Journal of Healthy Eating and Active Living
2020, Vol. 1, No. 1, pages 27-40

Peer Reviewed Research

Electronic Devices as Correlates of Sedentary Behavior and Screen Time Among Diverse Low-Income Adolescents During the School Year and Summer Time

James F. Sallis, Terry L. Conway, Kelli L. Cain, Carrie Geremia, Edith Bonilla, Chad Spoon

University of California San Diego, USA

Abstract
Excessive screen time among adolescents increases risk for overweight and obesity. Having electronic devices in the adolescent's bedroom is associated with more screen time. The present study expanded on previous studies by also examining portable personal electronic devices and social media membership as correlates of screen time use and total sedentary time in the school year and summer among diverse low-income adolescents. Adolescents aged 10-17 years were recruited from lower-income areas; *n*=150 (34 African Americans, 23 American Indians, 16 Asian/Pacific Islanders, 39 Latinos, and 38 White/non-Hispanics) completed surveys and wore accelerometers in both the school year and summer. Total sedentary time was computed from accelerometers. Recreational screen time was assessed with a 3-item validated scale. Adolescents reported the presence of 6 electronic devices in their bedrooms, ownership of 4 portable devices, and social media membership. General linear modeling was conducted for both time periods, with demographic covariates and interactions with sex and race/ethnicity. More electronic devices in bedrooms were related to more screen time during the school year and summer, and to more total sedentary time in summer. Personal electronics were related only to more screen time in the school year. Social media membership was related to more total sedentary time in summer, but only among African Americans, American Indians, and non-Hispanic Whites. Electronic devices in bedrooms was confirmed as a risk factor for sedentary behavior among low-income adolescents of color. Social media membership and use should be further studied with diverse adolescents.

Keywords*: health disparities, social media, home environment, sitting*

Sitting is a highly prevalent behavior among youth worldwide. In a longitudinal study in the United Kingdom that used accelerometers, children aged 7 years spent about half of their waking time sedentary, but by age 15, they were sedentary three-quarters of waking time (Janssen et al., 2016). While much sitting occurs at school, the other main source of sitting involves use of electronic screens. Television viewing is the most commonly studied source of screen time, but a proliferation of screen options has occurred in recent years, including computers, video game consoles, mobile phones, and tablets. Personal electronic environments continue to become more complex, and options for using devices include live TV, recorded shows, livestreaming, internet browsing, social media, and solitary or networked games.

In 2009, youth in the United States reported about 7 hours of total daily screen time, with 4.5 hours of television, 1.5 hours of recreational computer use, and 1.2 hours of gaming (Rideout, Foehr, & Roberts, 2010). A 2018 report estimated U.S. adolescents spent about 6 hours and 40 minutes daily using media of all types (Rideout, 2015). The large portion of time spent with screens occurs in the context that about 80% of adolescents in 146 countries failed to meet the 60 minute per day physical activity guideline (Guthold et al., 2020).

Although screen time is undoubtedly a major contributor to overall sedentary time, there are substantial differences regarding apparent health outcomes of each. In cross-sectional and longitudinal studies there was little evidence objectively measured total sedentary time was related to overweight or obesity or other cardiometabolic risk factors (Barnett et al., 2018; Biddle et al., 2017; Cliff et al., 2014; Cliff et al., 2016; Mitchell & Byun, 2014). By contrast, there is a large amount of literature linking reported screen time, especially television time, with overweight and obesity (Barnett et al., 2018; Biddle et al., 2017; Carson et al., 2016; Coombs & Stamatakis, 2015; Crespo et al., 2001; Tremblay et al., 2011), even adjusting for physical activity (Bai et al., 2016) and diet (Crespo et al., 2001; Fletcher et al., 2015). Early studies linking television viewing to youth obesity risk led to recommendations for school-age youth to limit television time to two hours per day (American Academy of Pediatrics, 2001).

Disparities in accelerometer-measured sedentary time of youth were examined in a representative United States sample (Whitt-Glover et al., 2009). Expected differences in sedentary time by race/ethnicity and socioeconomic status (SES) were not found, and sex differences were small and varied by race/ethnic group. The dominant trend was age

differences, with about two hours more total sedentary time among high school age youth compared with elementary age youth. A recent review found few patterns of disparities in screen time by race/ethnicity, sex, and SES that were consistent across outcome variables (e.g., TV, gaming, total) (Barnett et al., 2018).

Understanding individual, social, environmental, and policy correlates of behavior in observational studies can be useful, because such results generate hypotheses that can be evaluated in intervention trials. Compared to a large literature on correlates of physical activity (Bauman et al, 2012), evidence about correlates of sedentary behavior and screen time among youth is limited (Barnett et al., 2018). Psychological variables have not been widely studied, and neighborhood physical activity environment attributes have rarely been related to screen time or sedentary behaviors in youth (Barnett et al., 2018). There is emerging evidence that parent rules about screen time and physical activity are related to various indicators of sedentarism (Barnett et al., 2018). The strongest evidence is number of televisions, computers, and game consoles in the home (Hoyos, Cillero, & Jago, 2010; Pate et al., 2011; Veldhuis et al., 2014), but having these devices in the bedroom, especially, is related to more screen time (Atkin, Corder, & van Sluijs, 2013; Borghese et al., 2015; Delmas et al., 2007; Gingold, Simon, & Schoendorf, 2014; Ramirez et al., 2011; Roberts et al., 2017; Salmon et al., 2011; Tandon et al., 2014; Veldhuis et al., 2014), video game play (Ramirez et al., 2011), and accelerometry-assessed sedentary time among youth (Atkin, Corder, & van Sluijs, 2013; Barnett et al., 2018).

Social media accounts are now an important part of personal electronic environments. An international survey studying 20 social media platforms reported 16–24-year-old members had the most social media use, at about three hours per day, and usage increased from 2012 to 2018 in all 31 countries with data (Bayindir & Kavanagh, 2018). Despite the central role of social media in the lives of many young people, a 2015 review of correlates of youth sedentary behaviors listed no studies that examined social media (Stierlin et al., 2015). A subsequent study of British 10–15-year-olds found social media use was associated with higher sedentary time in both sexes (Sandercock et al., 2016).

The present study addressed several gaps in the literature on correlates of screen time and sedentary behavior, specifically among low-income youth, and explored race/ethnic variation in the associations. Because of the rapid evolution of electronic devices and the ways adolescents interact with them, the present study examined less-studied but widely used hypothesized correlates of having personal mobile electronics and social media accounts, in addition to electronic devices in the bedroom. Variations in correlates of sedentary behaviors were examined among a wider diversity of racial/ethnic subgroups than has been reported previously. A previous report from the present study found consistently higher screen time during the summer than the school year, so analyses reported here were conducted for both the school year and summer (Sallis et al., 2019).

Methods

Study Design

Adolescents 10–17 years old were recruited from lower-income geographic areas, defined as less than median of 2010 census-based household income, and they self-identified as belonging to one of five racial/ethnic groups: African American, American Indian, Asian/Pacific Islander, Latino, and White/non-Hispanic. The study had a repeated measures design, and adolescents were measured once during the school year 2017–2018 and once during summer break 2018. The Institutional Review Board at University of California San Diego approved this study.

Study Procedures

Recruitment

Procedures were developed to recruit adolescents with highly diverse demographics living in low-income neighborhoods in parts of California, Hawaii, Maryland, Mississippi, and New Mexico. Low-income neighborhoods were defined as census block groups below the county median household income in urban and suburban areas or below the state median household income in rural areas, using 2010 census data. Census data were used to identify neighborhoods with a high proportion of residents representing a specific race/ethnic group, so recruitment efforts could be tailored to reach adolescents in targeted subgroups.

Several recruitment approaches were implemented. First, lists purchased from a commercial marketing company were used to identify households containing adolescents within the target age range. Potential participants were randomly selected from the resulting list and contacted by both phone and mail. Although this approach was used effectively in previous studies of adolescents (e.g., Sallis et al., 2018), it had limited success in the current study because the lists misidentified households with adolescents. Recruitment methods were expanded to establish contacts for distributing study fliers through community organizations, schools, and public internet sites (e.g., Craigslist) that served multiple racial/ethnic communities within the targeted low-income/high-ethnic population areas. See Botchwey et al. (2020) for more information on recruitment methods, challenges, and results with diverse youth.

When potential participants were reached by phone, recruiters first explained the study to a parent or guardian, followed by the adolescent. Criteria for participation included age range, targeted race/ethnic group, and no health condition that would affect their physical activity or ability to complete a survey. Parents or guardians and adolescents who agreed were mailed consent and assent forms to sign and return.

Response rates were challenging to estimate because various recruitment approaches were used, and details were reported previously (Sallis et al., 2019). In summary, of the

757 eligible households contacted, all verbally consented to participate. Of those, the participation rate was 41%, with 310 actually providing some data (survey or accelerometer) at one or both time points (school year and summer time). However, only 207 of the 310 completed surveys at both time points (i.e., loss-to-follow up rate = 33%), and 150 of the 207 also provided accelerometer data at both time points.

Data Collection

Participating adolescents were asked to complete a survey (either a mailed paper version or online version) and wear an accelerometer (mailed with instructions) once during the school year and once during summer break. Adolescents who completed measures at both time points received a $30 gift card incentive.

Participants

The 150 participants with both sets of measures were selected as the analysis sample so school year and summer results for both survey and accelerometer data represented the same individuals. As shown in Table 1, the analysis sample included 73 boys and 77 girls with an overall average age of 13.9 years. There were 34 African Americans (56% girls), 23 American Indians (48% girls), 16 Asian/Pacific Islanders (50% girls), 39 Latinos (56% girls), and 38 White/non-Hispanics (45% girls). Overall, 53% of the adolescents lived in households with one or more members having a college degree (subgroups ranged from 36% among Latinos to 76% among White/non-Hispanics). A majority of the parents or guardians were married or living with a partner (71% overall, ranging from 50% to 87% across subgroups). For the overall sample, the median BMI percentile (CDC age- and sex-adjusted calculations) was 75.6, ranging from 65.3 for Asian/Pacific Islanders to 88.0 for American Indians. Overall, the average number of valid accelerometer wearing days was eight days during the school year and seven days during the summer. Average daily accelerometer wearing time was 803 and 773 minutes per day (13.4 and 12.9 hours per day) during the school year and summer, respectively.

Table 1. Demographics of Participants (N=150) Who Completed Surveys and Wore Accelerometers During Both School Year and Summer by Race/Ethnic Groups

Variable		African American	American Indian	Asian/Pacific Islander	Latino	White, non-Hisp	Total
Number of participants:		34	23	16	39	38	150
Age [a] in years:							
	Mean	13.9	13.7	15.1	13.6	13.7	13.9
	SD	2.0	1.0	1.8	1.9	1.9	1.8
	Range	10–17	12–15	12–17	10–17	11–17	10–17
Sex [a]: counts							
	Boys	15	12	8	17	21	73
	Girls	19 (56%)	11 (48%)	8 (50%)	22 (56%)	17 (45%)	77 (51%)
Highest Household Education [b]: counts							
Less than high school degree		3	4	4	7	0	18
High school completed		7	3	0	8	3	21

Some college	5	7	4	10	6	32
College degree or higher	19	9	8	14	29	79
Percentage with college degree or higher	55.9%	39.1%	50.0%	35.9%	76.3%	52.7%
Parents' marital status [c]: counts						
Married or living with partner	17 (50%)	14 (60.9%)	11 (68.8%)	34 (87.2%)	30 (78.9%)	106 (70.7%)
Divorced or separated	9	4	4	5	8	30
Single/never married/widow	8	5	1	0	0	14
Adolescents' BMI Percentile [a] (CDC):						
Mean	74.1	73.8	61.4	62.1	62.7	66.7
SD	25.3	31.6	25.4	33.9	32.7	30.8
Median	79.6	88.0	65.3	66.4	71.2	75.6
Accelerometer [d]:						
School year:						
Average wearing days per person	8	6	8	8	8	8
Average daily wearing time (min/day)	796	781	818	809	809	803
Summer time:						
Average wearing days per person	7	5	6	8	7	7
Average daily wearing time (min/day)	776	758	770	773	781	773

[a] No significant ($p > .05$) differences across race/ethnic groups.
[b] Significant ($p < .05$) differences across race/ethnic groups with fewer Latinos and more White, non-Hispanics living in households with a college graduate.
[c] Significant ($p < .05$) differences across race/ethnic groups with fewer African Americans and more Latinos living in households with parents that were married/living with a partner.
[d] American Indian participants had significantly ($p < .05$) fewer valid wearing days on average than all other race/ethnic groups during the school year and all group except Asian/Pacific Islanders during summer. No significant ($p > .05$) differences in average daily wearing time across race/ethnic groups at either time period.

Study Measures

Screen Time Assessed by Self-Report

Three items from the Sedentary Behavior Questionnaire (SBQ) were used to measure recreational screen time. The items prompted adolescents to report minutes per day spent on a typical weekday and weekend day in three screen-time behaviors: computer/internet use for leisure; playing computer/video games; and watching TV/videos. Weighted sums of weekday plus weekend days were computed to yield minutes per week for each behavior, and the final score was the sum of three items. A longer version of the SBQ had good test-retest reliability (*ICC*=0.67), and construct validity was supported by correlations with body mass index among adolescents (Rosenberg et al., 2010).

Sedentary Time Assessed by Accelerometers

Participants were instructed to wear ActiGraph accelerometers (models GT3X+ or GT3X-BT; Pensacola, Florida) on a belt around the waist during all waking hours (except when bathing or swimming) for 7–10 days, as well as complete a wear-diary. When accelerometers were returned, data were downloaded and aggregated to 30-second epochs using the Low Frequency Extension (Cain, Sallis, et al., 2013) and screened for valid data and device malfunction. A valid wearing day was defined as having at least 10 hours of wearing time, with nonwear time defined as 60 or more minutes of consecutive '0' counts (Cain et al., 2017). Sedentary time was scored with the commonly used cut point of ≤100 counts per minute (Evenson et al., 2008; Cain, Conway, et al., 2013) using MeterPlus version 5.0. The sedentary time variables used in analyses were "average minutes per day," calculated by averaging minutes per day of sedentary time across all valid wearing days for each participant. For both the school year and summer wearing periods, measures of average daily sedentary time (minutes per day with <100 counts) as well as average valid wearing minutes per day were computed across all valid days during each period.

Four days of accelerometer monitoring are generally considered a good estimate of habitual physical activity for a given season (Trost et al., 2000). In the current sample of adolescents with accelerometer data at both time points, 90% of participants during the school year and 80% during summer had four or more valid wearing days. However, to maximize the sample size available for statistical analyses, only one or more valid days of accelerometer wearing was required.

Electronic Devices and Social Media Accounts

Three dimensions of electronic environments were assessed. A measure of electronic devices in the adolescent's bedroom (Rosenberg et al., 2010) was updated to enquire about the presence (yes/no) of six electronic devices or resources: television, DVD player, music player (radio, CD player, stereo), computer, video game system (non-handheld—PlayStation, Xbox, etc.), and internet access. The sum of "yes" responses (0–6) was analyzed. The earlier 8-item scale had test-retest reliability of *ICC*=0.88 for adolescents, and construct validity was supported by positive associations with sedentary behavior and body mass index (Rosenberg et al., 2010).

A survey of portable electronic devices (Rosenberg et al., 2010) was updated to reflect current devices. Adolescents indicated which of four types of devices were available "for your own use" (yes/no): cell phone, handheld video game player (Game Boy, Sony PSP), personal stereo (iPod, MP3 player), and laptop/tablet/iPad. The sum of "yes" responses (0–4) was analyzed. The earlier portable electronics scale had a test-retest reliability of *ICC*=0.60 among adolescents, and construct validity was supported by a positive association with sedentary behavior (Rosenberg et al., 2010). An additional single item assessed (yes/no) whether participants had their own social media account (e.g., Facebook, Instagram).

Statistical Analyses

Analyses were conducted using SPSS Version 26. Descriptive analyses examined distributional characteristics of all measures and ensured there were no improbable outliers. To address the paper's primary aim examining sedentary behavior (self-reported screen time and accelerometer-measured sedentary time) in relation to personal electronic environments (i.e., sum of electronic devices in the bedroom, sum of personal portable electronics, and having a social media account), the SPSS General Linear Model (GLM)-Univariate procedure was used. Because this study was designed to assess differences among race/ethnic groups, targeted two-way interactions between the three measures of personal electronic environments with race/ethnic groups and sex were also tested in the GLM models. All models were run separately for school year and summer data. All models adjusted for age as a covariate, and models testing accelerometer outcomes also adjusted for average daily wearing time (min/day) as a covariate. In testing interactions with race/ethnicity and sex, all two-way interactions were initially included in the model, then eliminated one at a time (least significant first) until only significant ($p < .05$) interactions remained (if any). Significant interaction effects were graphed to show the patterns of association.

Results

Participants' reports of number of electronic devices in the bedroom, number of portable personal electronics, and having social media accounts were generally consistent across school-year and summer surveys. Median values were 3 (of 6) electronic devices in bedrooms and 2 (of 4) portable personal electronics; 75% had their own social media account(s).

Screen Time During School Year and Summer

Results from the GLM models explaining self-reported screen time are summarized in Table 2. During the school year, minutes per week of screen time was significantly positively associated with having more electronic devices in one's bedroom ($p = .011$) and having more personal electronics ($p = .020$). Self-reported screen time during the summer also was significantly positively associated with having more electronic devices in one's bedroom ($p = .007$), but not with more personal electronics.

Adolescents who said they did *not* have their own social media account reported significantly (p = .006) *more* screen time during the summer (1,322 more minutes per week) than did those who reported having their own social media account. A similar trend (p = .063) was seen during the school year with 674.9 *more* minutes per week of screen time reported by those who did *not* have their own social media account.

There was a significant (p = .003) race/ethnicity main effect in reported screen time during the summer, but not the school year. African American adolescents reported more screen time during summer than did American Indians, Latinos, and White/non-Hispanics (post hoc comparisons significant at $p < .05$). There were no sex differences in reported screen time in either time period.

There were no significant interactions of electronic environment variables with sex or race/ethnicity in relation to screen time either in the school year or summer.

Table 2. Screen Time During the School Year and Summer in Relation to Three Scales Indicating Personal Electronic Environments for Sedentary Behavior, by Sex and Race/Ethnicity

Dependent Variable	**School Year – Screen Time [a] (total min per week)** Overall Adjusted Mean = 2874.4 (SE=170.5)						**Summer – Screen Time [a] (total min per week)** Overall Adjusted Mean = 3859.7 (SE=233.9)					
Predictors	B est.	SE of B	Adj. Mean	SE of Mean	*F*	*p*	B estimate	(SE of B)	Adj. Mean	(SE of Mean)	*F*	*p*
Intercept	2467.7	333.2	--	--	281	<0.01	2271.5	468.8	--	--	273.8	<0.001
Electronic devices in bedroom (sum)	241.6	93.4	--	--	6.7	**0.011**	347.2	127.5	--	--	7.4	**0.007**
Personal electronics (sum)	375.3	159.5	--	--	5.5	**0.020**	-97.2	212.1	--	--	0.2	0.647
Have own social media acct:					3.5	0.063					7.7	**0.006**
No	674.8	359.7	3211.8	307.8			1322.1	476.2	4520.8	411.9		
Yes	0[b]	--	2536.9	167.6			0[b]	--	3198.7	230.6		
Sex:					0.4	0.551					2.5	0.120
Boys	166.9	279.3	2957.8	213.0			617.6	394.5	4168.5	301.7		
Girls	0[b]	--	2790.9	227.6			0[b]	--	3550.9	310.1		
Race-Ethnicity:					0.9	0.461					4.2	**0.003**
African American	401.0	399.6	3215.0	307.6			2075.2	565.6	5264.6[c]	438.7		
American Indian	255.8	443.3	3069.8	365.2			217.9	626.6	3407.2[c]	514.8		
Asian/Pacific Islander	-54.5	507.3	2759.6	436.0			777.7	711.1	3967.1[c]	614.0		
Latino	-300.7	386.1	2513.3	285.9			280.9	529.1	3470.3[c]	383.5		
White, non-Hispanic	0[b]	--	2814.0	273.5			0[b]	--	3189.4[c]	375.8		

[a] Screen Time (total min per week): sum of time spent on computer/internet, video games, and TV/video watching

[b] This parameter is set to zero because it is the reference group.

[c] During summer time, African Americans reported more screen time than American Indians, Latinos, and White, non-Hispanics (p<.05)

Note: Adolescents' age was adjusted for as a covariate in each model. The 2-way interactions between the three personal electronic environments measures and both sex and race/ethnicity were tested, but all were removed because they were not significant (p>.05).

Sedentary Time (Accelerometer-Measured) During School Year and Summer

Results from the models explaining objective sedentary time (minutes per day) are summarized in Table 3. For summer, similar to what was found with screen time, objective sedentary time was marginally positively associated with having more electronic devices in one's bedroom (p = .057), but not related to more personal electronics. During summer there was a significant (p = .014) association between sedentary time and having a social media account, but in the opposite direction to self-reported screen time. Adolescents *with* their own social media account had 34.4 more minutes per day of objective sedentary time than did those *without* a social media account. A significant (p = .025) sex difference was found, with girls having 25.5 more sedentary minutes per day during the summer than boys. There were no significant sex or race/ethnicity interactions with electronic environment variables in the summer.

Table 3. Accelerometer-Measured Sedentary Time (Average Min/Day) During the School Year and Summer in Relation to Three Scales Indicating Personal Electronic Environments for Sedentary Behavior, by Sex and Race-Ethnicity

Dependent Variable	**School Year – Sedentary Time[a] (min per day)** Overall Adjusted Mean = 520.4 (SE=6.8)						**Summer -- Sedentary Time[a] (min per day)** Overall Adjusted Mean = 492.1 (SE=6.7)					
Predictors	B estimate	SE of B	Adj. Mean	SE of Mean	*F*	*p*	B estimate	SE of B	Adj. Mean	SE of Mean	*F*	*p*
Intercept	581.5	13.9	--	--	5554.0	<0.001	524.1	13.4	--	--	5317.2	<0.001
Electronic devices in bedroom (sum)	10.9	5.0	--	--	0.2	0.671	7.0	3.7	--	--	3.7	**0.057**
Personal electronics (sum)	4.9	6.0	--	--	0.7	0.410	-0.8	6.0	--	--	0.01	0.897
Have own social media acct:					2.0	0.159					6.2	**0.014**
No	-62.1	21.4	510.0	12.7			-34.4	13.8	474.9	11.9		
Yes	0[b]	--	530.8	16.3			0[b]	--	509.3	6.6		
Sex:					8.4	**0.004**					5.1	**0.025**
Boys	-30.4	10.5	507.5	8.4			-25.6	11.3	479.3	8.6		
Girls	0[b]	--	533.3	8.7			0[b]	--	504.8	8.9		
Race-Ethnicity:					1.5	0.208					1.7	0.155
African American	-38.8	17.1	505.1	15.1			-27.5	16.0	465.2	12.4		
American Indian	-41.4	19.1	502.5	17.4			12.2	17.9	505.0	14.7		
Asian/Pacific Islander	-50.0	21.8	520.4	20.4			8.9	20.3	501.7	17.5		
Latino	-38.4	17.3	540.5	11.7			2.9	15.1	495.7	11.0		
White, non-Hispanic	0[b]	--	533.5	10.3			0[b]	--	492.8	10.8		

Sex demographic by electronic devices in bedroom (sum)					7.5	**0.007**	
Boys	-18.8	6.8	--	--			
Girls	0[b]	--	--	--			
Race-Ethnicity by Social Media Account Interaction					2.6	**0.041**	
African American by Social Media Acct=No	20.824	36.415	484.5[d]	(27.9)			
African American by Social Media Acct=Yes	0[b]	--	525.7[c]	(11.6)			
American Indian by Social Media Acct=No	20.621	40.702	481.7[d]	(31.7)			
American Indian by Social Media Acct=Yes	0[b]	--	523.2[c]	(14.3)			
Asian/Pacific Islander by Social Media Acct=No	73.819	44.436	526.3	(36.5)			
Asian/Pacific Islander by Social Media Acct=Yes	0[b]	--	514.5[c]	(17.8)			
Latino by Social Media Acct=No	90.633	30.460	554.7[d]	(20.4)			
Latino by Social Media Acct=Yes	0[b]	--	526.2[c]	(11.7)			
White, non-Hispanic by Social Media Acct=No	0[b]	--	502.5[de]	(16.6)			
White, non-Hispanic by Social Media Acct=Yes	0[a]	--	564.6[ce]	(13.0)			

[a] Accelerometer-measured sedentary time (average min per valid wearing day with <100 counts).

[b] This parameter is set to zero because it is the Reference Group.

[c] Of those *with their own social media accounts*, White, non-Hispanics have the highest average sedentary time and significantly (p<.05) *more* sedentary min/day than all other race/ethnic groups.

[d] Of those *without their own social media accounts*, Latinos have the highest sedentary time and significantly *more* sedentary min/day than African Americans (p<.05), White, non-Hispanics (p<.05), and American Indians (p=.055).

[e] White, non-Hispanics with their own social media accounts had significantly (p=.004) more average sedentary min/day than White, non-Hispanics who did not have their own social media account. Although not significant (p >.05), similar trends were seen for African American and American Indian adolescents.

Note: Adolescent's age and average accelerometer wearing time (min/day) were adjusted for as covariates in each model. The 2-way interactions between the three personal electronic environments measures and both sex and race/ethnicity were tested and retained in the model if significant (p<.05).

For the school year data, there was only one significant (p = .004) main effect. Girls had 25.8 more total sedentary minutes per day than boys, which was similar to the summer data. However, there were two significant interactions: sex-demographic by electronic devices in the bedroom (p = .007) and race/ethnicity-by-social media account (p = .041). Figure 1 illustrates the interaction of participant's sex and electronic devices in the bedroom. For girls there was a *positive* association between more electronic devices in the bedroom and more sedentary time. For boys there was a slight negative association (i.e., fewer sedentary minutes per day with more electronic devices in the bedroom).

Figure 2 illustrates the interaction of race/ethnicity by social media account. Looking within each race/ethnic group and comparing those with and without social media accounts, White/non-Hispanic, African American, and American Indian adolescents *with* their own social media accounts had *more* sedentary minutes per day than those in

the same race/ethnic group who did not have their own social media account. The opposite pattern was found for Latinos and Asian/Pacific Islander adolescents; those *without* their own social media accounts had *more* sedentary minutes per day than those with an account. Figure 1 shows that among those *with* their own social media accounts, White/non-Hispanics had the highest sedentary minutes per day, which was more than all other racial/ethnic groups (post hoc tests significant at $p < .05$). Of those *without* their own social media accounts, Latinos had the highest number of sedentary minutes per day, which was significantly more minutes than African Americans ($p < .05$), White/non-Hispanics ($p < .05$), and American Indians ($p = .055$).

Figure 1. School-Year Sedentary Time (min/day): Interaction of Sex Demographic by Electronic Devices in Bedroom ($F = 7.5$, $p = 0.007$)

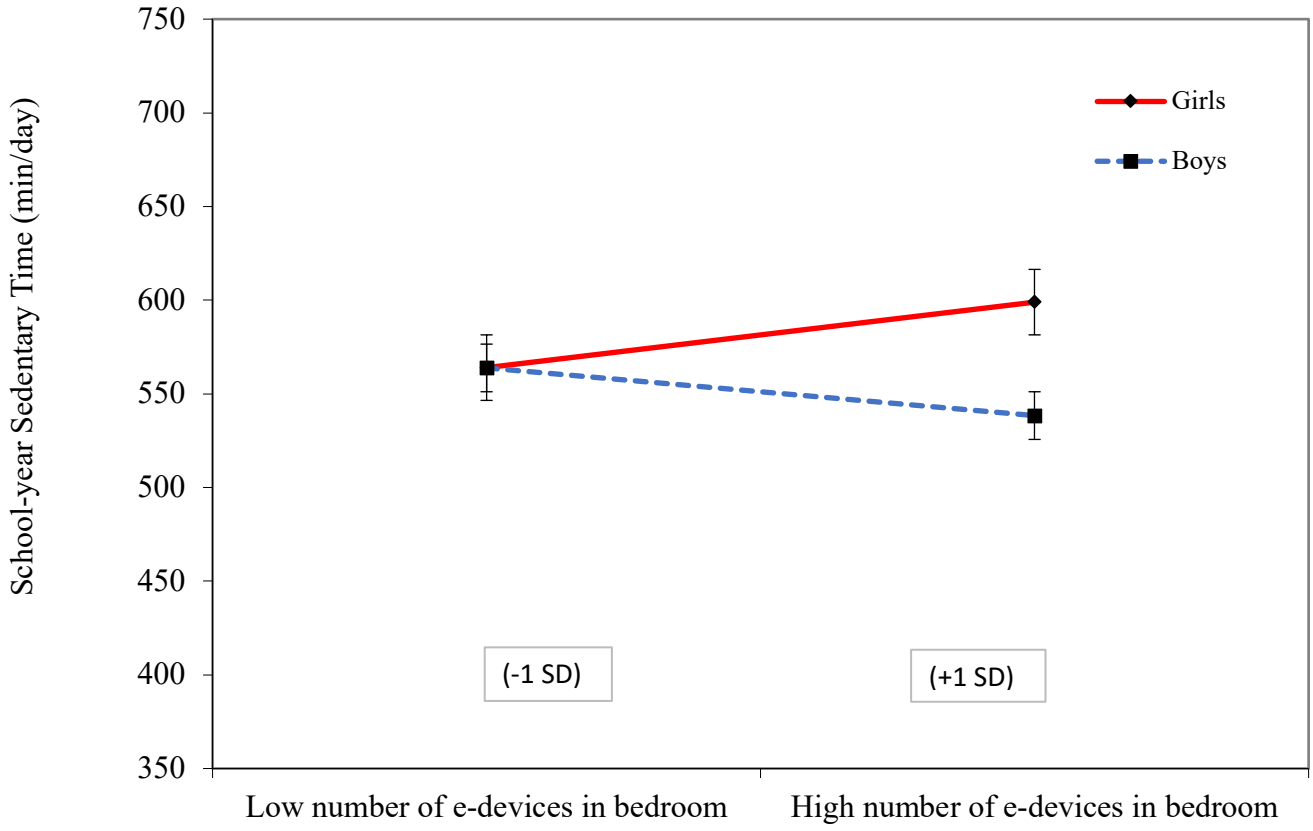
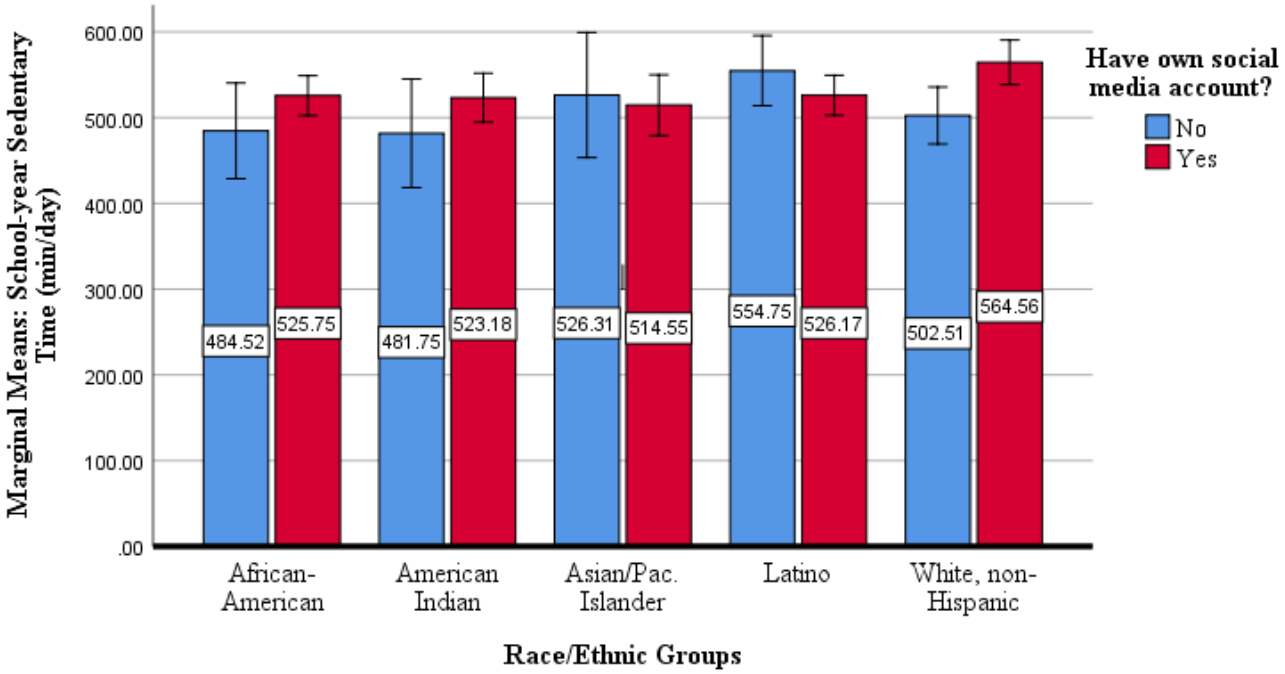


Figure 2. School-Year Sedentary Time (min/day): Interaction of Race/Ethnicity by Social Media Account (F = 2.6, p = 0.041)



Discussion

Similar to the pattern of results in previous studies of correlates of adolescent sedentary behavior, findings differed according to the measure of sedentary behavior (Atkin, Corder, & van Sluijs, 2013; Barnett et al., 2018). Present results replicated the often-reported finding (Atkin, Corder, & van Sluijs, 2013; Borghese et al., 2015; Delmas et al., 2007; Gingold, Simon, & Schoendorf, 2014; Ramirez et al., 2011; Roberts et al., 2017; Salmon et al., 2011; Tandon et al., 2014; Veldhuis et al., 2014) that number of electronic devices in the bedroom were related to more self-reported screen time in both the school year and summer. Present results indicate prior results generalized to this highly diverse sample of adolescents from lower-income areas. Though devices in the bedroom were not associated with accelerometer-assessed sedentary time during the school year, the association was significant in the summer. Perhaps the substantial time all adolescents spent sitting in school made it difficult to detect associations during the school year. Stronger evidence that electronic devices in the bedroom were more consistently related to screen time and total sedentary behavior in the summer could be explained by more opportunities for adolescents to spend time in the bedroom during the summer and perhaps less parental supervision in the summer.

The less-studied variable of number of personal electronic devices was related to more overall screen time during the school year but not in the summer, and access to these devices was not related to total sedentary time in either time period. A United Kingdom–based study found smart phone ownership was related to less sedentary time among adolescent girls only, and laptop computer and tablet ownership were unrelated to sedentary time (Sandercock et al., 2016). In the present study, weaker evidence of a potential impact of personal electronic devices could be due to their portable nature, meaning adolescents do not have to be stationary to use them. Casual observations reveal young people often interact with mobile phones while walking, although it is not recommended. Use of mobile devices can be incorporated into other activities, such as texting or using social media while being driven to activities or during breaks in sports or social events. Therefore, it is not surprising that mobile devices have ambiguous associations with sedentary time. Two of the four devices counted in the personal electronics scale (cell phones and 'personal stereo' like iPod or MP3 player) can be used to listen to music or podcasts. Adolescents might not have included 'listening' time in their self-reported screen time, possibly explaining the lack of an association during summer when they might have spent more time listening to music on their personal electronic devices.

In the present study, the findings with having a social media account appear to be contradictory. During the summer, having a social media account was related to significantly *less* screen time but *more* total sedentary time among diverse, low-income adolescents. During the school year, less screen time among those with a social media account was replicated, but there was no association with accelerometer-assessed sedentary time. Reasons for differing results of social media across measures of sedentary time are not obvious, but the complex results justify further studies of social media membership and use, especially because of the widespread use among adolescents (Bayindir & Kavanagh, 2018). A prior study

conducted with United Kingdom adolescents reported minutes of social media use were associated with higher total sedentary time among girls and boys (Sandercock et al., 2016). Thus, social media membership, as well as amount and pattern of use, should be measured in future studies. One explanation of current findings could be a measurement limitation. Reported screen time items did not specifically include mobile phones or tablets, the devices most likely used for social media interactions. Thus, reported screen time could be systematically underestimated among social media users. The finding of more total sedentary time among social media members is consistent with this hypothesis. In future studies it will be important to assess membership in social media platforms, identify which platforms are used, and assess frequency and duration of social media engagement.

There were no interactions between demographics and electronic environment variables for screen time, but two significant interactions were detected for accelerometer-assessed total sedentary time. During the school year, the participant's sex-demographic by electronic devices in the bedroom interaction showed a positive association only for girls. The association for boys was slightly negative. An implication of this finding is that having multiple electronic devices in the bedroom potentially has a stronger impact on girls, but this finding needs to be replicated.

The second significant interaction revealed social media membership was associated with total sedentary time differently across race/ethnic groups. Social media membership was related to more sedentary time only among African American, American Indian, and White/non-Hispanic adolescents. More studies of this association should be conducted with larger samples of each race/ethnic group. It would be useful to examine how adolescents in various race/ethnic groups use social media.

Strengths and Limitations

Strengths of the study included a sample of adolescents diverse in race/ethnicity, both reported and accelerometer-assessed measures of sedentary behavior, examination of less-studied electronic environment variables, and exploration of demographic by electronic environment interactions. The most important limitation was the sample for each race/ethnic group was small and not intended to be representative. The sample size made it infeasible to conduct more detailed analyses, such as examining associations of each type of electronic device with sedentary behaviors. The small subsamples provided limited power to detect interactions between demographics and electronic environments, although two significant interactions were found. Between 10 percent and 20 percent of participants had fewer than the recommended four days of accelerometer data, but participants with fewer than four days were included in analyses to maximize the analytic sample.

Another set of limitations concerned the clarity and completeness of survey measures of sedentary behaviors, access to electronic devices, and social media membership. The measures of sedentary behaviors did not provide instructions about how to report simultaneous use of multiple devices, which appears to be common (Rideout 2015). Sedentary behavior measures did not distinguish between use of devices in the bedroom vs elsewhere, or use of portable vs stationary devices. The measures did not distinguish "non-screen" use of devices, such as listening to music or talking on a mobile phone, or use of devices while sitting vs standing vs moving. As mentioned above, our social media measure did not specify which social media platforms were used or frequency or duration of use. All of these limitations indicate a need for further development of measures of sedentary behaviors as well as access and use of electronic devices, in the context that both of these categories appear to be continually evolving.

Conclusions

The majority of these diverse adolescents from lower-income areas reported having multiple electronic devices in their bedrooms, multiple portable personal electronics, and a social media account. These values demonstrate the extent to which even adolescents who could be considered disadvantaged live their daily lives in electronic environments that are ever-present, complex, and continually evolving. Thus, research to improve understanding of the health implications of these environments, including on sedentary behavior, should be a high priority.

Extending previous findings to the present low-income diverse sample, having more electronic devices in the bedroom was the only significant correlate of both more screen time and more total sedentary behavior among adolescents. Having more personal portable electronics had the weakest evidence of associations with sedentary behaviors, perhaps because some of them can be used while moving. Social media membership is a seldom-studied variable, and there was inconsistent evidence it was related to more total sedentary time in the present study, so it should be examined in future studies. Electronic devices in the bedroom and social media membership seem to increase risk for greater total sedentary time more consistently during the summer. This could be because adolescents have more free time and less supervision in the summer, providing more opportunities for sitting. Our previous analyses of the same sample showed total sedentary time was similar in the school year and summer, but screen time was significantly higher in the summer (Sallis et al., 2019). Based on present results, taking electronic devices out of bedrooms and restricting access to social media accounts are promising intervention strategies, and they may be needed most in the summer.

Corresponding author:
James F. Sallis, Ph.D.
Distinguished Professor Emeritus
Herbert Wertheim School of Public Health and Human Longevity
University of California, San Diego, MC 0631
9500 Gilman Drive. La Jolla, CA 92093-0631
Email: jsallis@ucsd.edu

Suggested citation (APA 7th edition):
Sallis, J.F., Conway, T.L., Garemia, C., Cin, K.L., Bonilla, E. & Spoon, C. (2020). Electronic Devices as Correlates of Sedentary Behavior and Screen Time Among Diverse Low-Income Adolescents During the School Year and Summer Time. *Journal of Healthy Eating and Active Living, 1(*1), 17–30.

James F. Sallis https://orcid.org/0000-0003-2555-9452
Terry L. Conway https://orcid.org/0000-0002-8369-5455
Carrie Geremia https://orcid.org/0000-0001-9159-8172
Kelli L. Cain http://orcid.org/0000-0002-7934-9680
Edith Bonilla http://orcid.org/0000-0002-7573-4186

Author Contributions:
Conceptualization, J. F. S., T. L. C., and K. L. C.; Methodology, J. F. S., T. L. C., and K. L. C.; Investigation, K. L. C., C. G., E. B., and C. S.; Writing—Original Draft, J. F. S., T. L. C., and K. L. C., Writing—Review & Editing, J. F. S., T. L. C., K. L. C., C. G., E. B., and C. S.; Funding Acquisition, C. G., E. B., and C. S.; Supervision, J. F. S.

Acknowledgments

Funding:
This work was supported by a grant from The Robert Wood Johnson Foundation as part of the Physical Activity Research Center (award number 73742). The funder had no role in the study design; in the collection, analysis, and interpretation of data; in the writing of the report; or in the decision to submit the article for publication.

Human Subjects:
The Institutional Review Board at University of California San Diego approved this study.

Conflict of Interest:
James F Sallis receives royalties and honoraria for SPARK physical activity programs through Gopher Sports Inc. He is employed by Australian Catholic University. All other authors report no disclosures.

References

American Academy of Pediatrics, Committee on Public Education. Children, adolescents, and television. *Pediatrics*. 2001;*107(2)*:423–426. https://doi.org/10.1542/peds.107.2.423

Atkin, A. J., Corder, K., & van Sluijs, E. M. (2013). Bedroom media, sedentary time and screen-time in children: a longitudinal analysis. *International Journal of Behavioral Nutrition and Physical Activity*, *10*, Article 137. https://doi.org/10.1186/1479-5868-10-137

Bai, Y., Chen, S., Laurson, K. R., Kim, Y., Saint-Maurice, P. F., & Welk, G. J. (2016). The associations of youth physical activity and screen time with fatness and fitness: The 2012 NHANES National Youth Fitness Survey. *PLoS One*, *11*(1), e0148038. https://doi.org/10.1371/journal.pone.0148038

Barnett, T. A., Kelly, A. S., Young, D. R., Perry, C. K., Pratt, C. A., Edwards, N. M., Rao, G., Vos, M. B. & American Heart Association Obesity Committee of the Council on Lifestyle and Cardiometabolic Health; Council on Cardiovascular Disease in the Young; and Stroke Council. (2018). Sedentary behaviors in today's youth: Approaches to the prevention and management of childhood obesity: A scientific statement from the American Heart Association. *Circulation*, *138*(11), e142–e159. https://doi.org/10.1161/CIR.0000000000000591

Bauman, A. E., Reis, R S., Sallis, J. F., Wells, J. C., Loos, R. J., Martin, B. W., & Lancet Physical Activity Series Working Group. (2012). Correlates of physical activity: Why are some people physically active and others not? *The Lancet*, *380*(9838), 258–271. https://doi.org/10.1016/S0140-6736(12)60735-1

Biddle, S. J., Bengoechea, E. G., & Wiesner, G. (2017). Sedentary behaviour and adiposity in youth: A systematic review of reviews and analysis of causality. *International Journal of Behavioral Nutrition and Physical Activity*, *14*, Article 43. https://doi.org/10.1186/s12966-017-0497-8

Borghese, M. M., Tremblay, M. S., Katzmarzyk, P. T., Tudor-Locke, C., Schuna, J. M., Leduc, G., Boyer, C., LeBlanc, A. G. & Chaput, J. P. (2015). Mediating role of television time, diet patterns, physical activity and sleep duration in the association between television in the bedroom and adiposity in 10 year-old children. *International Journal of Behavioral Nutrition and Physical Activity*, *12*, Article 60. https://doi.org/10.1186/s12966-015-0221-5

Botchwey, N., Conway, T. L., Floyd, M., Hipp, A., Kim, A., Porter, K. M. P., Meyer, M. R. U., Burnett, J., & Sallis, J. F. (2020). Challenges recruiting diverse youth for physical activity research. *Preventive Medicine, 131*:105888. https://doi.org/10.1016/j.ypmed.2019.105888

Cain, K. L., Bonilla, E., Conway, T. L., Schipperijn, J., Geremia, C. M., Mignano, A., Kerr, J., & Sallis, J. F. (2017). Defining accelerometer nonwear time to maximize detection of sedentary time in youth. *Pediatric Exercise Science, 30*(2), 288–295. https://doi.org/10.1123/pes.2017-0132

Cain, K. L., Conway, T. L., Adams, M. A., Husak, L. E., & Sallis, J. F. (2013). Comparison of older and newer generations of ActiGraph accelerometers with the normal filter and the low frequency extension. *International Journal of Behavioral Nutrition and Physical Activity, 10,* Article 51. https://doi.org/10.1186/1479-5868-10-51

Cain, K. L., Sallis, J. F., Conway, T. L., Van Dyck, D., & Calhoon, L. (2013). Using accelerometers in youth physical activity studies: a review of methods. *Journal of Physical Activity and Health, 10*, 437–450. https://doi.org/10.1123/jpah.10.3.437

Carson, V., Hunter, S., Kuzik, N., Gray, C. E., Poitras, V. J., Chaput, J. P., Saunders, T. J., Katzmarzyk, P. T., Okely, A. D., Connor Gorber, S., Kho, M. E., Sampson, M., Lee, H., & Tremblay, M. S. (2016). Systematic review of sedentary behaviour and health indicators in school-aged children and youth: An update. *Applied Physiology, Nutrition, and Metabolism*, *41*(6), S240–S265. https://doi.org/10.1139/apnm-2015-0630

Cliff, D. P., Hesketh, K. D., Vella, S. A., Hinkley, T., Tsiros, M. D., Ridgers, N. D., Carver, A., Veitch, J., Parrish, A. M., Hardy, L. L. & Plotnikoff, R. C. (2016). Objectively measured sedentary behaviour and health and development in children and adolescents: Systematic review and meta-analysis. *Obesity Reviews,* 17, 330–344. https://doi.org/10.1111/obr.12371

Cliff, D. P., Ridgers, N. D., Tsiros, M. D., Hinkley, T., Vella, S., Lubans, D. R., Salmon, J., Hesketh, K. D., Hardy, L. L., & Carver, A. (2014). Associations between objectively measured sedentary behaviour and adiposity in children and adolescents: Systematic review and meta-analysis. *Journal of Science and Medicine in Sport*, *18*, e154. https://doi.org/10.1016/j.jsams.2014.11.169

Coombs, N. A., & Stamatakis, E. (2015). Associations between objectively assessed and questionnaire-based sedentary behaviour with BMI-defined obesity among general population children and adolescents living in England. *BMJ Open*, *5*(6). https://doi.org/10.1136/bmjopen-2014-007172

Crespo, C. J., Smit, E., Troiano, R. P., Bartlett, S. J., Macera, C. A., & Andersen, R. E. (2001). Television watching, energy intake, and obesity in US children: results from the third National Health and Nutrition Examination Survey, 1988–1994. *Archives of Pediatrics & Adolescent Medicine*, *155*(3), 360–365. http://doi.org/10.1001/archpedi.155.3.360

Delmas, C., Platat, C., Schweitzer, B., Wagner, A., Oujaa, M., & Simon, C. (2007). Association between television in bedroom and adiposity throughout adolescence. *Obesity*, *15*(10), 2495–2503. https://doi.org/10.1038/oby.2007.296

Evenson, K. R., Catellier, D. J., Gill, K., Ondrak, K. S., & McMurray, R. (2008). Calibration of two objective measures of physical activity for children. *Journal of Sports Sciences, 26*(14), 1557–1565. https://doi.org/10.1080/02640410802334196

Fletcher, E., Leech, R., McNaughton, S. A., Dunstan, D. W., Lacy, K. E., & Salmon, J. (2015). Is the relationship between sedentary behaviour and cardiometabolic health in adolescents independent of dietary intake? A systematic review. *Obesity Reviews*, *16*(9), 795–805. https://doi.org/10.1111/obr.12302

Gingold, J. A., Simon, A. E., & Schoendorf, K. C. (2014). Excess screen time in US children: Association with family rules and alternative activities. *Clinical Pediatrics*, *53*(1), 41–50. https://doi.org/10.1177/0009922813498152

Guthold, R., Stevens, G. A., Riley, L. M., & Bull, F. C. (2020). Global trends in insufficient physical activity among adolescents: A pooled analysis of 298 population-based surveys with 1.6 million participants. *The Lancet Child & Adolescent Health*, *4*(1), 23–35. https://doi.org/10.1016/S2352-4642(19)30323-2

Hoyos Cillero, I. H., & Jago, R. (2010). Systematic review of correlates of screen-viewing among young children. *Preventive Medicine*, *51*(1), 3–10. https://doi.org/10.1016/j.ypmed.2010.04.012

Janssen, X., Mann, K. D., Basterfield, L., Parkinson, K. N., Pearce, M. S., Reilly, J. K., Adamson, A. J., & Reilly, J. J. (2016). Development of sedentary behavior across childhood and adolescence: longitudinal analysis of the Gateshead Millennium Study. *International Journal of Behavioral Nutrition and Physical Activity*, *13*, Article 88. https://doi.org/10.1186/s12966-016-0413-7

Mitchell, J. A., & Byun, W. (2014). Sedentary behavior and health outcomes in children and adolescents. *American Journal of Lifestyle Medicine,* 8, 173–199. https://doi.org/10.1177/1559827613498700

Pate, R. R., Mitchell, J. A., Byun, W., & Dowda, M. (2011). Sedentary behaviour in youth. *British Journal of Sports Medicine*, *45*(11), 906–913. https://doi.org/10.1136/bjsports-2011-090192

Ramirez, E. R., Norman, G. J., Rosenberg, D. E., Kerr, J., Saelens, B. E., Durant, N., & Sallis, J. F. (2011). Adolescent screen time and rules to limit screen time in the home. *Journal of Adolescent Health*, *48*(4), 379–385. https://doi.org/10.1016/j.jadohealth.2010.07.013

Rideout, V. The common sense census: Media use by tweens and teens. (2015). https://www.commonsensemedia.org/research/the-common-sense-census-media-use-by-tweens-and-teens

Rideout, V. J., Foehr, U. G., & Roberts, D. F. (2010). Generation M2: Media in the lives of 8–18 year olds. https://www.kff.org/other/poll-finding/report-generation-m2-media-in-the-lives/

Roberts, J. D., Rodkey, L., Ray, R., Knight, B., & Saelens, B. E. (2017). Electronic media time and sedentary behaviors in children: Findings from the Built Environment and Active Play Study in the Washington DC area. *Preventive Medicine Reports*, *6*, 149–156. https://doi.org/10.1016/j.pmedr.2017.02.021

Rosenberg, D., Sallis, J. F., Kerr, J., Maher, J., Norman, G. J., Durant, N., Harris, S. K., & Saelens, B. E. (2010). Brief scales to assess physical activity and sedentary equipment in the home. *International Journal of Behavioral Nutrition and Physical Activity, 7,* Article 10. https://doi.org/10.1186/1479-5868-7-10

Sallis, J. F., Conway, T. L., Cain, K. L., Carlson, J. A., Frank, L. D., Kerr, J., Glanz, K., Chapman, J.E., & Saelens, B. E. (2018). Neighborhood built environment and socioeconomic status in relation to physical activity, sedentary behavior, and weight status of adolescents. *Preventive Medicine, 110*, 47–54. https://doi.org/10.1016/j.ypmed.2018.02.009

Sallis, J. F., Conway, T. L., Cain, K. L., Geremia, C., Bonilla, E., & Spoon, C. (2019). Racial/ethnic variations in school-year versus summer differences in adolescent physical activity. *Preventive Medicine, 129(12)*, 105795. https://doi.org/10.1016/j.ypmed.2019.105795

Salmon, J., Tremblay, M. S., Marshall, S. J., & Hume, C. (2011). Health risks, correlates, and interventions to reduce sedentary behavior in young people. *American Journal of Preventive Medicine*, *41*(2), 197–206. https://doi.org/10.1016/j.amepre.2011.05.001

Sandercock, G. R., Alibrahim, M., & Bellamy, M. (2016). Media device ownership and media use: Associations with sedentary time, physical activity and fitness in English youth. *Preventive Medicine Reports*, *4*, 162–168. https://doi.org/10.1016/j.pmedr.2016.05.013

Stierlin, A. S., De Lepeleere, S., Cardon, G., Dargent-Molina, P., Hoffmann, B., Murphy, M. H., Kennedy, A., O'Donoghue, G., Chastin, S. F., & De Craemer, M. (2015). A systematic review of determinants of sedentary behaviour in youth: A DEDIPAC-study. *International Journal of Behavioral Nutrition and Physical Activity*, *12*, Article 133. https://doi.org/10.1186/s12966-015-0291-4

Tandon, P., Grow, H. M., Couch, S., Glanz, K., Sallis, J. F., Frank, L. D., & Saelens, B. E. (2014). Physical and social home environment in relation to children's overall and home-based physical activity and sedentary time. *Preventive Medicine*, *66*, 39–44. https://doi.org/10.1016/j.ypmed.2014.05.019

Tremblay, M. S., LeBlanc, A. G., Kho, M. E., Saunders, T. J., Larouche, R., Colley, R. C., Goldfield, G., & Connor Gorber, S. (2011). Systematic review of sedentary behaviour and health indicators in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity*, *8*, Article 98. https://doi.org/10.1186/1479-5868-8-98

Trost, S. G., Pate, R. R., Freedson, P. S., Sallis, J. F., & Taylor, W. C. (2000). Using objective physical activity measures with youth: How many days of monitoring are needed? *Medicine and Science in Sports and Exercise, 32*(2), 426–431. http://dx.doi.org/10.1097/00005768-200002000-00025

Veldhuis, L., van Grieken, A., Renders, C. M., HiraSing, R. A., & Raat, H. (2014). Parenting style, the home environment, and screen time of 5-year-old children; the 'be active, eat right' study. *PLoS One*, *9*(2), e88486. https://doi.org/10.1371/journal.pone.0088486

Whitt-Glover, M. C., Taylor, W. C., Floyd, M. F., Yore, M. M., Yancey, A. K., & Matthews, C. E. (2009). Disparities in physical activity and sedentary behaviors among US children and adolescents: Prevalence, correlates, and intervention implications. *Journal of Public Health Policy*, *30*, S309–S334. https://doi.org/10.1057/jphp.2008.46