

Longitudinal Sedentary Time Among Females Aged 17 to 23 Years



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Introduction: Time spent in sedentary behaviors is a newer risk factor for poor cardiometabolic health. This study examined longitudinal correlates of sedentary time among a cohort of females from about age 17 to age 23 years.

Methods: The cohort included females originally participating in the Trial of Activity for Adolescent Girls Maryland site who had assessments in 2009 and 2015 ($n=431$). Percentage daily time in sedentary behaviors was determined from accelerometers. Sociodemographics, psychosocial factors, and health behaviors were assessed by questionnaire. Lasso variable selection identified potential variables included in linear mixed effects models. As a secondary analysis, a k-means algorithm for longitudinal data identified homogeneous clusters of individual sedentary time trajectories.

Results: Percentage daily sedentary time did not change over time (67% to 68%). Not of black race ($p=0.04$), higher father's education ($p<0.001$), more weekday computer hours ($p<0.001$), more weekend TV hours ($p=0.01$), more physical activity barriers ($p=0.003$), fewer days per week driving ($p=0.01$), and more vehicles in the household ($p=0.02$) were associated with greater sedentary time. Cluster analysis resulted in two patterns: more (70%) versus less (60%) time being sedentary. The more sedentary individuals were more likely to be college graduates ($p<0.001$), have a higher income ($p=0.03$), and work fewer hours ($p=0.009$). They were also less likely to be married or in a common-law relationship ($p=0.05$) or in a parenting role ($p=0.02$).

Conclusions: Time spent in sedentary behaviors remained stable. Factors associated with sedentary time were significant across the socioecologic framework and included several factors indicating higher SES.

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INTRODUCTION

Time spent in sedentary behaviors is a relatively new risk factor for poor health in youth and adults. It is defined as waking behavior characterized by an energy expenditure less than or equal to 1.5 METs while in a sitting, reclining, or lying posture.¹ In adults, prolonged sedentary time is associated with all-cause mortality, cardiovascular disease, and type 2 diabetes.^{2,3} Among youth, longer TV viewing and other screen time are associated with unfavorable body composition^{4,5} and adverse cardiometabolic risk scores.^{6,7} TV time assessed during young adulthood tracked over a 25-year period, indicating that time spent viewing TV was stable over this period.⁸ Given the

deleterious associations of sedentary behavior on health and the possibility that sedentary behavior tracks into adulthood, it is important to understand factors associated with sedentary time across the critical

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developmental phase from late adolescence to early adulthood. Sedentary time—reducing interventions targeting adolescents and young adults may provide health benefits that extend into adulthood, when cardio-metabolic diseases tend to manifest.

Prior to developing interventions, factors associated with time spent in sedentary behaviors need to be identified. Cross-sectional studies suggest that demographic factors (e.g., age, race/ethnicity, employment status), weight status, and eating patterns are consistent correlates with sedentary behaviors.^{9–12} Although cross-sectional studies are valuable, longitudinal studies provide more useful information relevant to possible intervention targets (e.g., vulnerable populations with high sedentary activity) and strategies (e.g., personal, social, behavioral attributes). The studies that have evaluated youth and adults' longitudinal sedentary behavior are largely atheoretic, with few associations found,^{13–15} or focus mainly on associations of sedentary time and adiposity.^{14,16,17} Of studies that used a theoretic basis for selecting predictors of longitudinal sedentary behavior, most have employed socioecologic models.^{18–20} High BMI was associated with greater sedentary time in young adult women,²⁰ but other studies found it was not in adolescent girls.^{18,19} Lower education, working more than 40 hours per week, current smoking, alcohol intake, and stress were also associated with high levels of sitting time among young adult women.²⁰ For adolescents, positive attitudes towards TV viewing and computer use predicted a 1-year increase in TV and computer use, respectively.¹⁹ Change in unhealthy eating behaviors predicted change in TV and computer use.¹⁸ Environmental factors, such as availability of outdoor playing environments, did not predict sedentary behaviors.¹⁸

This study aims to identify longitudinal correlates of sedentary time among females from late adolescence to early adulthood (about age 17 to age 23 years). The study was conceptualized using a socioecologic model of factors associated with sedentary behavior in cross-sectional studies, including sociodemographics, psychological factors, and health behaviors. Environmental variables are not included in this study's analytic models because previous testing of built environmental variables with this cohort indicated they were not associated with sedentary time.²¹

METHODS

Study Sample

The cohort originated from the Trial of Activity for Adolescent Girls, a group RCT to reduce the decline in moderate to vigorous physical activity in middle school girls.²² A total of 730 eighth grade girls were enrolled at the Maryland field center in the

Baltimore, MD/Washington, DC area in 2006. Of these, 589 (81%) were re-recruited and measured in 2009 (age 17 years).²³ In 2015, a total of 460 (78%) participants (aged 23 years) were re-recruited, consented, and measured. The cohort included participants originally from intervention and control middle schools. Recruitment efforts are described elsewhere.²⁴ This analysis included data collected in 2009 and 2015. The study was approved by the University of Maryland and Kaiser Permanente Southern California IRB.

Measures

Sedentary time was measured objectively with Actigraph accelerometers (MTI model 7164). Participants wore the monitor during waking hours for 7 consecutive days. If inadequate wear time was noted (<4 days, 10 hours per day), a participant was asked to re-wear the accelerometer. Data were stored in 30-second intervals. Sedentary time was defined as <50 counts per 30 seconds. Because most daily time is spent in sedentary activities, sedentary time reflects the amount of time the accelerometer is worn (i.e., a person wearing monitor for 14 hours would collect more sedentary time than one with 10 hours wear time). Thus, sedentary time was expressed as percentage daily sedentary time.

Participants self-identified as white, black or African American, Hispanic/Latina, Asian/Pacific Islander, American Indian/Alaska Native, or other, and were combined into white, black, Hispanic, or other. Parent education level was used as the SES proxy.²⁵ Cigarette smoking behavior was ascertained from questions used in the 2003 Youth Risk Behavior Survey. Self-rated health status was determined by one item, *How do you describe your health in general?*

At age 17 years, height and weight were measured using a stadiometer and calibrated scale. At age 23 years, participants self-reported height and weight. BMI was calculated as weight in kg/height in meters².

Because the study was originally designed with physical activity as the outcome, most psychological factors assessed were those known to influence physical activity. Thus, the variables chosen were those that could plausibly be associated with sedentary time.

Physical activity enjoyment was measured using seven items from the Physical Activity Enjoyment Scale.²⁶ Perceived barriers to physical activity were assessed by an adapted scale.²⁷ The Center for Epidemiologic Studies—Depression Scale²⁸ was used to measure depressive symptoms. It has moderate predictive validity for screening major depressive episodes in adolescent females.²⁹ Twenty items from the Physical Self-Description Questionnaire³⁰ were used to measure self-esteem and global physical self-concept.

Items on beverage intake were taken from an adolescent beverage consumption screener developed by Nelson and Lytle³¹ that assesses the monthly frequency of consuming milk, soda, sport drinks, other sweetened drinks, and sugary coffee drinks, respectively. The 2009 Youth Risk Behavior Survey questions were used to assess weekly intake of fruits and vegetables. Three behaviors associated with obesity status in youth (i.e., number of days in the past week in which breakfast and fast food were consumed and whether meals were consumed with family or others living together) were assessed.

Sleep duration was assessed by asking what time participants usually went to bed and what time they woke up. Weekdays and weekend days were assessed separately.

Average weekday and weekend hours spent on a computer, tablet, or similar device; watching TV or DVDs; playing video-games; and talking on the telephone or texting were assessed. Responses ranged from 0 to ≥ 6 hours for each item. The instrument is similar to those used in other longitudinal studies.³²

Travel-related behaviors were assessed from five questions. Two related to how one got to and from work or school (i.e., drive, ride in a car, public transportation, ride a bike, walk). One item queried about how often the respondent drove a car in the past 7 days, with response options: *every day*, *4–6 days*, *2–3 days*, *1 day*, and *never*. One item asked about the number of vehicles available for regular use by people who lived in the household. Responses were *one*, *two*, *three or more*, or *none*. One item asked about the availability of adult-sized bicycles.

To characterize participants in different sedentary time groups, the authors included demographic characteristics assessed by self-report at age 23 years. These variables were only available at age 23 years, which included marital status, household size, parental role, education, employment, hours worked for pay, and annual income.

Statistical Analysis

Percentage daily time in sedentary behavior and independent variables were compared between ages 17 and 23 years using the McNemar or McNemar–Bowker test, or unadjusted generalized linear models for categorical data and the paired *t*-test or Wilcoxon signed rank sums test for continuous measures. To model sedentary time longitudinally, a linear mixed effects model with random intercepts was fit using time as an independent variable.³³ To avoid overfitting and to build the most robust and parsimonious model, the Lasso selection technique³⁴ was employed in the linear mixed effects model to identify factors most relevant to sedentary time. The number of variables included in the final linear mixed effects model depended on the tuning parameter of the penalty function and was determined by the minimum Bayesian Information Criterion to ensure the balance between adequate fitting and parsimony. The model required that all included variables were available at both time periods. To aid in interpretation of estimates of significant associations with sedentary time, estimated differences in minutes per day and minutes per week of sedentary time per 1-unit change in the independent variable were calculated.

To identify if there were different individual sedentary time groups, a second analysis using a k-means algorithm for longitudinal data was run to cluster participants with similar sedentary time. The optimal number of clusters was decided based on the minimum Bayesian Information Criterion. To describe participants in each cluster, demographic characteristics of participants at age 23 years by cluster were compared. For these unadjusted group comparisons, Pearson's chi-square test or Fisher's exact test for categorical variables was used.

R version 3.5.0, package *lmmlasso*³⁵ was used to fit linear mixed effects model with Lasso selection for the fixed effects, and R package *kml*^{36,37} was used to perform k-means clustering of the longitudinal data. SAS version 9.3 was used for all other analyses.

RESULTS

A total of 431 participants had complete data at 2009 and 2015. Almost 50% were white, with about 21% black, 14% Hispanic, and 18% other (i.e., Asian, mixed race). Less than 50% of the cohort's parents were college graduates, based on their daughters' reports in 2015. About 8% reported being current smokers at age 23 years. Mean BMI significantly increased ($p < 0.001$). Mean percentage daily sedentary time did not change (67% to 68%, $p < 0.23$).

There were 45 variables included in the Lasso selection technique, with 12 variables chosen for the longitudinal model examining associations with sedentary time (Table 1). Barriers to physical activity score was significantly higher at age 23 years (i.e., more barriers; $p < 0.001$). Depressive symptoms score did not change ($p = 0.27$). No difference was noted for eating together as a family ($p = 0.08$). Average daily TV hours increased on weekdays and weekends from 1.8 (SD=1.45) and 2.3 (SD=1.65), respectively, to 2.3 (SD=1.61) hours per day on weekdays and 2.8 (SD=1.81) hours per day on weekend at age 23 years (all, $p < 0.001$). Time spent using a computer increased by about 2 hours per day on weekdays and 1.2 hours on weekends (both, $p < 0.001$). Weekday sleep duration increased ($p < 0.001$). Participants were more likely to drive themselves at age 23 years than at age 17 years ($p < 0.006$). Most (>70%) had at least two vehicles available in the household, which was slightly higher at age 23 years ($p = 0.03$).

Of the variables included in the main analysis, seven were independently associated with longitudinal sedentary time (Table 2). Father's education ($p = 0.004$), more weekday hours on the computer ($p < 0.001$) and more weekend hours watching TV ($p = 0.01$), more physical activity barriers ($p = 0.003$), fewer days per week driving ($p = 0.01$), and more vehicles in the household ($p = 0.02$) were associated with greater sedentary time. Participants who identified as black had lower sedentary time ($p = 0.04$). Although statistically significant, the magnitude of the effect was low. For example, controlling for the other factors in the model, 1 additional weekday hour spent on the computer was associated with 5.18 more minutes of daily sedentary time or 36.27 weekly minutes (Table 2). One category increase in father's education was associated with 12.58 more minutes of daily sedentary time and one more vehicle in the household was associated with 5.87 more minutes of daily sedentary time. Black race was associated with 11.30 fewer minutes of sedentary time compared with other race/ethnicities.

Cluster analysis resulted in two groups with sedentary time that remained consistent at both time points: 59.4%

Table 1. Independent Variables Selected From Lasso for the Longitudinal Analysis of Percent Daily Sedentary Time

Characteristics	Age 17 years (n=431)	Age 23 years (n=431)	p-value ^a
Race/ethnicity			N/A
Black	91 (21.1)	91 (21.1)	
Other	76 (17.6)	76 (17.6)	
Hispanic	59 (13.7)	59 (13.7)	
White	205 (47.6)	205 (47.6)	
Father's education			N/A
Some high school/graduate	143 (37)	143 (37)	
Some college	82 (21.2)	82 (21.2)	
College graduate	161 (41.7)	161 (41.7)	
Current smoker	24 (5.6)	35 (8.1)	0.07
BMI	23.2 (4.78)	26.0 (6.67)	<0.0001
Physical activity barriers score	21.8 (5.89)	19.5 (5.58)	<0.0001
Depressive symptoms score	15.1 (8.69)	14.5 (9.25)	0.27
Eating together as a family			0.08
Never/do not know	78 (18.1)	95 (22.0)	
1–4 days per week	252 (58.5)	260 (60.3)	
≥5 days per week	101 (23.4)	76 (17.6)	
Weekday daily TV hours	1.8 (1.45)	2.3 (1.61)	<0.0001
Weekend daily TV hours	2.3 (1.65)	2.8 (1.81)	<0.0001
Weekday daily computer hours	1.9 (1.52)	3.9 (1.92)	<0.0001
Weekend daily computer hours	2.1 (1.69)	3.3 (1.90)	<0.0001
Weekday sleep duration, hours	7.3 (1.13)	8.0 (1.42)	<0.0001
Vehicle driving frequency			<0.0001
Never	182 (42.2)	67 (15.5)	
1 day in past 7 days	44 (10.2)	21 (4.9)	
2–3 days in past 7 days	77 (17.9)	51 (11.8)	
4–6 days in past 7 days	53 (12.3)	96 (22.3)	
Every day in past 7 days	75 (17.4)	196 (45.5)	
Vehicles available in household			0.03
None	11 (2.6)	31 (7.2)	
1	86 (20)	87 (20.2)	
2	148 (34.3)	139 (32.3)	
≥3	186 (43.2)	174 (40.4)	

Note: Boldface indicates statistical significance ($p < 0.05$). Categorical variables listed as n (column %) and continuous variables as mean (SD).

^a p -values calculated using McNemar's or McNemar-Bowker test, or unadjusted generalized linear models for categorical data and the paired t -test or Wilcoxon signed rank test for continuous measures.

N/A, not applicable.

of the cohort was on average sedentary 70% of the time (more) and 40.6% spent an average of 60% of the time in sedentary activities (less) being sedentary. Members in the more sedentary group spent, on average, about 1.37 more hours per day being sedentary. From the sociodemographics at age 23 years, the more sedentary group tended to be of higher SES. The more sedentary group were more likely to be college graduates (63.7% vs 42.3%, $p < 0.001$), have a higher income (39.1% vs 30.9% with $> \$25,000$ annual income, $p = 0.03$), and work fewer hours (36.0% vs 22.9% worked 0–19 hours per week, $p = 0.009$; Table 3). Female participants who were more sedentary were less likely to be married or partnered

(16.0% vs 23.4%, $p = 0.05$) or in a parenting role (18.8% vs 28.0%, $p = 0.02$).

DISCUSSION

Sedentary time in a cohort of females was stable between ages 17 to 23 years, with about 67.5% of waking hours spent being sedentary. Perceived barriers to physical activity and specific sedentary behaviors (computer time, TV time) were associated with sedentary time. The strongest association with lower sedentary time was black race, which may be a result unique to the age group studied and sedentary time assessment, given that previous work in adults found

Table 2. Estimated Effects of the Selected Variables on Percent Time Spent in Sedentary Activities of Females Aged 17 to 23 Years

Variable	Estimate ^a (SE)	p-value	Estimated minutes per day	Estimated minutes per week
Intercept	0.6309 (0.02013)	<0.0001	—	—
Time	0.001785 (0.005917)	0.57	—	—
Black race	−0.01375 (0.006715)	0.04	−11.30	−79.12
Father's education	0.01531 (0.003231)	<0.001	12.58	88.09
Smoking status (yes vs no)	−0.01302 (0.009978)	0.19	—	—
Physical activity barriers score	0.001387 (0.000466)	0.003	1.14	7.98
Depressive symptoms score	−0.00053 (0.000292)	0.07	—	—
Eating together as a family	−0.00709 (0.003865)	0.07	—	—
Weekend daily TV hours	0.003711 (0.001457)	0.01	3.05	21.35
Weekday daily computer hours	0.006303 (0.001436)	<0.0001	5.18	36.27
Weekday sleep duration hours	−0.00195 (0.001843)	0.29	—	—
Vehicle driving frequency (days per week)	−0.00457 (0.001779)	0.01	−3.76	−26.30
Vehicles available in household (count)	0.007143 (0.003005)	0.02	5.87	41.10

Note: Boldface indicates statistical significance ($p < 0.05$).

^aEstimates are from linear mixed effects model adjusted for other variables in the model. Estimates can be interpreted as difference in percent daily time in sedentary activity per 1-unit change in the independent variable.

mixed results.³ Two distinct groups were identified—those who spent more and less time being sedentary, with no significant difference for either group over time. The group that spent more time being sedentary exhibited higher SES

at age 23 years. A novel aspect of this study was using accelerometry data to assess sedentary time, a method that captures all sedentary time, rather than self-report that assesses only specific sedentary activities.

Table 3. Sociodemographics in 2015 (Age 23 Years) by Sedentary Time Group

Variable	70% of time being sedentary, n (%) (n=256)	60% of time being sedentary, n (%) (n=175)	p-value ^a
Completed education			<0.0001
Some high school/graduate	25 (9.8)	34 (19.4)	
Some college	68 (26.6)	67 (38.3)	
College graduate	163 (63.7)	74 (42.3)	
Annual income			0.03
<\$10,000	88 (34.4)	54 (30.9)	
<\$25,000	68 (26.6)	67 (38.3)	
≥\$25,000	100 (39.1)	54 (30.9)	
Relationship status			0.05
Single/divorced/separated	215 (84)	134 (76.6)	
Unmarried couple/married	41 (16.0)	41 (23.4)	
Parenting role, yes	48 (18.8)	49 (28.0)	0.02
Employment status			0.004
Employed student	59 (23.0)	48 (27.4)	
Unemployed student	35 (13.7)	6 (3.4)	
Employed	147 (57.4)	107 (61.1)	
Unemployed	15 (5.9)	14 (8.0)	
Hours worked for pay			0.009
0	48 (18.8)	19 (10.9)	
1–19	44 (17.2)	21 (12)	
20–40	130 (50.8)	117 (66.9)	
>40	34 (13.3)	18 (10.3)	

Note: Boldface indicates statistical significance ($p < 0.05$).

^ap-values assessed using χ^2 test or Fisher's exact test in cases of sparse data for categorical variables.

Higher paternal education and more vehicles available in a household were associated with more sedentary time, and at age 23 years, being a college graduate, having a higher income, being an unemployed student, and working fewer hours were associated with being in the more sedentary time category. These variables may collectively indicate that higher SES was associated with greater sedentary time. Available data regarding associations between SES and sedentary time are mostly from cross-sectional studies using self-report measures of sedentary time. Results are mixed: In a review, O'Donoghue et al.³⁸ reported that higher TV viewing was associated with lower educational status, whereas higher occupational sitting time was associated with higher education. Except for one study that used accelerometers to assess sedentary time,³⁹ total sitting time was associated with lower education. However, results of the accelerometer-based study align with results of this study. Although occupation type was not assessed, college graduates may be more likely to have desk jobs with higher salaries, which is associated with more sedentary time captured by accelerometers. Unemployed students may have more time available for sedentary study rather than participating in “college-type jobs” (e.g., foodservice worker) that may be less sedentary. None of these prior studies were conducted in young adults, whose individual SES is developing.

Higher weekday screen time was associated with greater sedentary time, although the magnitude of the associations was remarkably low. Others have noted weak associations between reported TV time and accelerometry-derived sedentary time.^{32,40} Individuals often sit or recline while viewing screens. Accelerometers are a nonspecific assessment of sedentary time and cannot distinguish between standing, sitting, or reclining. Additionally, screen time was estimated in broad categories (i.e., hours), and may be subject to misreport. Although higher screen time is associated with adverse health outcomes in youth^{4,5} and adults,³ higher screen time may be compensated by lower sedentary time from other behaviors.

The association of frequency of vehicle driving with less sedentary time was an unexpected finding. Clearly, time spent in a vehicle necessitates being sedentary. However, how often the participant drove a car was assessed, not how long the participant spent in the car. Those who drove more often may have taken shorter trips (e.g., running errands), resulting in less time sitting in a vehicle.

A positive, albeit small, association was noted for higher physical activity barriers to be associated with greater sedentary time. Although physical activity and sedentary time are independent constructs,³ those who perceive more barriers, which may imply physical activity indifference, may spend more time being sedentary.

Contrary to previous studies,^{5,41} BMI was not associated with sedentary time. Janz and colleagues³² found that objectively measured sedentary time did not predict longitudinal adiposity among a cohort aged 5–19 years, although self-reported TV time was. They and others speculate that TV time may contribute to adiposity through mechanisms other than it being a sedentary behavior; its association with obesity may be through increased snacking or sleep disturbances.^{32,42}

Most factors associated with sedentary time changed from age 17 to age 23 years. Perceived barriers to physical activity increased, as did daily TV viewing, daily computer use, and driving frequency, whereas the number of vehicles in the household declined. Nonetheless, percentage daily sedentary time did not change, suggesting that the contribution of these factors to sedentary time are stable across young women from late adolescence to young adulthood.

The women who were parenting at age 23 years were more likely to be in the less sedentary time group. Studies have found that parenting is associated with lower sitting and sedentary time.^{20,43} These results contribute to that literature. Given the age of the cohort, the women who were parents likely had young children who required quite a bit of running after.

Limitations

Study limitations exist. The accelerometer used was hip-placed and not as accurate as thigh-placed accelerometers/inclinometers that can distinguish sitting from standing. Accelerometry does not allow for understanding the actual sedentary behaviors in which individuals are engaging. Assessing young adult SES is challenging; current income or education may not predict future SES. Many of the psychosocial assessments were relevant to physical activity rather than sedentary behaviors. The cohort was limited to females and longitudinal sedentary time may differ by sex.¹⁴ Additional measurement periods and a longer follow-up period may identify different sedentary time pattern changes. Nonetheless, there are study strengths. The cohort was diverse with respect to race/ethnicity, SES, and life paths. Longitudinal studies of accelerometry-assessed sedentary time from late adolescence to young adulthood are rare. Independent variables were well-validated measures and available at both time periods. Missing data were minimal.

CONCLUSIONS

Time spent in sedentary behaviors remained stable among females from ages 17 to 23 years. Although factors associated with sedentary time were significant

across the socioecologic framework, most were associated with SES. Young adult women with higher SES may be particularly vulnerable to highly sedentary behaviors.

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