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Physical and Social Contextual Influences on Children's Leisure-Time Physical Activity: An Ecological Momentary Assessment Study

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Background: This study used real-time electronic surveys delivered through mobile phones, known as Ecological Momentary Assessment (EMA), to determine whether level and experience of leisure-time physical activity differ across children's physical and social contexts. ***Methods:*** Children (N = 121; ages 9 to 13 years; 52% male, 32% Hispanic/Latino) participated in 4 days (Fri.–Mon.) of EMA during nonschool time. Electronic surveys (20 total) assessed primary activity (eg, active play/sports/exercise), physical location (eg, home, outdoors), social context (eg, friends, alone), current mood (positive and negative affect), and enjoyment. Responses were time-matched to the number of steps and minutes of moderate-to-vigorous physical activity (MVPA; measured by accelerometer) in the 30 minutes before each survey. ***Results:*** Mean steps and MVPA were greater outdoors than at home or at someone else's house (all $P < .05$). Steps were greater with multiple categories of company (eg, friends and family together) than with family members only or alone (all $P < .05$). Enjoyment was greater outdoors than at home or someone else's house (all $P < .05$). Negative affect was greater when alone and with family only than friends only (all $P < .05$). ***Conclusion:*** Results describing the value of outdoor and social settings could inform context-specific interventions in this age group.

Keywords: physical activity, environment, pediatrics, accelerometry

Preliminary evidence exists for associations of the environmental features such as the availability of home exercise equipment, access to recreational facilities, and social support from friends and family with greater physical activity in youth.[1–5] However, little is known about how environmental characteristics impact the level and experience of physical activity taking place in those settings. Recent calls for research emphasize greater understanding of context-based physical activity.[2] This perspective is largely based upon *behavior setting theory*, which suggests that characteristics of the immediate situation can shape mood and behavior occurring in that setting.[6] Preliminary studies have shown that children are more motivated and engage in higher intensity activities when in the presence of others as compared with when they are alone,[7,8] and when outdoors as compared with inside homes.[9] Yet, little is known about children's physical activity behaviors and experiences across the full range of settings in which they take place throughout the day. This limitation may be partially addressed by real-time data capture methods such as Ecological Momentary Assessment (EMA), which can simultaneously measure where and with whom children's physical activity occurs, as well as how children feel in those contexts. This study used EMA with mobile phones to determine whether leisure-time physical activity levels and experiences differ across social and physical contexts among primarily low-to-middle income, ethnically-diverse children in Southern California.

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Methods

Participants

Participants included 121 fourth through eighth grade children (ages 9 to 13 years) living in Chino, CA or surrounding communities within 30 minutes driving time from Chino.

Ecological Momentary Assessment

Electronic Ecological Momentary Assessment (EMA) data were collected through a mobile phone (HTC Shadow, T-Mobile USA, Inc.) with a custom software program installed (http://myexperience.sourceforge.net). The mobile phone calling and internet capabilities were disabled. EMA data were collected during children's

leisure time across 4 days (Friday afternoon through Monday evening, excluding Monday during school hours). Survey prompts were programmed to occur at a random time within preestablished intervals to allow for adequate spacing across each day (see Table 1). Upon hearing the signal, children were instructed to stop their current activity and complete a short electronic question sequence using the device (requiring about 2 to 3 min). If a signal occurred during an incompatible activity (such as sleeping or bathing), participants were instructed to ignore it. If no entry was made, the phone emitted up to 3 reminder signals at 5-min intervals. Children were compensated $20 plus an additional $1 for each completed EMA entry over the 4 days (up to $40 total). EMA has been shown to be a feasible method of investigating physical activity in children and adolescents.[7,8,10–12]

Measures

EMA Items. EMA question sequences measured main activity type, social context, physical location, mood, and enjoyment (see Table 2). Only 1 response could be provided for each item. The questions were administered in English. Scores for happy and joyful (2 items) were averaged to create a composite scale for positive affect (PA) (Cronbach's α = .88); and scores for sad, mad/angry, stressed, nervous/anxious (4 items) were combined for a composite negative affect (NA) scale (Cronbach's α = .75). For the physical location item, "School," "Store/Mall," "Gym/Recreation center," and "Someplace else" were recoded as "Other" due to low frequencies of endorsement. "Car/Van/Truck" and "Restaurant" were also recoded as "Other" because they were considered unlikely settings for physical activity. If a child indicated that he/she was "Outdoors" and simultaneously responded "At home" to the distance from home question, his/her physical context was recoded as "front/backyard (at home)." Also, "Classmates" were recoded as "Friends." When children reported being with more than 1 type of companion (eg, friends and family), social context was coded as "Multiple Categories." To maintain participant interest and reduce burden, a random subset of the constructs/variables (eg, negative affect, physical location, social context) were assessed in each electronic survey, resulting in 40% planned missing EMA data. The one exception was the assessment of main activity type, which occurred during every electronic survey. All EMA items were thoroughly pilot tested in the target population for comprehension and applicability.

Physical Activity. The Actigraph, Inc. activity monitor (models 7164 and GT2M) provided an objective measure of physical activity (in steps and activity counts). The devices were worn on the right hip attached to an adjustable belt. The devices were not worn when sleeping, bathing, or swimming. A 30-sec epoch was used. All accelerometer recordings were time-stamped to be linked with EMA data. Outcome variables consisted of the (1) number of steps and (2) at least 5 minutes of moderate-to-vigorous physical activity (MVPA) minutes within the 30 minutes before each EMA electronic survey. MVPA was defined using age-specific thresholds generated from the Freedson prediction equation (≥4 Metabolic Equivalents; METs).[13] EMA entries with a total of 0 steps in the 30-minute interval before the survey prompt were considered accelerometer nonwear and excluded from analyses (n = 336 entries).

Height and Weight. Children's height and weight were measured in duplicate using an electronically calibrated digital scale and professional stadiometer. Discrepant values were averaged. Body Mass index (BMI) was calculated (kg/m^2), and each child's weight status was classified according to CDC age- and gender-specific BMI percentile cut-offs.

Demographics Characteristics. Participants' age, sex, and ethnicity were assessed through a child self-report survey. Parents reported annual household income.

Data Analyses

Data were analyzed with SUDAAN 10.0 (RTI International, Research Triangle Park, NC). EMA entries reporting "People you don't know" for current social context (n = 5) were not included in the analyses. Multiple linear and logistic regression analyses tested whether steps, NA, PA, and enjoyment (continuous dependent variables) and the likelihood of at least 5 minutes of MVPA (binary dependent variable) differed by type of social and physical environment (categorical independent variables). A Generalized Estimating Equations (GEE) regression approach was taken, which employed a robust variance estimation method (SEMETHOD = Zeger) to adjust the standard errors for the clustering of EMA observations within each child. The without replacement (WR) design statement was used, as it is the most appropriate setting for implementing GEE model-fitting techniques (see http://www.rti.org/sudaan/page.cfm/SUDAAN_Design_Options). Differences across social

Table 1 Ecological Momentary Assessment Electronic Survey Prompting Schedule

Day	8:30–10 AM	10 AM–12 PM	12–2 PM	2–4 PM	4–6 PM	6–8 PM	8–8:30 PM
Friday					X	X	X
Saturday	X	X	X	X	X	X	X
Sunday	X	X	X	X	X	X	X
Monday					X	X	X

Note. X = electronic survey prompt made. Electronic surveys were prompted at a random time within each interval.

Table 2 Ecological Momentary Assessment Electronic Survey Items

Variable	Item	Response choices
Main activity (1 item)	"What were you DOING just before the beep went off?"	Reading/Computer/Homework, Watching TV/Movies, Playing video games, Active Play/Sports/Exercising, Eating/Drinking, Talking/On the phone, Chores, Riding in a car, Something else
Physical location (1 item)	"WHERE were you just before the beep went off?"	Home (indoors), School, Car/Van/Truck, Outdoors, Restaurant, Store/Mall, Someone else's house, Gym/Rec. center, Someplace else
Distance from home (1 item)	"How FAR are you from your home right now?"	At home, A few blocks, More than a few blocks
Social company (7 items)	"Were you (ALONE, WITH YOUR MOM OR DAD, SISTER(S) OR BROTHER(S), OTHER FAMILY MEMBERS, FRIEND(S), CLASSMATES, PEOPLE YOU DON'T KNOW) just before the beep went off?"	Yes, No
Positive affect (2 items)	"How (HAPPY, JOYFUL) were you feeling just before the beep went off?"	Not at all, A little, Quite a bit, Extremely
Negative affect (4 items)	"How (STRESSED, MAD OR ANGRY, NERVOUS OR ANXIOUS, SAD) were you feeling just before the beep went off?"	Not at all, A little, Quite a bit, Extremely
Enjoyment (1 item)	"How much FUN is this activity"	Not at all, A little, Quite a bit, Extremely

and physical environments were examined in separate models. The interaction effects of age and gender with social and physical contexts were also tested. All of the models adjusted for sex, age, annual household income (quartiles), race/ethnicity, weight status, weekend day vs. weekday, and time of day [morning (8:30 AM–11:59 AM), afternoon (12:00 PM–5:59 PM), evening (6:00 PM–8:30 PM)]. Predicted marginal means and margins were calculated from the linear and logistic regressions, respectively. These predictions are standardized values that adjust for all of the other covariates in the model.[14] For the models testing differences in NA, PA, and enjoyment, only EMA entries reporting physical activity (ie, active play, sports, or exercise) as the main activity were included in the analyses.

Results

Descriptive Statistics

EMA data for 1 participant was irretrievable due to a missing memory card upon return of that child's mobile phone. No mobile phones were lost, and 1 display screen was damaged. Accelerometer data were unavailable for 8

children due to problems with initializing and downloading the devices. On average, children responded to 80.3% (range 7%–100%) of the electronic survey prompts that could be matched to accelerometer data. The percent of unanswered prompts per child was unrelated to gender, age, race/ethnicity, household income, weight status, time of day and day of the week. Overall, physical activity (ie, active play, sports, or exercise) was reported as the main activity in 17% (241 of 1465) of electronic surveys. Demographics for the sample are shown in Table 3.

Differences in Physical Activity Levels Across Contexts

Table 4 shows the number of steps and percentage of entries with at least 5 minutes of MVPA in the 30 minutes before each EMA survey by type of physical and social context. Total steps were significantly greater when children were outdoors and in their front/back yards than when at home (indoors), at someone else's house, or in other locations (all $P < .05$). In addition, a significantly greater percentage of entries occurring outdoors (23%) attained at least 5 minutes of MVPA as compared with at home (indoors; 5%), at someone else's house (9%), or in other locations (8%; all $P < .05$). Total steps were significantly greater when children were with multiple categories of company (eg, friends and family together) than with family members only ($P < .05$). Steps were also greater when with multiple categories of company or friends only than alone (all $P < .05$). The likelihood of attaining at least 5 minutes of MVPA in the 30 minutes before the survey did not differ by social context. The interactions of age and gender with social and physical contexts predicting steps and MVPA minutes were not significant.

Differences in Physical Activity Experiences Across Contexts

Mood during and enjoyment of physical activity differed across physical and social contexts (See Table 4). Children reported significantly lower mean ratings for positive affect and enjoyment when they were physically active at

Table 3 Demographic Characteristics (N = 120)

	n (%)
Sex	
Male	62 (51.7)
Female	58 (48.3)
Age	
9	12 (10.3)
10	30 (25.9)
11	30 (25.9)
12	32 (27.6)
13	12 (10.3)
Annual household income[a]	
Less than $45,000	30 (25.2)
$45,000–$79,999	34 (28.6)
$80,000–$99,999	27 (22.7)
$100,000 and above	28 (23.5)
Race/ethnicity[b]	
African-American	12 (10.1)
Asian	15 (12.6)
Hispanic/Latino	38 (31.9)
White/Caucasian	28 (23.5)
Biracial/mixed	19 (16.0)
Other	7 (5.9)
Weight status	
Underweight (BMI < 5%)	6 (5.0)
At risk for underweight (BMI = 5–14%)	6 (5.0)
Normal weight (BMI = 15- 84%)	61 (51.3)
At risk for overweight (BMI = 85–94%)	21 (17.6)
Overweight (BMI ≥ 95%)	25 (21.0)

[a] The parent of 1 child declined to report annual household income information.

[b] Race/ethnicity information was missing for 1 child.

Table 4 Differences in Physical Activity Levels and Experiences Across Contexts

	Total steps§	5+ Min. MVPA§	NA	PA	Enjoyment
	PMM (SE)	PM (SE)	PMM (SE)	PMM (SE)	PMM (SE)
Physical contexts	n = 870 (108 persons)	n = 860 (108 persons)	n = 90 (59 persons)	n = 87 (53 persons)	n = 93 (55 persons)
Outdoors (not at home)	462.79 (42.22)^{abc}	0.23 (0.04)^{abc}	0.34 (0.09)	2.22 (0.15)^{a}	2.44 (0.15)^{ab}
Front/backyard (at home)	448.58 (80.83)^{def}	0.16 (0.11)	0.42 (0.23)	2.36 (0.24)^{bc}	2.40 (0.41)^{c}
Someone else's house	274.88 (49.29)^{ad}	0.09 (0.04)^{a}	0.31 (0.13)	1.31 (0.23)^{ab}	0.86 (0.45)^{acd}
Home (indoors)	210.61 (12.50)^{beg}	0.05 (0.01)^{b}	0.26 (0.07)^{a}	1.81 (0.15)^{c}	1.80 (0.21)^{b}
Other	354.16 (25.94)^{cfg}	0.08 (0.02)^{c}	0.56 (0.16)^{a}	1.96 (0.32)	2.15 (0.27)^{d}
Social contexts	n = 836 (108 persons)	n = 831 (107 persons)	n = 104 (63 persons)	n = 96 (61 persons)	n = 105 (56 persons)
Multiple categories	357.53 (33.04)^{ab}	0.15 (0.03)	0.38 (0.08)	1.95 (0.20)	2.00 (0.16)
Friends only	280.93 (19.29)^{c}	0.15 (0.03)	0.17 (0.10)^{ab}	1.75 (0.23)	2.34 (0.22)
Family only	273.97 (43.52)^{a}	0.14 (0.05)	0.35 (0.10)^{a}	2.12 (0.20)	2.21 (0.22)
Alone	204.68 (22.58)^{bc}	0.12 (0.03)	0.53 (0.12)^{b}	1.34 (0.35)	2.06 (0.30)

§ Measured in the 30 minutes before the electronic survey prompt.

Abbreviations: MVPA, Moderate-to-Vigorous Physical Activity; PA, Positive Affect; NA, Negative Affect; EMA, Ecological Momentary Assessment; PMM, Predicted Marginal Mean; PM, Predicted Margin; SE, Standard Error.

Note. "Other" physical contexts included school, restaurant, store/mall, gym/recreation center, car/truck/van and someplace else (about 15% of EMA responses). "Multiple Categories" refers to when children reported being with more than 1 type of companion (eg, friends and family together). NA, PA, and Enjoyment were measured using a 4-point scale ranging from 0 = not and all to 3= extremely. Differences between values with common subscripts (eg, $_{abc}$) are statistically significant at $P < .05$. Variations in sample size are due to planned missing EMA data (ie, physical context, social context, NA, PA, and enjoyment were not assessed in a randomly programmed 40% of electronic surveys). All models are adjusted for day of the week, time of day, sex, age, race/ethnicity, household income, and weight status.

someone else's house as compared with activity occurring outdoors or in their front/backyards (all $P < .05$). Positive affect and enjoyment during physical activity was also significantly greater outdoors as compared with at home (indoors; $P < .05$). Mean ratings for negative affect were significantly greater when children engaged in physical activity alone and with family only than friends only (all $P < .05$). It was not possible to test interactions with age and gender because the small sample sizes within the subgroups created unstable statistical models.

Discussion

The current study used a novel research methodology to compare children's leisure-time physical activity levels and experiences across different social and physical contexts. For this sample of ethnically-diverse, primarily low-to-middle income youth, total steps were greater when outdoors or with other people than indoors or alone. Engaging in physical activity in outdoor settings was also more enjoyable than home-based activity. Furthermore, children reported more negative affect when engaging in solitary physical activity as compared with activity that occurred with friends. Consistent with past research,[15,16] these findings highlight the importance of outdoor and social settings for physical activity in children.

Results from this study support the viability of using EMA methodology in larger scale research projects that could form the basis for context-specific interventions in this age group. Interestingly, physical activity taking place outdoors (not at home) and in children's front/backyards did not differ in terms of total steps and MVPA. These findings suggest that while policy efforts to increase the availability of neighborhood playgrounds and sports fields may promote children's physical activity,[17,18] it may be equally effective to teach parents to encourage their children to spend time outdoors in their own yards (if front/backyard space is available). In addition, results suggest that promoting physical activity that occurs with family and friends together may result in greater overall energy expenditure than activity taking place only with family members. One caveat is that the EMA items in the current study did not measure whether both family members and friends were engaging in the same activity as the participants (as opposed to watching or supervising).

Despite its methodological strengths, this study had limitations. First, not all physical activity bouts were captured due to the signal-contingent sampling protocol used. In addition, almost 20% of survey prompts were unanswered, resulting in unplanned missing data. Other weaknesses are the relatively short monitoring period (4 days), which might not represent children's usual behavior and the lack of monitoring during school time. In addition, this study used a higher threshold (4 METs) for moderate-intensity physical activity, which could result in some undetected MVPA. Furthermore, the moderating effect of weight status was not examined. Lastly, this study focused on children's leisure time. Physical activity taking place to, from, and at school was not included.

Overall, results from this study suggest that encouraging children to spend more time outdoors with friends and family could result in more enjoyable, lengthy, and

intense physical activity experiences. Thus, methods of increasing the amount of children's leisure time spent outdoors need to be evaluated.

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