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Understanding the Physical and Social Contexts of Children's Non-School Sedentary Behavior: An Ecological Momentary Assessment Study

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Abstract

Background: Research on children's sedentary behavior has relied on recall-based self-report or accelerometer methods, which do not assess the context of such behavior.

Purpose: This study used Ecological Momentary Assessment (EMA) to determine where and with whom children's sedentary behavior occurs during their non-school time.

Methods: Children (N = 120) ages 9–13 years (51% male, 33% Hispanic) wore mobile phones that prompted surveys (20 total) for four days. Surveys measured current activity (e.g., exercise, watching TV), physical location (e.g., home, outdoors), and social company (e.g., family, friends).

Results: Children engaged in a greater percentage of leisure-oriented (e.g., watching TV) than productive (e.g., reading, doing homework) sedentary behavior (70% vs. 30%, respectively). Most of children's sedentary activity occurred at home (85%). Children's sedentary activity took place most often with family members (58%). Differences in physical context of sedentary behavior were found for older vs. younger children ($p < .05$). Type of sedentary behavior differed by gender, racial/ethnic group, and social context (p 's $< .05$).

Conclusion: Children may prefer or have greater opportunities to be sedentary in some contexts than others. Research demonstrates the potential for using EMA to capture real-time information about children's sedentary behavior during their non-school time.

Keywords

Pediatrics; environment; measurement

INTRODUCTION

Over the past 30 years, the introduction of cable television, video games and the Internet have enhanced the attractiveness of sedentary behaviors.¹ In fact, children spend more time using electronic media than any activity other than sleeping.² The American Academy of Pediatrics (AAP) recommended that children should limit their total electronic media time to no more than 1–2 hours a day.³ However, findings from the National Health and Nutrition Examination Survey indicate that about half of the children surveyed spent more than 2

hours in screen-related activities. Also, from 2001 to 2006, the time spent in front of TV/video and computers among U.S. children remained at a high rate.⁴ In addition, longitudinal studies have indicated that time spent in sedentary behavior increases from early to late adolescence, and boys spend more time in screen-related sedentary activities than girls.^{5,6}

Sedentary behavior is emerging as an important component of obesity and is recognized as an independent risk factor for chronic disease in adults and children.^{7–10} Sedentary behavior is not highly correlated with physical activity in children.^{11,12} Elevated likelihood of being overweight or obese was found in those who were sufficiently active but who had high levels of sedentary behavior.^{11,13} Therefore, it is useful to consider the risk factors and interventions for sedentary behavior separately from physical activity. Depending on the purpose, sedentary behaviors can be either productive or leisure-oriented. Productive sedentary behaviors are those that are done for an educational purpose such as increasing knowledge and awareness (e.g., reading, doing homework, researching on the Internet). Leisure-oriented sedentary behaviors are those lacking the gains noted for productive activity, and are mainly used for one's entertainment and enjoyment (e.g., watching TV, playing video games). Several studies^{14–16} have suggested a positive correlation between time spent in reading and healthier weight management behaviors (e.g., increased physical activity, greater consumption of fruits and vegetables, decreased fat intake) among children. On the other hand, leisure-oriented sedentary behaviors such as watching TV have been associated with greater risk of obesity-related health problems including type 2 diabetes, cardiovascular disease, and various metabolic risk factors.^{8,17} These associations have been found in a gradient dose-response manner, independent of physical activity.^{18,19}

Although a number of studies^{4, 20–22} have investigated patterns of sedentary behaviors among children, no studies have examined *where* and *with whom* children's sedentary behavior occurs. According to Behavior Setting Theory, physical and social situations in which behaviors take place can promote certain behaviors and discourage others.²³ Therefore, assessment of the physical and social settings of children's sedentary activities may be important in developing interventions to reduce such behaviors.

Previous studies of children's sedentary behavior patterns suffer from a number of limitations. Many studies only used TV watching as the indicator of sedentary behavior while children actually engage in a wide range of sedentary activities.²⁰ Moreover, most studies assessed children's sedentary behavior either through parental survey or children's self-reported recall, or by objective measurement such as accelerometer readings. Traditional survey measures may introduce memory errors and biases, especially *since* parents might not be fully aware of their children's sedentary activities throughout the day. Although accelerometers can more accurately record children's activity levels, researchers are not able to distinguish the different types of sedentary activity in which the child engages. Also, previous studies have not systematically examined where and with whom children's sedentary behaviors occur.

These limitations may be partially addressed by real-time data capture methods such as Ecological Momentary Assessment (EMA), which can measure the various types, locations and social context of children's sedentary behavior throughout the day.^{24,25} EMA is a novel

approach to collect self-reported responses to surveys during the course of everyday life in real-time. EMA utilizes electronic devices such as mobile phones to prompt surveys with an auditory signal that is programmed to occur at predetermined intervals throughout the day. Thus, current behavioral and psychosocial states of participants can be assessed.^{26,27}

This study used EMA with mobile phones among children to (1) describe the social and physical contexts of sedentary behavior taking place during non-school time; (2) determine whether the type of sedentary behavior (leisure-oriented versus productive) differs by physical and social contexts, (3) determine whether the physical and social contexts of sedentary behavior differ by children's demographic characteristics (gender, age, race/ethnicity, and household income) and weight category; (4) determine whether the type of sedentary behavior differs by children's demographic characteristics and weight category.

METHODS

Participants

A total of 121 children ages 9–13 years who lived in Chino, CA or surrounding communities (within 30 minutes driving time from Chino) were recruited for this study. These children were a subgroup of participants for a larger 4-year intervention trial (Healthy PLACES) investigating the effects of smart growth community design principles on the prevention of family obesity risk. Children were eligible to participate if they: a) were currently enrolled in the 4–8th grade, b) lived in Chino, CA or a surrounding community, c) lived in a household with an annual income less than \$165,000, and d) were able to complete questionnaires in English. Upper income households were excluded because the goal of the Healthy PLACES study was to focus on children from low- to middle-income families who have higher obesity risk. Children who met the eligibility criteria were scheduled for a data collection appointment at a local community site or their home. This study used data collected at the baseline. This research was reviewed and approved by the Institutional Review Board at the University of Southern California.

Equipment

This study used electronic EMA to measure current activity, physical location, and type of social company. EMA data were collected through an HTC Shadow mobile phone (T-Mobile USA, Inc.) with a custom software program (*MyExperience*) installed to prompt surveys.^{28,29} The mobile phone calling and Internet capabilities were disabled. Children received the mobile phone at the data collection appointment. Verbal and written instructions were provided to the child and parent(s) on how to use the device. Children completed a practice assessment in the presence of a research staff member and were given the opportunity to ask questions. Parents were taught how to use the device, so that they could assist the child if needed.

Children were instructed to wear the mobile phone on a belt for four days. Monitoring time started from Friday at 4 pm to Monday at 8:30 pm with 20 auditory prompts (3 random prompts during preprogrammed intervals on weekdays and 7 random prompts on weekends). No prompting occurred between 8 am and 4 pm on Monday during school hours. Children

were asked to stop their current activity and complete a short electronic survey using the mobile phone upon hearing the signal. The survey required about 2–3 minutes to finish. If a signal occurred during an incompatible activity (i.e., showering), children were instructed to ignore it. If a prompt was not answered, the mobile phone emitted up to three reminder signals at 5-minute intervals. After the third reminder signal, the electronic survey became inaccessible until the next preprogrammed interval. Survey responses were stored on the phone in an electronic file until downloaded by researchers. Children were compensated up to \$40 for participating in the study: \$20 plus an additional \$1 for each completed EMA survey entry (up to \$20 total) over the four days. EMA has been shown to be a feasible and valid method of investigating type of activity in children and adolescents.^{24,30} All data were collected during the spring (April to early July) and fall months (September and October).

Measures

EMA items.—The EMA questions assessed children’s current main activity type and the corresponding physical and social contexts during non-school hours. The response choices were designed to reflect the activities, locations, and types of social company that are most likely to occur during children’s non-school time. All questions were in English. During each EMA prompting sequence, children were asked, “What were you DOING right before the beep went off (Choose your main activity)?” and selected one of the following response options (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). Then children were asked, “WHERE were you just before the beep went off?” with the following response options (Home, School, Car/Van/Truck, Outdoors, Restaurant, Store/Mall, Someone else’s house, Gym/Rec Center, Somewhere else). Children were also asked to answer either “yes” or “no” to indicate whether they were alone right before the beep went off. If they reported that they were not alone, they received a series of follow-up questions requiring “yes” or “no” responses to indicate whether they were with their mom or dad, brother(s) or sister(s), other family members (cousins, aunts, uncles), friend(s), classmates, or people they don’t know. To reduce participant burden, each item appeared in a randomly programmed 12 out of the 20 question sequences (60% of sequences), with the exception of current activity type, which occurred during every sequence. All EMA items were thoroughly pilot tested in the target population for comprehension and applicability.²⁴

Body Composition.—Children’s height and weight were measured in duplicate using an electronically calibrated digital scale (Tanita WB-110A) and a professional stadiometer (PE-AIM-101) to the nearest 0.1 kg and 0.1 cm, respectively. Body Mass Index (BMI) was calculated (kg/m^2). Children were classified as underweight (less than 5th percentile), normal weight (5th–84th percentile), overweight (85–94th percentile), or obese (95th percentile or greater) according to the age- and gender-specific BMI percentile cut-offs.³¹

Demographic Characteristics.—Children’s age, sex, and ethnicity were assessed through a self-report survey at the data collection appointment. Parents reported annual household income.

Data Analyses

Only EMA entries reporting sedentary behavior were included in the analyses. Sedentary behavior was coded as either (1) *Productive* (Reading/Computer/Homework), or (2) *Leisure-oriented* (Watching TV/Movies or Playing video games). Of the 9 possible choices for physical context, only Home and Someone else's house had a measurable rate of reported sedentary behaviors. The other remaining physical context categories were reported less than 3% of the time. Therefore, physical context was recoded as either (1) *Home*, (2) *Someone else's house*, or (3) *Other Location* (including School, Store/Mall, Car/Van/Truck, Gym/Rec Center, Outdoors, and Someplace else). The social context of physical activity was categorized as either (1) *Alone*, (2) *Family Only* (e.g., parents and/or siblings), (3) *Friends Only* (friends and/or classmates), or (4) *Family and Friends*. There were no EMA entries that reported engaging in sedentary behavior with strangers only. Annual household income data was divided into quartiles (less than \$45,000; \$45,000-\$79,999; \$80,000-\$99,999; and \$100,000 and above).

Data were analyzed with SUDAAN 10.0 (RTI International, Research Triangle Park, NC). The without replacement (WR) design statement was used, as it is the most appropriate for implementing generalized estimation equation (GEE) model-fitting techniques on clustered data.³² Modeling used a robust variance estimation method (SEMETHOD=Zeger) to adjust for the clustering of EMA observations within each child. The unit of analysis was the EMA entry rather than the individual.

Multinomial logistic regression was used to test whether demographic factors (i.e., sex, age, annual household income, race/ethnicity, weight category) predicted the likelihood of sedentary behavior occurring in each physical and social environment. Logistic regression was used to test whether demographic factors and physical and social environments predicted the likelihood of sedentary behavior type. Adjusted Wald F statistics and associated p-values were used to determine the statistical significance of each factor in the regression analyses. In order to describe demographic differences, predicted marginal probabilities (i.e., standardized proportions adjusting for all of the other model covariates) were calculated using the multinomial logistic regressions.³³

RESULTS

Descriptive Statistics

No mobile phones were lost or severely damaged. However, a memory card was missing for one mobile phone when returned. Therefore, data for that one participant was irretrievable. On average, children answered 77% (range 5% – 100%) of prompted surveys. The percent of unanswered survey prompts per child was not related to gender, age, race/ethnicity, family annual household income, or weight category. About 8% of surveys were unprompted due to technical problems (e.g., software crash, phone battery drain).

Overall, sedentary behavior was reported as the main activity in 39% (682 of 1,746) of EMA responses. The other reported activities were active play/exercising (16%, n = 287), riding in a car (8%, n = 137), eating/drinking (8%, n = 134), chores (2%, n = 43), talking/on the phone (2%, n = 33), or something else (25%, n = 430). Forty-five percent (232 of 517) of

the answered weekday prompts reported activities were sedentary, and 37% (438 of 1,200) of the answered weekend day prompts reported activities were sedentary. On weekend days, 36% (122 of 337) of the reported activities in the morning (8 am – 12 pm) were sedentary; as were 36% (185 of 517) of the reported activities in the afternoon (12 pm – 6 pm) and 38% (131 of 346) of the reported activities in the evening (6 pm – 8:30 pm). Demographic characteristics of children are shown in Table 1. The rate of sedentary behavior did not significantly differ by children's gender, race/ethnicity, or family annual household income. Of the 682 EMA observations reporting sedentary behavior, 413 asked about where they were, and 384 asked about whom they were with. The most commonly reported physical context was at home (85%, $n = 349$), followed by at someone else's house (8%, $n = 33$), and at another location (7%, $n = 31$). The largest proportion of children's sedentary behavior occurred with family members (58%, $n = 224$), followed by alone (26%, $n = 98$), with friends and family (9%, $n = 36$), and with friends only (7%, $n = 26$).

Differences in Sedentary Behavior Type by Social and Physical Contexts

As shown in Figure 1, type of sedentary behavior varied by social context after controlling for demographic characteristics and weekend/weekday (adj. Wald $F = 3.74$, $df = 3$, $p = .01$). When with friends, children were six times as likely to engage in leisure-oriented (pred. marginal prob. = .86, $SE = .078$) than productive sedentary behaviors (pred. marginal prob. = .14, $SE = .078$). When alone, children were equally likely to engage in leisure-oriented (pred. marginal prob. = .53, $SE = .061$) and productive sedentary behaviors (pred. marginal prob. = .47, $SE = .061$). The type of sedentary behavior did not differ by physical context.

Differences in Physical and Social Contexts of Sedentary Behavior by Demographic Characteristics

Results showed that physical locations of children's sedentary behavior varied by age (adj. Wald $F = 3.65$, $df = 2$, $p = .03$; see Figure 2). Children ages 12–13 years were twice as likely to engage in sedentary behavior at someone else's house than 9–11 year olds (pred. marginal prob. = .11, $SE = .034$ vs. pred. marginal prob. = .05, $SE = .015$, respectively). There was no significant difference in the physical context of children's sedentary behavior between boys and girls, or among different race/ethnicity groups, household income groups, or weight category. The social context of children's sedentary behavior did not differ by demographic characteristics.

Differences in Sedentary Behavior Type by Demographic Characteristics

Univariate analysis showed that weekend/weekday was associated with type of sedentary behavior in which children engaged (adj. Wald $F = 14.78$, $df = 1$, $p < .001$). Children were more likely to engage in leisure-oriented sedentary behavior on weekend days (pred. marginal prob. = .42, $SE = .037$) than on weekdays (pred. marginal prob. = .27, $SE = .030$). Therefore, weekend/weekday was added in the model as a covariate to control for its confounding effects. Gender differences were found in the type of sedentary behavior in which children engaged (adj. Wald $F = 12.20$, $df = 1$, $p < .001$). Boys were three times as likely to engage in leisure-oriented (pred. marginal prob. = .77, $SE = .031$) than productive sedentary behaviors (pred. marginal prob. = .23, $SE = .031$), whereas girls were equally likely to engage in leisure-oriented (pred. marginal prob. = .58, $SE = .042$) and

productive sedentary behaviors (pred. marginal prob. = .42, SE = .042). Figure 3 shows that type of sedentary behaviors varied by race/ethnicity (adj. Wald $F = 3.62$, $df = 2$, $p = .03$). Children of other race/ethnicity were more likely to engage in productive sedentary behavior compared to Hispanic children (pred. marginal prob. = .38, SE = .040 vs. pred. marginal prob. = .24, SE = .036, respectively). No significant differences in sedentary behavior type were found in children's age, weight category or household income.

DISCUSSION

The current study examined where and with whom children engage in sedentary behaviors during their non-school time. It is one of the first studies to use EMA with mobile phones to describe sedentary behavior contexts in children aged 9–13 years, which is considered to be a high risk age group for obesity.³⁴ Home and family members were found to be the most common physical and social context when children engaged in sedentary activity in their non-school time. This study found that the physical context of children's sedentary behavior differed by age, but not by gender, race/ethnicity, household income, or weight category. The social context of children's sedentary behavior did not differ among demographic sub-groups. Results from this study also suggest that the types of sedentary activity in which children engage may differ by gender and racial/ethnic groups, as well as the social context.

As shown from the current study, the majority of children's sedentary behaviors occurred at home. However, our results show that older children (ages 12–13) were more likely to engage in sedentary behavior at someone else's house while younger children (ages 9–11) were more likely to engage in sedentary behavior in other places, such as the public library. This finding suggests that although home is the common place for children's sedentary behavior, children of different age groups may have a different "second place" for sedentary behavior. Therefore, in addition to targeting the home as a physical setting for children's sedentary behavior, interventions might need to emphasize other settings based on a child's age. Future studies could further explore what types of "other places" younger children are likely to engage in sedentary behavior.

More than half of children's sedentary behavior took place with family members (e.g., parents, siblings, cousins, uncles/aunts). Furthermore, when engaging in sedentary activity with family members, children were twice as likely to do leisure-oriented than productive sedentary activity. This finding shows the opportunity for interventions to target sedentary behavior reduction for the whole family. For instance, interventions could encourage families to take a walk after dinner around the neighborhood instead of sitting and watching TV together. On the other hand, while only 7% of the overall reported sedentary behaviors were with friends, children were six times as likely to engage in leisure-oriented than productive sedentary behavior when with friends. Interventions could provide examples or opportunities of non-sedentary activities for children when they socialize with their peers (e.g., exergames, dancing, frisbee). Interventions could also suggest replacing leisure-oriented sedentary activities with productive sedentary activities with friends such as study groups and reading clubs.

Our results also show that boys were more likely to engage in leisure-oriented sedentary behavior than girls, which is consistent with previous studies showing that boys spent more time in screen-related activities than girls.^{6,35,36} In general, children of all racial/ethnic groups were more likely to engage in leisure-oriented than productive sedentary behavior. However, children of other racial/ethnic groups (i.e., African American, Asian, biracial, and others) engaged in more productive than leisure-oriented sedentary behavior during non-school time as compared with Hispanic children. Due to our small sample size, we could not further explore the racial/ethnic differences in type of sedentary behavior for African American, Asian, biracial, and others. However, previous studies have found that Asian families are more likely to promote studying, and Asian children spend significantly more time in educational activities.^{37,38}

Despite the advantages of using EMA methodology, this study had a few limitations. Given the sample size of this study, results obtained from the demographic sub-groups may not be representative. However, the demographics of our study sample are quite comparable to the study area, with the exception of the underrepresentation of Hispanic children. Also, since the number of answered prompts varied among children (compliance rate ranged from 5% to 100%, with an average of 77%), some children may be under-represented due to their low response rate. However, our models have controlled for response rate imbalance by adjusting for the clustering of EMA responses within each child using GEE model-fitting technique. Only three surveys were prompted on weekdays and seven surveys were prompted on weekends. The limited number of surveys may not fully capture children's sedentary behavior patterns throughout the day. However, the pre-programmed intervals that we used in this study allowed sampling across a wide range of naturally occurring activities and situations during non-school time for children. We chose not to use event-contingent sampling methods (prompting a survey if no activity moment was detected by accelerometer for a certain period) because the goal of this study was to capture children's everyday behavior as it occurs. Event-contingent prompts may cause children to modify their naturalistic behaviors. One limitation is that weekend days might be overrepresented since there were a total of 14 EMA surveys prompted during weekend days and only 6 EMA surveys prompted during weekdays. However, the purpose of this study is to capture children's sedentary behavior during their non-school time, which is mainly weekend hours and weekday afternoons and evenings. Another concern is that children may misreport their behaviors. Children may report to engage in physical activity when they were actually watching TV or playing video games. However, a separate analysis on the same sample showed high correspondences between children's reported activity type and the activity counts from the accelerometer.²⁴ Without an open-ended answer option, it is difficult to know the type of activity and context when children chose "other" (about 25% of the all the reported activities). However, in order to limit the length of each EMA survey to less than 2–3 minutes and to keep the operation of answering surveys easy for children of this age group, it is necessary to only provide a set number of choices to each survey question. One limitation of the pre-set EMA response choices was that they combined computer use with reading and doing homework into one option, "Reading/Computer/Homework", to the question asking about current activity. Since children may spend time using the computer to engage in non-productive activities (e.g., online chatting,

computer games), future studies examining children's sedentary behavior should distinguish between productive vs. leisure-oriented computer use. The EMA questions used in this study were not originally designed to specifically measure children's sedentary behaviors. The purpose of the EMA survey was to capture children's usual activities during their non-school time. Therefore, the response categories for the survey questions were somewhat broad for understanding sedentary activities. Future studies that are interested in using EMA method to measure children's sedentary behaviors could develop more tailored questions towards this particular activity. Lastly, one should interpret the results with caution since the productive and leisure-oriented sedentary behaviors that children engage in are not mutually exclusive. Children may watch educational TV programs such as news and scientific videos, or read comic books that have no educational value.

Overall, this study demonstrates the potential for using EMA to capture real-time information about children's sedentary behaviors during their non-school time. Future research could use EMA methodology with more sedentary-specific questions and a larger sample size to better understand patterns and contexts of sedentary behaviors.

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Figure 1.
Type of sedentary behavior by social context

Figure 2.
Physical context of sedentary behavior by age

Figure 3.
Type of sedentary behavior by race/ethnicity

Table 1.

Demographic characteristics (N = 120)

	<i>n</i> (%)
Sex	
Male	62 (51.7)
Female	58 (48.3)
Age	
9	13 (10.8)
10	30 (25.0)
11	32 (26.7)
12	32 (26.7)
13	13 (10.8)
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	
Hispanic/Latino	38 (31.9)
White/Caucasian	28 (23.5)
Other ^c	53 (44.5)
Weight Category	
Underweight/Normal weight (BMI < 85%)	74 (61.7)
Overweight (BMI = 85–94%)	21 (17.5)
Obese (BMI ≥ 95%)	25 (20.8)

^a The parent of one child declined to report annual household income information.

^b Race/ethnicity information was missing for one child.

^c Other includes African American, Asian, mixed/bi-racial, and other racial/ethnic groups.