

Green Spaces in Healthy Places:

Objective data demonstrates an association between greenness and momentary measures of physical activity in children



Estela Almanza, Michael Jerrett, Genevieve Dunton,
Edmund Seto, Maryann Pentz

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Map of the Talk



- Effect of community design and green space on physical activity behavior
- Use of GPS and accelerometer data
- Data integration and analysis methods
- Results and future steps



Healthy Places Study

Chino, California

Main hypothesis: Families residing in a smart growth community will show increased physical activity and healthier eating habits compared to residents of conventional communities

- Natural intervention study to evaluate the effects of smart growth community design on family obesity risk
- Survey, anthropometric, accelerometer and GPS data
- Data collected annually for 4 years
- 362 families (1 parent and 1 child each, 724 subjects)

Preserve Community Plan



Key Smart Growth Principles

- Walkable neighborhoods
- Green space
- Compact building design

Is Green Space associated with higher levels of physical activity?



Space-Time-Activity Data Collection

GPS and Accelerometer (ACC) Monitoring Devices



GPS Logger GlobalSat BT 335

- Date & Time
- Location (Latitude, Longitude)
- Speed



Accelerometer ActiGraph GT2M

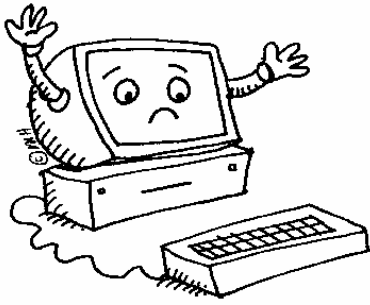
- Date & Time
- Activity Counts (index for activity)

**GPS-ACC collected every 30 seconds for 7 days
(except when bathing, swimming, or sleeping)**

Data Merging

- Created a backbone of 30 second date-time stamps covering the range of GPS/ACC sampled data
- Assigned GPS/ACC records to nearest 30 second date-time stamp
- Incremental processing of data for handling memory constraints





Identification of Problematic Data

- **ACC Global Outliers:** Activity > 16383 counts per 30 sec.
- **GPS Global Outliers:** GPS speeds > 169kph/105mph
- **ACC Non-Wear:** > 1 hour continuous zero counts
- **Missing Data** (GPS or ACC)

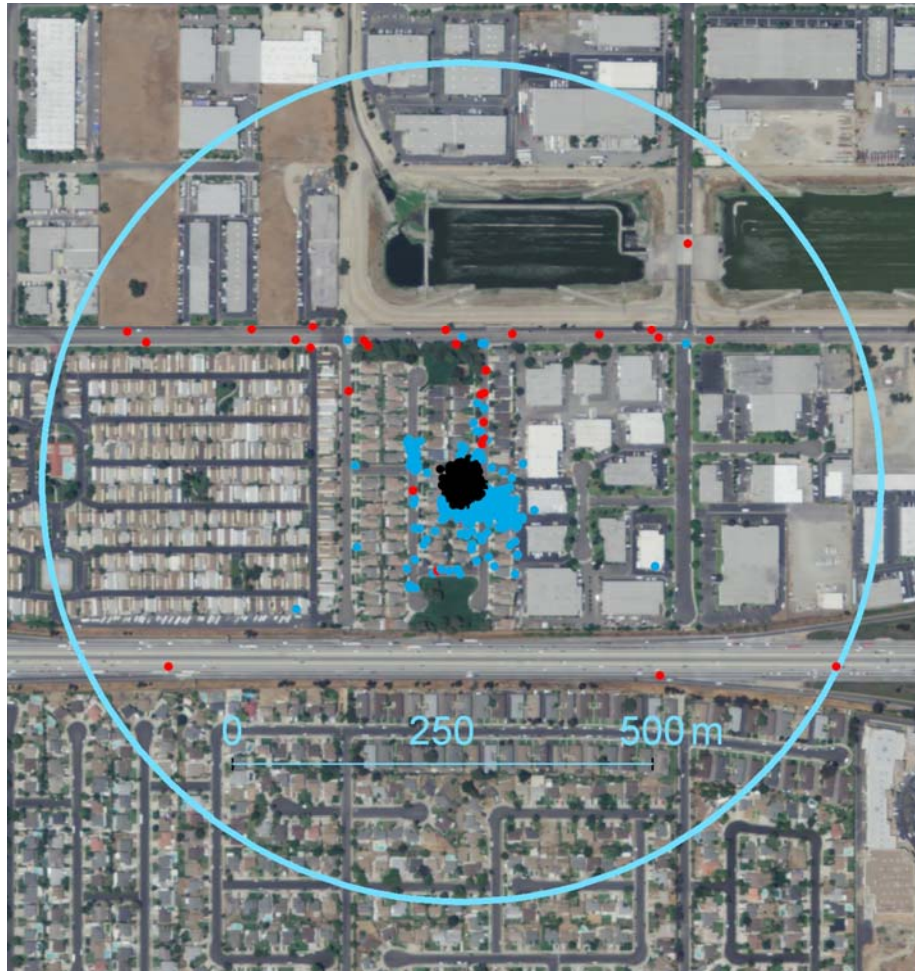
Analysis of Neighborhood Level Physical Activity Behavior of Children

Inclusion Criteria

- Valid Data: Exclude missing, non-wear, outlier, night (11pm-5am)
- Valid Subject: At least 3 days with at least 4 hours per day
- Limit to non-motorized, neighborhood points outside of home
- Exclude subjects with less than 1 hour of neighborhood points



Neighborhood Points Outside of Home



Neighborhood

500 m buffer

Motorized Excluded

>32 kph/20mph

Home Excluded

30m buffer

Physical Activity Response Variable

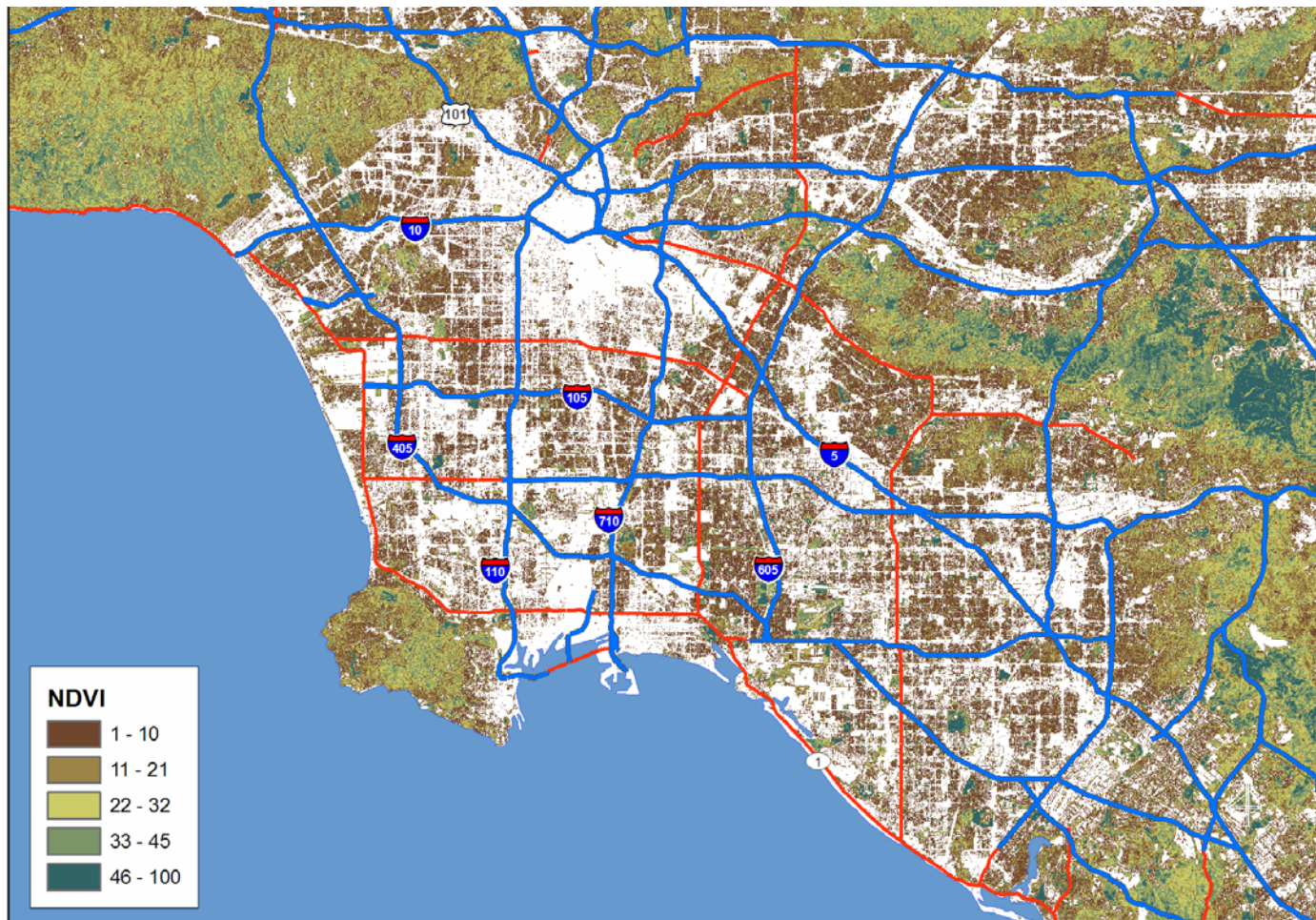
- Accelerometer activity count data classified into intensity levels based on age-specific cut-points
- Binary variable for moderate and vigorous physical activity, ≥ 4 METs (**MVPA**)



Remote Sensed Indicator of Vegetation

Normalized Difference Vegetation Index

$$= (NIR - RED) / (NIR + RED)$$



Results – Example Data (selected fields)

SID	Female	Age	Race	Community	Time	Lat	Long	Speed	MVPA
12345	1	10	Hispanic	1	85.19479	34.xxxx	-117.xxxx	0.3	0
12345	1	10	Hispanic	1	85.19514	34.xxxx	-117.xxxx	0.2	0
12345	1	10	Hispanic	1	85.19549	34.xxxx	-117.xxxx	0.2	0
12345	1	10	Hispanic	1	85.19583	34.xxxx	-117.xxxx	0.3	0
12345	1	10	Hispanic	1	85.19618	NA	NA	NA	0
12345	1	10	Hispanic	1	85.19653	NA	NA	NA	1
12345	1	10	Hispanic	1	85.19688	NA	NA	NA	0
12345	1	10	Hispanic	1	85.19722	NA	NA	NA	0
12345	1	10	Hispanic	1	85.19757	34.xxxx	-117.xxxx	0.2	0
12345	1	10	Hispanic	1	85.19792	34.xxxx	-117.xxxx	0.2	0
12345	1	10	Hispanic	1	85.19826	34.xxxx	-117.xxxx	0.2	0
12345	1	10	Hispanic	1	85.19861	34.xxxx	-117.xxxx	0.2	0
12345	1	10	Hispanic	1	85.19896	34.xxxx	-117.xxxx	0.2	0
12345	1	10	Hispanic	1	85.19931	34.xxxx	-117.xxxx	0.1	0
12345	1	10	Hispanic	1	85.19965	34.xxxx	-117.xxxx	0.6	0
12345	1	10	Hispanic	1	85.2	34.xxxx	-117.xxxx	0.8	1
12345	1	10	Hispanic	1	85.20035	34.xxxx	-117.xxxx	0.4	1
12345	1	10	Hispanic	1	85.20069	34.xxxx	-117.xxxx	0.7	1
12345	1	10	Hispanic	1	85.20104	34.xxxx	-117.xxxx	0.5	1
12345	1	10	Hispanic	1	85.20139	34.xxxx	-117.xxxx	0.9	0
12345	1	10	Hispanic	1	85.20174	34.xxxx	-117.xxxx	0.4	0
12345	1	10	Hispanic	1	85.20208	34.xxxx	-117.xxxx	2.29	1
12345	1	10	Hispanic	1	85.20243	34.xxxx	-117.xxxx	0.7	0
12345	1	10	Hispanic	1	85.20278	34.xxxx	-117.xxxx	0.1	0

Average Number Records per Subject: 21,000



Results – Descriptive Statistics, Demographic

Demographic characteristics of the 208 participants included in the analyses by community design group, Healthy Places Study, 2009-2010

	Smartgrowth (n=65)	Conventional (n=143)	Total (n=208)
Gender (n, %)			
Female	35 (53.85)	73 (51.05)	108 (51.92)
Male	30 (46.15)	70 (48.95)	100 (48.08)
Age (mean, range)	10.94 (9-13)	11.20 (8-14)	11.12 (8-14)
BMI kg/m ² (mean, range)	19.59 (13-33)	20.37 (13-39)	20.13 (13-39)
Race (n, %)			
Caucasian	18 (27.69)	37 (25.87)	55 (26.44)
African Am./Black	5 (7.69)	3 (2.10)	8 (3.84)
Hispanic	19 (29.23)	68 (47.55)	87 (41.83)
Asian	14 (21.54)	8 (5.60)	22 (10.58)
Other (mixed, other, Haw/Pisl, Am. Ind)	9 (13.85)	27 (18.88)	36 (17.31)
Income (mean, range)	81968 (5000- 160000)	58221 (5000-160000)	65739 (5000- 160000)



Results – Descriptive Statistics, GPS/ACC

Accelerometer and GPS sampling characteristics of the 208 participants included in the analyses by community design group, Healthy Places Study, 2009-2010

	Smartgrowth (n=65) Mean % (range)	Conventional (n=143) Mean % (range)
Number Days (mean, range)	7.9 (7-8)	7.9 (6-8)
Missing ACC Data	1.4 (0-23)	0.8 (0-25)
Missing GPS Data*	42 (7-81)	33 (3-78)
ACC Outlier	0.23 (0-14.7)	0 (0-0.02)
GPS Outlier	0 (0-0.03)	0 (0-0.01)
ACC Non-Wear*	49 (10.7-73)	50 (30-77)
Speeds > 20mph (motorized)	3 (0 – 9.4)	2.3 (0-11.8)



*Percents for missing GPS data and accelerometer non-wear are large in part because calculations are based on 24 hours sampling time per day

Results – Analysis

Generalized Linear Mixed Model

n = 208 subjects

Total number of sampling points = 189,304

Unit of analysis: 30 second epoch

Random effect for repeat measures within subjects

$$\text{logit (MVPA)} \sim \text{NDVI} * \text{Community} + \text{NDVI} * \text{Female} \\ + \text{Income} + \text{random effect (1 | Subject)}$$

** Race, Age, and BMI were not significant

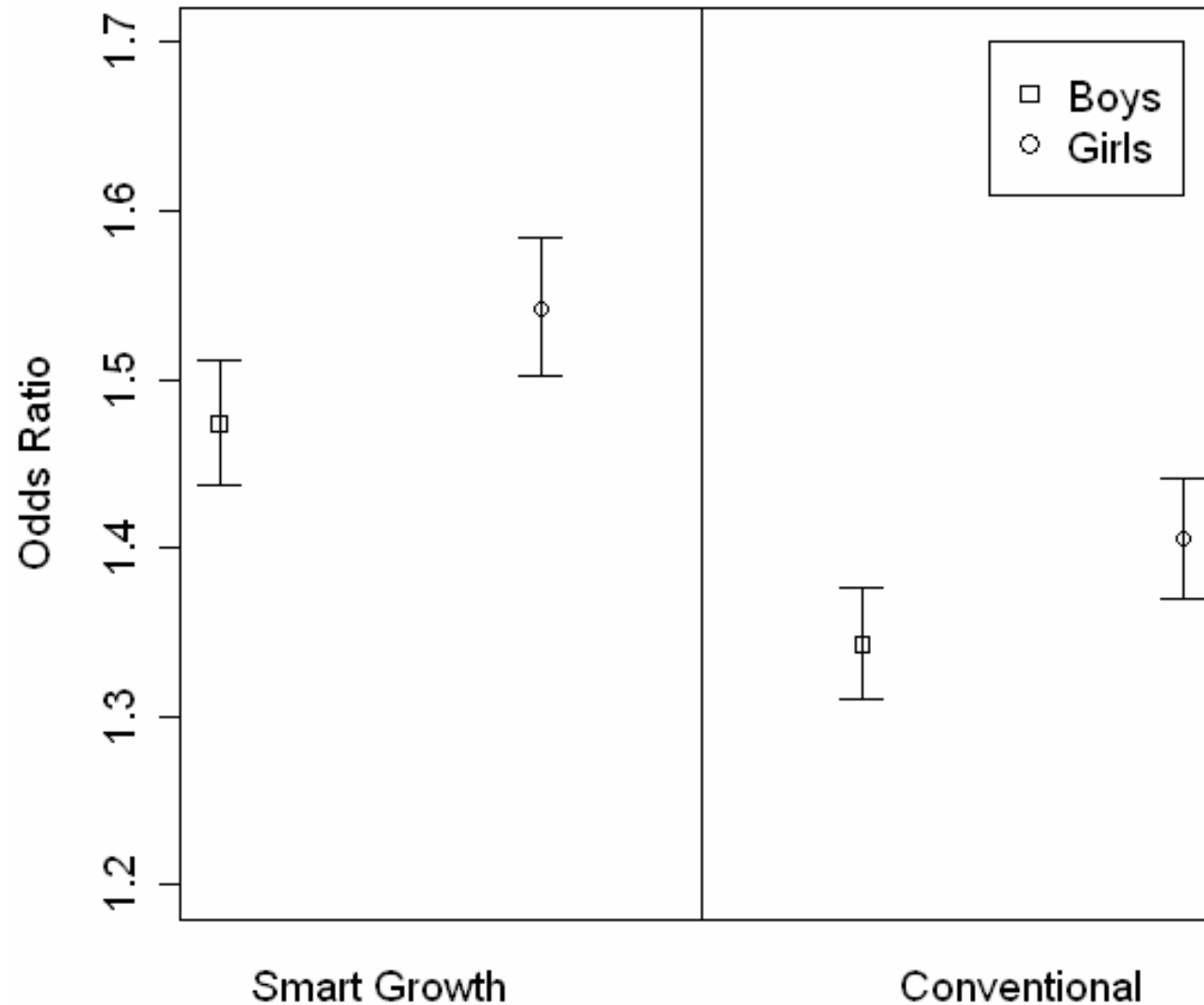


Results – Parameter Estimates

Covariate	Definition	β estimate	P-value
NDVI	30m pixel NDVI values re-scaled 0-1 then standardized	0.29	< 0.001
Community	1: Smartgrowth 0: Conventional	0.069	0.67
NDVI * Community	Interaction Term	0.093	< 0.001
Income	1: Annual Household Income (parameter is for income in thousands)	-0.0041	0.029
Female	1: Female 0: Male	-0.38	0.01
NDVI*Female	Interaction Term	0.045	0.003



Results – Odds Ratios (Odds MVPA between Greenness)



Smartgrowth OR's

Boys: 1.47

Girls: 1.54

Conventional OR's

Boys: 1.34

Girls: 1.41

Provisional Conclusions

- Greenspace (NDVI) appears to be associated with higher levels of physical activity on a momentary basis within neighborhoods of children
- This association appears stronger in the smart growth community compared to conventional communities, and is slightly stronger for girls compared to boys





Future Steps

- **GPS Outliers:** sensitivity analysis of identification of local outliers using moving window
- **Clouds of GPS points:** sensitivity analysis of imputation of points for known locations (e.g. home)
- **Spatial and temporal autocorrelation:** autoregressive models in progress
- **Classify Greenspace:** Ground-truthing, environmental audits, additional spatial layers to characterize green-space
- **Other Covariates:** Temperature, traffic, air pollution





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