid hours each day, with valid hours having no more than 20 minutes of consecutive zero counts. Most children (89%) wore the accelerometer in the same 1–2 months at T1 and T2 to control for seasonality. Accelerometer data were captured at 30-second epochs. MeterPlus 4.2 (www.meterplussoftware.com) categorized activity

counts into sedentary, light, moderate, and vigorous activity using calibration age-based thresholds specifically for youth (Freedson et al., 1997; Trost et al., 2002). Total MVPA was calculated by summing total minutes of MVPA (3 METS or above, with MET being multiples of resting energy expenditure) across all valid days. The proportion of total time spent in MVPA was estimated by dividing the total minutes in MVPA by the total minutes observed across all valid days.

Location—Parents were instructed to complete a daily "place log" of where their child was throughout each day that the child wore the accelerometer. Parents listed the name and address of each location where their child was, the time the child arrived at the location and child waking and bed time. Parents listed "neighborhood" if their child was in the area around their home (e.g. streets, sidewalks) but not in a specific address or place.

Twelve location types were created, using a systematic approach described in more detail previously (Kneeshaw-Price et al., 2013). The categories included home, own school, neighborhood (defined as playing in the street, on sidewalks, or in other non-specific outdoor locations within one's neighborhood), others' homes, others' school, public, outdoor parks and recreation facilities, public indoor recreation facilities, private recreation facilities, service locations (e.g., doctor's office), shopping, food eateries, and non-descript geographic locations. Logs from 150 days from unique participants were randomly selected, and two research team members categorized location types independently, with high inter-rater reliability (Kneeshaw-Price et al., 2013).

Linking Physical Activity and Location—Accelerometer data were linked with the location data by matching the date and time on the place logs with the day/time stamped accelerometer data. For example, if a parent reported a child woke at 7:00 AM, arrived at school at 9:00AM, came home at 3:15 PM, arrived at beauty shop at 4:00 PM, came home at 4:45 PM and went to bed at 8:45 PM, then four separate time frames were created and assigned a location type - 7:00AM to 8:59 AM (home), 9:00AM to 3:14 PM (school), 3:15 PM to 3:59 PM (home), 4:00 PM to 4:44 PM (service), and 4:45 PM to 8:45 PM (home). Then sedentary, light, moderate, vigorous and non-wear time were calculated within each timeframe of each location type and then aggregated. Total time in minutes and total minutes in MVPA at each location type were calculated. We calculated the percent of total time spent in each location type (relative to total time), average daily MVPA and percent of total MVPA in each location type, and the percent of total time in each location type spent in MVPA.

Demographics—At T1, parents completed a survey that included items on their race/ethnicity, annual household income, and their child's age, race/ethnicity, and gender.

Data Analysis

Unless otherwise noted, analyses were conducted on the sample of 584 children who had complete demographic, accelerometer and place log data at T1 and T2. We used paired t-tests to examine whether the time children spent in each location, and the proportion of time in each location that children spent in MVPA, changed significantly from T1 to T2.

We used ordinary least squares (OLS) regression with robust standard errors to assess whether children who were active in the neighborhood at either T2 or T1 were more active at T2 than their counterparts who did not engage in MVPA in the neighborhood at T2 or T1 or did not spend time in the neighborhood at T2 or T1. In the OLS models, the two dependent variables measuring activity levels at T2 were total time spent in MVPA at T2 and average daily MVPA for valid days at T2. First, we compared activity levels at T2 between those children who spent any time in MVPA the neighborhood at T2 or T1 (categorical measure) versus those who did not engage in MVPA in the neighborhood or had no time in the neighborhood at T2 or T1. Second, we restricted the sample to only children who spent any time in the neighborhood at T2 (n=121) or T1 (n=140) and compared activity levels at T2 by the percentage of time in the neighborhood spent in MVPA at T2 or T1 (continuous measure).

Baseline OLS models first assessed the bivariate relationships between engagement in activity in the neighborhood at T2 or T1 and activity levels at T2, and neighborhood activity levels at T2 or T1 and activity levels at T2. Then, covariates that might account for the bivariate associations between neighborhood activity engagement and overall activity levels at T2 were added to the models. These covariates included baseline activity levels at T1, child age at T1, gender, race (non-white versus white), Hispanic (versus non-Hispanic), child BMI z-score at T1, household income at T1 (categorical), research site, and median income of the census block group in which the child lived.

Results

Among this study sample, 50.5% were girls. Less than half of the sample had household incomes greater than $100,000 and 14% had household incomes under $50,000. Sixty-eight percent were non-Hispanic white, 17% Hispanic and 15% non-Hispanic, non-white. The average valid days of accelerometer data at T2 was 7.5 and at T1 was 6.7. The average daily minutes of MVPA on valid days at T2 was 100 and at T1 was 147.

The proportion of time that children spent in the 12 location types remained fairly stable from T1 to T2, with a few exceptions (Table 1). Children spent significantly less time at school (−5.7%) and significantly more time at home (+4.0%), in public outdoor parks and recreational areas (+1.0%), and at indoor public recreational facilities (+0.3%).

Children’s proportion of time in MVPA decreased significantly within all locations from T1 to T2 (Table 2). The decrease was over 10 percentage points in public outdoor parks and recreation spaces, public indoor recreation, and private recreation facilities, although these locations remained among those with the highest percentage of time spent in MVPA. The proportion of time spent in MVPA was highest in the neighborhood at both T1 and T2.

The amount of time spent in the neighborhood remained low at T2 (<1% of time). At T2 children who were active in the neighborhood had significantly higher overall MVPA (1.7% more total time in MVPA and 12.1 more daily MVPA minutes) relative to children who were not active in the neighborhood or whom did not spend any time in the neighborhood (Table 3, Models 1a and 2a). Being active in the neighborhood at T1 was not related to MVPA in

the neighborhood at T2 (Table 3, Models 3a and 4a). Among those who spent time in their neighborhood at either T1 or T2, overall MVPA at T2 was slightly higher as their percentage of total time spent in MVPA in the neighborhood increased (Table 4). Each percentage point increase of time in MVPA in the neighborhood at either T1 or T2 was associated with an increase in average daily MVPA at T2 of under one minute (Table 4).

In most cases, the inclusion of covariates in the OLS models attenuated the observed bivariate relationships between neighborhood activity and overall activity at T2. The covariates of activity levels at T1, gender, age, and site were all significantly related to overall activity at T2, and the inclusion of these covariates accounted for the relationships between neighborhood activity and overall activity at T2. One exception to this pattern was the relationship between percent of total time in the neighborhood in MVPA at T2 and activity levels at T2, which was small in magnitude but remained significant and positive with the addition of covariates (Table 4, Model 2b). An examination of the R-squared values across models shows that covariates such as age, gender, and site explain a higher proportion of the variance in activity levels at T2 than neighborhood activity measures alone.

Discussion

Using longitudinal data, this study examined changes in locations where children were active and whether the proportion of their time in MVPA within locations changed over 2 years among a large sample of children. There was no substantive change in the proportion of time that children spent in different types of locations over time, shifting no more than 6 percentage points from T1 to T2. However, total time and proportion of time spent in MVPA decreased significantly within every location type from T1 to T2. Notably, some of the largest decreases in the percent of time spent in MVPA occurred in places that appear to provide the greatest opportunities for PA, including indoor public recreation facilities, public outdoor parks and recreation areas, and private recreation facilities.

Over two years, children increased the proportion of their time spent in their own home, other’s homes, public outdoor parks, and indoor public recreation facilities. However, in these four locations there was a greater decrease in the proportion of time spent in MVPA than in almost all of the other locations. Children spending more time in places where their time engaged in MVPA decreased substantially might in part explain the precipitous decline in overall PA observed in children in this and other studies (Cooper et al., 2015; Nader et al., 2008). This age related decline in PA has been observed in diverse animal species, and a neurobiological mechanism has been identified (Sallis, 2000). It is likely that a combination of biological, psychological, social, and environmental factors explains age related decline.

A child’s neighborhood at T2 remained the location with the highest percentage of total time spent in MVPA, with 34.9% of neighborhood minutes spent in MVPA. However, on average children spent less than 1% of their waking time in their home neighborhoods. Over the past few generations the amount of time children spend outdoors has declined (Gester, 1991; Karsten, 2005; Tandy, 1999). Mothers in the US reported their children spend less time outdoors in unstructured, free play and more time in structured adult supervised activities compared to when the parents were children (Clements, 2004). Additionally, outdoor MVPA

decreases with advancing age (Cleland et al., 2010; Pagels et al., 2014). One study found that during school hours second graders spent 113 minutes (78% in PA) outdoors, fifth graders 78 minutes (79% in PA) and eighth graders 22 minutes (73% in PA) (Pagels et al., 2014). Another found that boys (ages 5–6) spent 19% and girls (ages 5–6) spent 14% less time outdoors five years later (Cleland et al., 2010). Thus, although children are more active outdoors, they are spending less time outdoors engaged in free play as they get older.

We found a positive association between being more active in the neighborhood at T2 and overall daily activity levels at T2. A 20 percentage point increase in time engaged in neighborhood MVPA would translate into an overall increase of daily average MVPA of 14 minutes. Thus, being active in the neighborhood at T2 directly contributed to total MVPA. The importance of MVPA in the neighborhood is consistent with a recent study that found children allowed to spend time independently in their neighborhood had greater overall PA compared with children not allowed to do so (Stone and Faulkner, 2014). We found that children who were more active at T1, male, younger, and living in Seattle were more active in the neighborhood and had higher overall activity levels. These findings are consistent with other studies (Aarts et al., 2010; Cooper et al., 2015; Rodriquez et al., 2011) and suggest the importance of establishing a habit of being active from a young age, targeting promotional efforts to girls and older children as well as improving environmental characteristics. Thus, encouraging children to spend more time active in the neighborhood could be an important strategy to countering the age related decline in PA.

Children in this study were less likely to be outside in their neighborhood than almost any other place. This is an important health issue given that children were most active when outside in their neighborhood, and this activity contributed directly to total MVPA. Thus, increasing time outside in the neighborhood could be a powerful PA intervention. There is rapidly growing evidence that aspects of neighborhood built environments are related to time spent in the neighborhood and total PA. Neighborhood characteristics that have been associated with children's PA include traffic speed and volume, pedestrian safety structures, walking and biking facilities, and access to recreation facilities (Ding et al., 2011). In one study, children in neighborhoods with greater "greenness" (tree lined streets, forested parks, sport fields) spent more time in the neighborhood (51.6 versus 31.9 daily minutes) compared with children living in neighborhoods with lower greenness (Almanza et al., 2012). Making multi-pronged changes to neighborhood built environments, such as improving crosswalks and landscaping/greenness, could increase the percent of time children spend in their neighborhoods, which could in turn translate into higher MVPA overall (US Preventive Services Task Force, 2015).

In addition to the neighborhood built environment, the family and social-cultural environment could be important influences on the time that children spend in outdoor play. Parental factors influencing children's outdoor play include safety concerns due to presence of negative social influences and traffic, attitudes towards active play, level of a child's independence, neighborhood social networks and parental rules (Remmers et al., 2014; Veitch et al., 2006; Xu et al., 2014). Prior studies have found that higher levels of perceived neighborhood social cohesion were associated with children spending more time in outdoor play (Aarts et al., 2010; Kimbro et al., 2011) and social cohesion, collective socialization,

more neighborhood social ties and neighborhood exchange were positively associated with children's PA (Franzini et al., 2009). Thus, changing parental perceptions and creating the social context in neighborhoods that builds connection among neighbors and supports children being outdoors and active appears necessary, in addition to built environment enhancements, to support children's PA.

The strength of this study was the two-year longitudinal design that allowed assessment of changes over time in PA and location types in children. However, limitations included reliance on the use of parent-report logs rather than the likely more precise GPS to ascertain a child's location. Thus, there are unknown inaccuracies in the location by time data. Collapsing travel time between locations into the last location would ascribe active or sedentary travel to that location rather than accounted for as travel, increasing the time spent in some locations. This could potentially have increased or decreased the portion of time in that location engaged in MVPA. Although children wore the accelerometer in the same month at each time point to control for seasonality, the weather might have been different, reducing the ability to compare across time points. In examining changes in activity levels in the neighborhood from T1 to T2, we recorded the value for the percent of time in the neighborhood spent in MVPA as zero if a child did not spend time in the neighborhood at T1 and/or T2. Given the limited number of children who spent time in the neighborhood at both T1 and T2 (n=49), this strategy provided some insight into changes in associations between background characteristics and children's activity patterns in the neighborhood from T1 to T2. However, this strategy conflates a lack of spending time in the neighborhood with inactivity in the neighborhood. Finally, the study sample was limited to two urban areas along the West Coast of the U.S., and findings cannot necessarily be generalized to rural areas or other parts of the U.S or globally.

Conclusions

Children did not markedly change the proportion of time spent in different types of locations over a two-year period, but the proportion of time being active decreased within all locations, particularly in some settings in which children are more likely to be active. Time spent in the neighborhood had the highest percent of MVPA time of any location type, and children who did any activity in the neighborhood at T2 engaged in 12.1 more minutes of total MVPA. However, children spent very little time outside their homes in their neighborhood. Thus, one avenue to increasing MVPA and reducing the decline in MVPA as children become older is to reduce their time inside the home and increase time outside in the neighborhood.

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Highlights

- Total mins. and proportion of time in MVPA decreased across all locations over time
- Over time, children spent more time at home but less time at home engaged in MVPA
- Children spent the highest proportion of time in MVPA in their home neighborhoods
- Neighborhood activity at time 2 was associated with 12.1 more MVPA min/day

Table 1

Percent of Total Time Spent at Each Location Type, Time 1 and Time 2

	Time 1		Time 2		Difference (T2−T1)			
Location	**Mean**	**Std. Error**	**Mean**	**Std. Error**	**Mean**	**Std. Error**	**t**	**p-value[a]**
Home	47.4	0.60	51.5	0.63	4.0	0.72	5.60	<0.001
School	29.1	0.70	23.4	0.70	−5.7	0.88	−6.46	<0.001
Neighborhood	0.8	0.11	0.7	0.10	−0.1	0.12	−0.72	0.471
Others' Homes	6.3	0.29	7.1	0.39	0.8	0.42	1.95	0.052
Other Schools	1.6	0.16	1.3	0.12	−0.3	0.19	−1.62	0.106
Public Outdoor Parks and Rec.	2.7	0.17	3.7	0.23	1.0	0.26	3.89	<0.001
Indoor Public Rec. Facilities	0.7	0.12	1.0	0.13	0.3	0.13	2.37	0.018
Private Rec. Facilities	1.4	0.12	1.4	0.13	0.0	0.2	0.02	0.981
Non-Food Service Locations	6.0	0.30	5.7	0.32	−0.3	0.40	−0.83	0.408
Non-Descript Geographical Locations	0.2	0.08	0.2	0.05	−0.1	0.08	−0.86	0.392
Shopping	2.3	0.11	2.2	0.11	−0.2	0.15	−1.04	0.298
Food Eateries	1.3	0.08	1.5	0.08	0.2	0.10	1.72	0.085

Note: n=584 cases.

[a]Paired t-test. Non-parametric Wilcoxian matched-pairs signed-ranks test and sign test of matched pairs were also estimated and yielded similar results.

Table 2

Percent of Total Time in Each Location Type Engaged in MVPA, Time 1 and Time 2

		Time 1		Time 2		Difference (T2−T1)			
Location[a]	**n**	**Mean**	**Std. Error**	**Mean**	**Std. Error**	**Mean**	**Std. Error**	**t**	**p-value**[b]
Home	581	18.3	0.3	9.6	0.2	−8.7	0.2	−0.24	<0.001
School	391	18.1	0.4	12.8	0.3	−5.2	0.4	−0.37	<0.001
Neighborhood	49	43.5	3.2	34.9	3.3	−8.6	3.6	−3.65	0.023
Others' Homes	346	22.4	0.7	14.0	0.6	−8.4	0.7	−0.75	<0.001
Other Schools	87	33.7	2.2	27.4	2.1	−6.3	2.4	−2.39	0.010
Public Outdoor Parks and Rec.	229	40.5	1.3	28.4	1.2	−12.1	1.5	−1.54	<0.001
Indoor Public Rec. Facilities	41	34.3	2.5	21.0	2.6	−13.3	2.7	−2.70	<0.001
Private Rec. Facilities	79	33.9	1.8	23.4	1.9	−10.5	2.1	−2.12	<0.001
Non-Food Service Locations	398	17.0	0.6	11.6	0.5	−5.4	0.6	−0.63	<0.001
Shopping	301	19.6	0.6	14.4	0.5	−5.2	0.7	−0.75	<0.001
Food Eateries	223	13.7	0.8	8.9	0.6	−4.8	0.9	−0.92	<0.001

Note: Only children spending any time in each location type at both time points were included in this analysis.

[a] Results for "Non-Descript Geographical Locations" have been omitted due to small sample sizes at Time 1 and Time 2 (n=5).

[b] Paired t-test. Non-parametric Wilcoxian matched-pairs signed-ranks test and sign test of matched pairs were also estimated and yielded similar results.

Table 3

Differences in Physical Activity at Time 2 Among Children By Engagement in Activities in the Neighborhood at Time 2 and Time 1, OLS Regression Models

	Percent of Total Time at T2 in MVPA		Average Daily MVPA (mins.), Valid Days at T2	
Variables	**Model 1a**	**Model 1b**	**Model 2a**	**Model 2b**
Neighborhood Engagement				
Spent time in the neighborhood in MVPA at T2	1.7** (0.5)	0.2 (0.4)	12.1** (4.5)	0.7 (3.1)
(Ref. Did not spend time in the neighborhood in MVPA or Did not spend time in the neighborhood at T2.)				
Covariates				
T1 percent of total time in MVPA		0.4*** (0.0)		
T1 average daily MVPA, valid days (mins.)				0.4*** (0.0)
T1 child age		−0.8*** (0.1)		−7.1*** (1.0)
Female (ref. Male)		−1.1*** (0.3)		−10.1*** (2.5)
Non-white race (ref. White)		−0.0 (0.3)		0.5 (2.8)
Hispanic (ref. Non-Hispanic)		0.1 (0.4)		1.2 (3.9)
T1 child BMI (z-score)		−0.2 (0.1)		−1.3 (1.2)
T1 household income: $30k–59k (Ref. <30k)		−0.4 (0.7)		−3.9 (6.5)
T1 household income: $60–89k (Ref. <30k)		−0.6 (0.7)		−4.8 (6.3)
T1 household income: $90k + (Ref. <30k)		−0.0 (0.7)		0.7 (6.1)
Seattle (Ref. San Diego)		1.1*** (0.3)		9.4*** (2.7)
Block group median household income		0.0* (0.0)		0.0* (0.0)
Constant	11.7*** (0.2)	10.1*** (1.8)	97.9*** (2.0)	95.8*** (14.7)
Observations	571	571	571	571
R-squared	0.0167	0.6392	0.0129	0.6040

	Percent of Total Time at T2 in MVPA		Average Daily MVPA (mins.), Valid Days at T2	
Variables	**Model 3a**	**Model 3b**	**Model 4a**	**Model 4b**
Neighborhood Engagement				
Spent time in the neighborhood in MVPA at T1	−0.3 (0.5)	−0.3 (0.3)	−3.5 (4.1)	−2.7 (2.7)

	Percent of Total Time at T2 in MVPA		Average Daily MVPA (mins.), Valid Days at T2	
Variables	**Model 3a**	**Model 3b**	**Model 4a**	**Model 4b**
(Ref. Did not spend time in the neighborhood in MVPA or Did not spend time in the neighborhood at T1)				
Covariates				
T1 percent of total time in MVPA		0.4*** (0.0)		
T1 average daily MVPA, valid days (mins.)				0.4*** (0.0)
T1 child age		−0.8*** (0.1)		−7.0*** (1.0)
Female (ref. Male)		−1.1*** (0.3)		−10.0*** (2.5)
Non-white race (ref. White)		−0.1 (0.3)		0.2 (2.8)
Hispanic (ref. Non-Hispanic)		0.2 (0.4)		1.5 (3.9)
T1 child BMI (z-score)		−0.2 (0.1)		−1.3 (1.2)
T1 household income: $30k–59k (Ref. <30k)		−0.4 (0.7)		−3.5 (6.5)
T1 household income: $60–89k (Ref. <30k)		−0.5 (0.7)		−4.3 (6.3)
T1 household income: $90k + (Ref. <30k)		0.1 (0.7)		1.3 (6.2)
Seattle (Ref. San Diego)		1.2*** (0.3)		9.6*** (2.6)
Block group median household income		0.0* (0.0)		0.0* (0.0)
Constant	12.1*** (0.3)	9.8*** (1.8)	101.3*** (2.1)	93.4*** (15.0)
Observations	571	571	571	571
R-squared	0.0007	0.6394	0.0012	0.6046

Robust standard errors in parentheses

*** p<0.001,

** p<0.01,

* p<0.05,

+ p<0.10

Table 4

Physical Activity in the Neighborhood at Time 1 and Time 2 as Predictors of Overall Activity Levels at Time 2, OLS Regression Models

	Percent of Total Time at T2 in MVPA		Average Daily MVPA (mins.), Valid Days at T2	
Variables	**Model 1a**	**Model 1b**	**Model 2a**	**Model 2b**
Neighborhood Activity Levels				
Percent of total time in neighborhood spent in MVPA at T2	0.1*** (0.0)	0.0* (0.0)	0.7*** (0.2)	0.2+ (0.1)
Covariates				
T1 percent of total time in MVPA		0.4*** (0.1)		
T1 average daily MVPA, valid days (mins.)				0.4*** (0.1)
T1 child age		−0.6* (0.3)		−5.4* (2.4)
Female (ref. Male)		−1.1+ (0.6)		−11.5* (5.8)
Non-white race (ref. White)		0.3 (1.0)		−3.2 (7.5)
Hispanic (ref. Non-Hispanic)		1.6 (1.2)		11.7 (8.6)
T1 child BMI (z-score)		−0.6 (0.4)		−5.8 (3.6)
T1 household income: $30k–59k (Ref. <30k)		−4.7* (1.8)		−41.9** (15.6)
T1 household income: $60–89k (Ref. <30k)		−2.0 (1.8)		−20.8 (14.3)
T1 household income: $90k + (Ref. <30k)		−2.3 (1.5)		−18.6 (12.8)
Seattle (Ref. San Diego)		0.8 (0.9)		7.6 (7.7)
Block group median household income		0.0+ (0.0)		0.0 (0.0)
Constant	10.6*** (0.8)	8.8+ (4.9)	88.0*** (6.9)	91.7* (36.3)
Observations	121	121	121	121
R-squared	0.1069	0.6503	0.104	0.6149

	Percent of Total Time at T2 in MVPA		Average Daily MVPA (mins.), Valid Days at T2	
Variables	**Model 3a**	**Model 3b**	**Model 4a**	**Model 4b**
Neighborhood Activity Levels				
Percent of total time in neighborhood spent in MVPA at T1	0.1*** (0.0)	0.0 (0.0)	0.5*** (0.1)	0.2 (0.1)

	Percent of Total Time at T2 in MVPA		Average Daily MVPA (mins.), Valid Days at T2	
Variables	**Model 3a**	**Model 3b**	**Model 4a**	**Model 4b**
Covariates				
T1 percent of total time in MVPA		0.4*** (0.1)		
T1 average daily MVPA, valid days (mins.)				0.5*** (0.1)
T1 child age		−0.5* (0.2)		−4.1* (1.9)
Female (ref. Male)		−1.2* (0.6)		−9.6* (4.6)
Non-white race (ref. White)		0.2 (1.1)		0.8 (8.2)
Hispanic (ref. Non-Hispanic)		0.8 (1.1)		4.0 (7.8)
T1 child BMI (z-score)		−0.5+ (0.3)		−4.0+ (2.4)
T1 household income: $30k–59k (Ref. <30k)		3.5 (2.8)		37.3 (31.7)
T1 household income: $60–89k (Ref. <30k)		4.4 (2.8)		44.6 (31.6)
T1 household income: $90k + (Ref. <30k)		4.2 (2.8)		44.5 (31.5)
Seattle (Ref. San Diego)		1.1+ (0.6)		9.1+ (4.8)
Block group median household income		0.0 (0.0)		0.0 (0.0)
Constant	9.2*** (0.8)	2.7 (4.5)	75.4*** (6.5)	13.9 (42.2)
Observations	140	140	140	140
R-squared	0.0804	0.6773	0.091	0.6646

Robust standard errors in parentheses

*** p<0.001

** p<0.01

* p<0.05

+ p<0.10