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Where can they play? Outdoor spaces and physical activity among adolescents in U.S. urbanized areas

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Abstract

Objective—To estimate behavior-specific effects of several objectively-measured outdoor spaces on different types of moderate to vigorous physical activity (MVPA) in a large, diverse sample of U.S. adolescents.

Methods—Using data from Wave I (1994–95) of the National Longitudinal Study of Adolescent Health (U.S., n=10,359) and a linked geographic information system, we calculated percent greenspace coverage and distance to the nearest neighborhood and major parks. Using sex-stratified multivariable logistic regression, we modeled reported participation in wheel-based activities, active sports, exercise, and ≥5 MVPA bouts/week as a function of each outdoor space variable, controlling for individual- and neighborhood-level sociodemographics.

Results—Availability of major or neighborhood parks was associated with higher participation in active sports and, in females, wheel-based activity and reporting ≥5 MVPA bouts/week [OR (95% CI): up to 1.71 (1.29. 2.27)]. Greater greenspace coverage was associated with reporting ≥5 MVPA bouts/week in males and females [OR (95% CI): up to 1.62 (1.10, 2.39) for 10.1 to 20% versus ≤10% greenspace] and exercise participation in females [OR (95% CI): up to 1.73 (1.21, 2.49)].

Conclusions—Provision of outdoor spaces may promote different types of physical activities, with potentially greater benefits in female adolescents, who have particularly low physical activity levels.

Keywords

Environment design; physical activity; adolescent; epidemiology; United States

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Conflict of Interest Statement
The authors declare that there are no conflicts of interest.

INTRODUCTION

Outdoor spaces such as greenspace and parks may be important community resources for youth activity (Tester, 2009). Outdoor spaces are reasonably equitable and related to physical activity (Mowen and Baker, 2009), but little is known about which outdoor spaces might promote different types of physical activities. Few studies examine multiple types of outdoor spaces and even fewer examine behavior-, sex-, or age-specific associations. To this end, we estimated effects of several types of outdoor spaces on different types of leisure-time moderate to vigorous physical activities (MVPA) in a large, geographically diverse sample of U.S. adolescents.

METHODS

Study design and sample

We used cross-sectional data from Wave I of The National Longitudinal Study of Adolescent Health (Add Health), a prospective cohort study of 20,745 adolescents representative of the U.S. school-based population (grades 7–12 in 1994–95). Survey design and sampling frame are described elsewhere (Resnick, et al., 1997). Using complex Geographic Information System (GIS) techniques, we linked time-varying, community-level data to circular buffers of 3 kilometer (km) radii (Boone-Heinonen, et al., 2010b) from each Add Health respondent home address (Boone-Heinonen, et al., 2010a).

Of the weighted full sample (n=18,924), we excluded individuals: living outside of U.S. Census urbanized areas (n=7,452) given urban-rural differences; reporting physical disability or pregnancy, and Native Americans due to sparse data (n=406); or missing geographic location or individual-level survey data (n=292); resulting in 10,773 adolescents for analysis.

Exposure variables: GIS-derived environmental characteristics

Greenspace coverage was a calculated from U.S. Geological Service's 1992 National Land Cover Dataset using Fragstats [version 3.3 build 5] to derive proportion of recreational or undeveloped land (greenspace). Distance to nearest neighborhood park (<200 acres aggregate area; mean=20 acres), and major park (≥200 acres aggregate area; mean=24,216 acres) boundaries were calculated from StreetMap Pro [version 5.2, July 2003] from Environmental Systems Research Institute, the premiere basemap street layer comprised of detailed maps, including park locations and boundaries. A previous validation indicated that business record data would not suffice for obtaining park locations (Boone, et al., 2008) Continuous variables were categorized into conceptually relevant categories based on existing research (Maas, et al., 2008) or policies, distribution of data, and homogeneity of associations within categories.

Outcome variables: Types of MVPA

In-home interviews assessed physical activity using a standard activity recall, similar to those validated in other epidemiological studies, which asked "During the past week, how many times did you…," (1) "go roller-blading, roller-skating, skate-boarding, or bicycling" (*wheel-based* activities), (2) "play an *active sport*, such as baseball, softball, basketball, soccer, swimming, or football?", and (3) "*exercise*, such as jogging, walking, karate, jumping rope, gymnastics or dancing," in addition to sedentary and low intensity activities. We classified adolescents as reporting ≥5 weekly bouts of MVPA and any participation in wheel-based, active sport, and exercise MVPA.

Individual- and neighborhood-level control variables

Individual-level controls included race/ethnicity; age at interview; highest parental education at Wave I, and household income (< or ≥ median, $36,000). Neighborhood-level controls

included census tract-level percent non-Hispanic white, below the Federal Poverty Level, and college educated; population density within 3km of respondents' home address (1990 U.S. Census), and county-level total crimes per 100,000 (1995 Uniform Crime Reporting Data).

Statistical Analysis

In separate sex-stratified logistic regression analyses, we estimated effects of (1) greenspace coverage and distance to the nearest (2) neighborhood park and (3) major park on four self-reported MVPA outcomes: (1) ≥5 MVPA bouts/week, (2) wheel-based activities, (3) active sport, and (4) exercise. Confounding was assessed using a >10% change in estimate criterion; reported models adjusted for the above-listed individual-level sociodemographics and neighborhood-level education, crime, and population density.

Census unit boundaries did not correspond with school catchment areas, so schools and census units were not hierarchically related; therefore, analyzing census units as higher levels in multi-level models was not possible while correcting for school-level clustering, the primary sampling unit for Add Health. Furthermore, census tracts contained sparse, unbalanced numbers of respondents (mean=8, range=1–275 respondents), which can lead to bias in non-linear multilevel models, and clustering within census tracts was minimal (0.03 intraclass correlation for MVPA). Thus, all analyses corrected for complex survey sampling (i.e., school-level clustering) and were weighted for national representation using Stata, version 10.1 survey commands.

RESULTS

Males reported more MVPA than females for all activities except exercise (Table 1). Neighborhood characteristics did not vary by sex ($p>0.05$).

In males, greater greenspace coverage was related to as much as 62% greater odds of reporting ≥5 MVPA bouts/week, with elevated but non-significant odds of reporting each type of MVPA (Table 2). Shorter distances to neighborhood and major parks were related to higher odds of active sports participation but unrelated to other MVPA outcomes.

In females, living closer to a major park was most strongly and consistently associated with each MVPA type, reaching 71% greater odds of reporting wheel-based activity in those living 3.1–5 miles from a major park (Table 2). Shorter distance to neighborhood parks was related to significantly greater odds of reporting ≥5 MVPA bouts/week. Greenspace coverage was positively associated with exercise.

DISCUSSION

Using unique landcover and parks data and a large, diverse sample of U.S. adolescents,,different types of outdoor spaces were related to different types of physical activities. Distance to neighborhood and major parks was significantly related to active sports, perhaps because parks often contain relevant sports facilities and, in females, with wheel-based physical activity, perhaps due to trails or other infrastructure. Higher greenspace coverage was related to greater overall leisure MVPA and, in females, exercise. Findings suggest potentially greater benefits in female adolescents, who are less active (Sanchez, et al., 2007) and may find more safety or social support in outdoor spaces in comparison to males.

Limitations and future research

While our findings are consistent with theorized behavior-specific effects of neighborhood features (Bedimo-Rung, et al., 2005), longitudinal, intervention, and natural experiment research is needed to demonstrate whether provision or improvement of outdoor spaces will

translate into increasing physical activity. We could not assess location-specific activities, specific amenities, quality or size of outdoor spaces, or control for residential selection bias. However, our large, diverse and nationally representative sample provides a unique opportunity to investigate differences in how several types of outdoor spaces are related to various types of physical activity.

Our self-reported MVPA measure yielded higher MVPA levels than other studies (Troiano, et al., 2008), though errors in self-reported MVPA and in objectively measured outdoor spaces likely arise from different mechanisms and are therefore unlikely to be correlated. StreetMap Pro 2003 provided park data for our national sample which was of higher quality than business record data (Boone, et al., 2008), and underwent preliminary comparisons with high resolution satellite imagery; however, we did not formally validate Streetmap Pro data and there may be some temporal mismatch in coverage. While we control for adolescents' sociodemographic characteristics and county-level crime, use of outdoor spaces may involve geographic clustering (Boone-Heinonen, et al., 2010a) with factors such as walkability, and complex dynamics across safety, race, and other factors that should be further investigated.

Conclusion

Greenspace and parks may be important settings for adolescent physical activity, each potentially providing resources for different types of physical activity, with active sport facilities provided by parks and more general activity resources provided by greenspace. While more research on specific features that influence use of outdoor space for physical activity is needed, provision of outdoor space is a promising strategy for increasing physical activity in youth.

Abbreviations

Add Health	National Longitudinal Study of Adolescent Health
GIS	Geographic Information System
MVPA	Moderate to Vigorous Physical Activity
U.S.	United States
ZIP	Zone Improvement Plan (United States Postal Service postal codes)

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Table 1

Individual-level and environment characteristics by sex[a].

	Male (n=5,391)		Female (n=5,382)		p[b]
	%/median	SE/25th, 75th percentile	%/median	SE/25th, 75th percentile	
Age (years) [% (SE)]					<0.01
11–15	48.2	(3.8)	53.0	(3.8)	
16–17	34.2	(2.6)	33.1	(2.8)	
18–21	17.7	(1.6)	13.9	(1.3)	
Race/ethnicity [% (SE)]					0.98
White	58.5	(3.7)	59.0	(3.9)	
Black	16.7	(2.6)	16.5	(2.4)	
Asian	5.5	(1.2)	5.3	(1.2)	
Hispanic	19.3	(2.7)	19.2	(2.8)	
Parental education [% (SE)]					1.00
<High School	18.8	(2.1)	18.8	(2.1)	
High School/GED	30.6	(1.8)	30.7	(1.7)	
Some college	26.0	(1.1)	25.8	(1.1)	
≥College	24.6	(2.4)	24.8	(2.5)	
Household Income ($U.S.) [% (SE)]					0.78
≤36,000	49.0	(3.3)	48.6	(3.3)	
>36,000	51.0	(3.3)	51.4	(3.3)	
≥5 MVPA bouts per week [% (SE)]	73.0	(1.2)	58.7	(1.5)	<0.01
Any wheel-based activity in past week [% (SE)]	46.0	(1.7)	32.9	(1.6)	<0.01
Any active sport in past week [% (SE)]	79.7	(0.9)	63.2	(1.4)	<0.01
Any exercise in past week [% (SE)]	80.7	(0.8)	86.9	(0.8)	<0.01
Percent greenspace coverage within 3km buffer [% (SE)]					0.81
≤10	10.9	(2.8)	11.5	(3.0)	
10.1 to 20	27.5	(3.3)	27.9	(3.5)	
19.9 to 32	30.8	(3.6)	29.8	(3.8)	
≥32	30.9	(3.8)	30.8	(4.3)	

	Male (n=5,391)		Female (n=5,382)		p*b*
	%/median	SE/25th, 75th percentile	%/median	SE/25th, 75th percentile	
Distance to neighborhood park (miles) [% (SE)]					0.58
>2	17.1	(3.4)	17.1	(3.3)	
0.5 to 2	36.6	(3.5)	34.9	(3.3)	
0.26 to 0.5	23.9	(1.9)	24.2	(2.0)	
≤0.25	22.4	(2.2)	23.8	(2.3)	
Distance to neighborhood park (miles) [% (SE)]					0.64
>5	31.9	(5.0)	32.1	(5.0)	
3.1 to 5	20.5	(2.7)	21.6	(2.8)	
1.1 to 3	37.1	(3.8)	36.7	(3.9)	
≤1	10.5	(2.2)	9.7	(1.9)	
County-level crimes (number per 100,000 population) [median (25^{th}, 75^{th} percentile)]	6108	(4449, 7713)	6108	(4710, 7713)	
Percent within census tract with college education or greater [median (25^{th}, 75^{th} percentile)]	22.7	(12.9, 31.0)	21.3	(12.7, 32.7)	
Population density within 3km buffer [median (25^{th}, 75^{th} percentile)]	1248	(675, 1,870)	1252	(713, 1,910)	

*a*National Longitudinal Study of Adolescent Health, Wave I (U.S., 1995–96). Weighted for national representation, standard errors corrected for survey design effects of multiple stage cluster sampling.

*b*Difference between sexes, per design based F-test

Table 2

Relationship between greenspace and distance to neighborhood or major park with four physical activity outcomes[a]

	≥5 MVPA bouts/week		Any wheel-based MVPA[c]		Any active sport[d]		Any exercise[e]	
	Count[b] (no/yes)	Adjusted OR (95% CI)	Count[b] (no/yes)	Adjusted OR (95% CI)	Count[b] (no/yes)	Adjusted OR (95% CI)	Count[b] (no/yes)	Adjusted OR (95% CI)
MALES (n=5,391) Percent greenspace coverage								
≤10	20.7/45.5	1.00	39.1/27.0	1.00	15.1/51.1	1.00	13.0/53.2	1.00
10.1 to 20	40.2/126.9	**1.62 (1.10, 2.39)***	91.7/75.4	1.24 (0.87, 1.76)	28.5/138.5	1.48 (0.93, 2.36)	29.9/137.1	1.26 (0.82, 1.94)
19.9 to 32	51.4/136.0	1.37 (0.90, 2.07)	98.9/88.5	1.33 (0.90, 1.97)	37.5/149.9	1.21 (0.74, 1.99)	34.2/153.2	1.28 (0.79, 2.09)
≥32	51.7/136.2	1.47 (0.94, 2.30)	99.1/88.8	1.37 (0.94, 2.02)	42.8/145.1	1.07 (0.64, 1.79)	40.2/147.7	1.09 (0.68, 1.74)
Distance to neighborhood park (miles)								
>2	30.1/74.2	1.00	53.2/51.1	1.00	24.9/79.4	1.00	20.5/83.7	1.00
0.5 to 2	61.7/160.7	1.05 (0.82, 1.34)	123.0/99.4	0.83 (0.61, 1.13)	45.8/176.6	1.19 (0.94, 1.50)	43.2/179.3	1.00 (0.77, 1.32)
0.26 to 0.5	38.7/106.6	1.09 (0.81, 1.46)	78.0/67.3	0.96 (0.69, 1.34)	28.0/117.3	1.28 (0.94, 1.76)	28.4/116.9	0.92 (0.65, 1.29)
≤0.25	33.5/102.9	1.26 (0.93, 1.69)	74.6/61.9	0.97 (0.70, 1.35)	25.2/111.3	**1.37 (1.02, 1.84)***	25.2/111.3	0.99 (0.71, 1.40)
Distance to major park (miles)								
>5	52.7/141.4	1.00	104.5/89.6	1.00	42.4/151.8	1.00	34.9/159.2	1.00
3.1 to 5	30.2/94.5	1.14 (0.91, 1.44)	67.1/57.6	1.01 (0.78, 1.32)	26.2/98.5	1.02 (0.79, 1.32)	24.3/100.4	0.87 (0.65, 1.17)
1.1 to 3	64.2/161.5	0.91 (0.71, 1.15)	123.3/102.4	1.02 (0.81, 1.29)	45.3/180.4	1.07 (0.82, 1.38)	46.0/179.7	0.83 (0.65, 1.06)
≤1	16.9/47.0	0.90 (0.68, 1.20)	33.9/30.0	1.04 (0.79, 1.36)	10.0/54.0	1.36 (1.00, 1.84)	12.1/51.8	0.85 (0.59, 1.22)
FEMALES (n=5,382) Percent greenspace coverage								
≤10	35.5/29.5	1.00	48.5/16.5	1.00	30.1/34.9	1.00	12.0/52.9	1.00
10.1 to 20	60.7/97.1	**1.49 (1.05, 2.10)***	103.1/54.8	1.19 (0.80, 1.77)	57.4/100.4	1.09 (0.81, 1.47)	16.9/140.9	**1.73 (1.21, 2.49)***
19.9 to 32	66.3/102.4	1.33 (0.96, 1.85)	108.7/60.1	1.19 (0.81, 1.74)	62.4/106.3	0.98 (0.70, 1.36)	21.0/147.8	**1.50 (1.02, 2.19)***
≥32	70.9/103.1	1.13 (0.75, 1.68)	119.5/54.5	0.90 (0.58, 1.40)	58.2/115.9	1.01 (0.70, 1.46)	24.3/149.7	1.23 (0.85, 1.80)
Distance to neighborhood park (miles)								

	≥5 MVPA bouts/week		Any wheel-based MVPA[c]		Any active sport[d]		Any exercise[e]	
	Count[b] (no/yes)	Adjusted OR (95% CI)	Count[b] (no/yes)	Adjusted OR (95% CI)	Count[b] (no/yes)	Adjusted OR (95% CI)	Count[b] (no/yes)	Adjusted OR (95% CI)
>2	45.1/51.8	1.00	67.2/29.6	1.00	37.1/59.7	1.00	14.9/81.9	1.00
0.5 to 2	73.1/124.1	**1.62 (1.25, 2.11)***	126.8/70.5	1.29 (0.94, 1.77)	68.8/128.4	1.25 (0.97, 1.61)	23.2/174.0	**1.42 (1.03, 1.95)***
0.26 to 0.5	58.7/78.3	**1.42 (1.05, 1.92)***	94.6/42.4	1.13 (0.75, 1.70)	51.7/85.3	1.28 (0.94, 1.73)	17.0/120.0	1.35 (0.93, 1.96)
≤0.25	56.6/77.9	**1.50 (1.13, 2.00)***	91.0/43.5	1.21 (0.80, 1.83)	50.5/84.0	1.31 (1.00, 1.72)	19.1/115.4	1.15 (0.81, 1.63)
Distance to major park (miles)								
>5	75.7/105.6	1.00	132.3/49.0	1.00	70.9/110.3	1.00	23.5/157.8	1.00
3.1 to 5	51.1/71.1	1.15 (0.86, 1.53)	77.6/44.6	**1.71 (1.29, 2.27)***	42.1/80.1	**1.46 (1.10, 1.96)***	16.5/105.7	1.02 (0.76, 1.36)
1.1 to 3	86.6/120.9	1.20 (0.95, 1.51)	134.3/73.2	**1.66 (1.29, 2.12)***	77.4/130.1	**1.38 (1.13, 1.69)***	28.5/179.0	1.03 (0.78, 1.37)
≤1	20.1/34.6	**1.37 (1.04, 1.81)***	35.5/19.2	**1.59 (1.01, 2.49)***	17.7/37.0	**1.62 (1.22, 2.16)***	5.8/48.8	1.29 (0.85, 1.96)

[a] National Longitudinal Study of Adolescent Health, Wave I (U.S., 1995–96). Estimates obtained from logistic models adjusted for age, race, parental education, household income, neighborhood crime rate, and neighborhood poverty

[b] Crude, weighted count, in 10,000's

[c] Wheel-based physical activity such as roller-blading, roller-skating, skate boarding or bicycling

[d] Active sport such as baseball, softball, basketball, soocer, swimming or football

[e] Exercise such as jogging, walking, karate, jumping rope, gymnastics or dancing

* $p<0.05$

CI, confidence interval; MVPA, moderate to vigorous physical activity