JAMA | Original Investigation

Trends in Sedentary Behavior Among the US Population, 2001-2016

Lin Yang, PhD; Chao Cao, MPH; Elizabeth D. Kantor, MPH, PhD; Long H. Nguyen, MD, MS; Xiaobin Zheng, MD; Yikyung Park, ScD; Edward L. Giovannucci, MD, ScD; Charles E. Matthews, PhD; Graham A. Colditz, MD, DrPH; Yin Cao, MPH, ScD

IMPORTANCE Prolonged sitting, particularly watching television or videos, has been associated with increased risk of multiple diseases and mortality. However, changes in sedentary behaviors over time have not been well described in the United States.

OBJECTIVE To evaluate patterns and temporal trends in sedentary behaviors and sociodemographic and lifestyle correlates in the US population.

DESIGN, SETTING, AND PARTICIPANTS A serial, cross-sectional analysis of the US nationally representative data from the National Health and Nutrition Examination Survey (NHANES) among children aged 5 through 11 years (2001-2016); adolescents, 12 through 19 years (2003-2016); and adults, 20 years or older (2003-2016).

EXPOSURES Survey cycle.

MAIN OUTCOMES AND MEASURES Prevalence of sitting watching television or videos for 2 h/d or more, computer use outside work or school for 1 h/d or more, and total sitting time (h/d in those aged ≥12 years).

RESULTS Data on 51 896 individuals (mean, 37.2 years [SE, 0.19]; 25 968 [50%] female) were analyzed from 2001-2016 NHANES data, including 10 359 children, 9639 adolescents, and 31 898 adults. The estimated prevalence of sitting watching television or videos for 2 h/d or more was high among all ages (children, 62% [95% CI, 57% to 67%]; adolescents, 59% [95% CI, 54% to 65%]; adults, 65% [95% CI, 61% to 69%]; adults aged 20-64 years, 62% [95% CI, 58% to 66%]; and ≥65 years, 84% [95% CI, 81% to 88%] in the 2015-2016 cycle). From 2001 through 2016, the trends decreased among children over time (difference, −3.4% [95% CI, −11% to 4.5%]; *P* for trend =.004), driven by non-Hispanic white children; were stable among adolescents (−4.8% [95% CI, −12% to 2.3%]; *P* for trend =.60) and among adults aged 20 through 64 years (−0.7% [95% CI, −5.6% to 4.1%]; *P* for trend =.82); but increased among adults aged 65 years or older (difference, 3.5% [95% CI, −1.2% to 8.1%]; *P* for trend =.03). The estimated prevalence of computer use outside school or work for 1 h/d or more increased in all ages (children, 43% [95% CI, 40% to 46%] to 56% [95% CI, 49% to 63%] from 2001 to 2016; difference, 13% [95% CI, 5.6% to 21%]; *P* for trend <.001; adolescents, 53% [95% CI, 47% to 58%] to 57% [95% CI, 53% to 62%] from 2003 to 2016, difference, 4.8% [95% CI, −1.8% to 11%]; *P* for trend =.002; adults, 29% [27% to 32%] to 50% [48% to 53%] from 2003 to 2016, difference, 21% [95% CI, 18% to 25%]; *P* for trend <.001). From 2007 to 2016, total hours per day of sitting time increased among adolescents (7.0 [95% CI, 6.7 to 7.4] to 8.2 [95% CI, 7.9 to 8.4], difference, 1.1 [95% CI, 0.7 to 1.5]) and adults (5.5 [95% CI, 5.2 to 5.7] to 6.4 [95% CI, 6.2 to 6.6]; difference, 1.0 [95% CI, 0.7 to 1.3]; *P* for trend <.001 for both).

CONCLUSIONS AND RELEVANCE In this nationally representative survey of the US population from 2001 through 2016, the estimated prevalence of sitting watching television or videos for at least 2 hours per day generally remained high and stable. The estimated prevalence of computer use during leisure-time increased among all age groups, and the estimated total sitting time increased among adolescents and adults.

JAMA. 2019;321(16):1587-1597. doi:10.1001/jama.2019.3636

Supplemental content

CME Quiz at jamanetwork.com/learning

Author Affiliations: Author affiliations are listed at the end of this article.

Corresponding Author: Yin Cao, MPH, ScD, Division of Public Health Sciences, Department of Surgery, Washington University School of Medicine, 660 S Euclid Ave, Campus Box 8100, St Louis, MO 63110 (yin.cao@wustl.edu).

Prolonged total sitting time and domain-specific sedentary behaviors, particularly sitting watching television, have been associated with increased risk of obesity,[1] cardiovascular disease,[2] cancer,[3] diabetes,[4] and overall mortality.[5] Physical activity eliminates the excess risk associated with prolonged sitting only among highly active individuals (ie, 10-11 h/wk of brisk walking),[6] leaving the majority of the US population who are inactive or who merely participate in the recommended amount of physical activity[7] at higher risk of mortality associated with sitting. Indeed, the second edition of the seminal 10-year update of the *Physical Activity Guidelines for Americans*[8] not only acknowledged the health risks associated with sedentary behaviors but also, for the first time suggested that most people would benefit from both increasing moderate to vigorous physical activity and reducing time spent sitting.[9]

However, the second edition of the *Physical Activity Guidelines for Americans*[9] does not prescribe a quantitative key guideline for sitting time. Trends in sedentary behaviors remain poorly described in the US population. Increased screen time has been reported in children,[10] but findings among adolescents are mixed.[11,12] Analyses among adults have not reported trends over time[13] or were limited by the use of regional data.[14] A recent analysis of 2015-2016 National Health and Nutrition Examination Survey (NHANES) data suggested that 25.7% of US adults reported more than 8 hours of total sitting time per day, yet the report utilized a single cross-sectional sample.[7] Because the pattern of sedentary behaviors varies substantially by age, comprehensive temporal trend analysis across major age groups utilizing nationally representative data would be essential for the development of age-specific public health campaigns or programs. In addition, sociodemographic and lifestyle correlates of prolonged sitting have not been systematically evaluated in the population.

To address these, trends in sedentary behaviors among the US population were examined, overall and according to sociodemographic and lifestyle characteristics, utilizing data from the NHANES.

Key Points

Question What were the levels and changes of sedentary behaviors among the US population from 2001 through 2016?

Findings In this serial cross-sectional study that included 51 896 participants, the estimated prevalence of sitting watching television or videos at least 2 h/d was high in 2015-2016 (ranging from 59% to 65%); the estimated prevalence of computer use outside school or work for at least 1 h/d increased from 2001 to 2016 (from 43% to 56% for children, from 53% to 57% among adolescents, and from 29% to 50% for adults); and estimated total sitting time increased from 2007 to 2016 (from 7.0 to 8.2 h/d among adolescents and from 5.5 to 6.4 h/d among adults).

Meaning In the US population, sedentary behaviors generally remained stable and high or increased from 2001 through 2016, depending on the specific activity.

Methods

Study Population

The NHANES, described in detail elsewhere,[15] has since 1999 surveyed a nationally representative, complex, stratified, multistage probability sample of the civilian noninstitutionalized US population continuously in 2-year cycles, including a household interview and a physical examination in a mobile examination center. The NHANES obtained approval from the National Center for Health Statistics Research Ethics Review Board, and participants provided written consent. In the present study, age groups were defined as children 5 through 11 years, adolescents 12 through 19 years, and adults 20 years or older.[16] Information on sociodemographic characteristics, weight and height, lifestyle, and sedentary behaviors was combined into a single data set for each data cycle from the 2001-2002 to 2015-2016 cycles, while excluding those who were younger than 5 years (due to unavailable sedentary behavior measure) or living with physical function limitations (defined as crawl, walk, run, or play limitations for children and adolescents; and difficulty walking for a quarter mile or walking up 10 steps for adults).[16] Trends in screen-based sedentary behaviors were presented using estimated prevalence of sitting watching television or videos for 2 h/d or more and computer use outside school or work for 1 h/d or more from 2001 through 2016 in children and from 2003 to 2016 for adolescents and adults. Trends in total sitting time were presented from 2007 through 2016 for adolescents and adults. All trends were examined by sex, race/ethnicity, annual household income, weight status, leisure-time physical activity, and educational attainment and smoking status (adult only).

Assessment of Sedentary Behaviors

Screen-based sedentary behaviors, including time spent sitting watching television or videos and computer use outside school or work were assessed using 2 consistent questions for children (cycle 2001-2002 to 2015-2016; reported by parents) and adolescents and adults (cycle 2003-2004 to 2005-2006, and 2011-2012 to 2015-2016) (eTable 1 in the Supplement). They were asked, (1) "Over the past 30 days, on average, how many hours per day did [you/child's name] sit and watch television or videos?" and (2) "Over the past 30 days, on average, about how many hours per day did [you/child's name] use a computer or play computer games outside of school or work?" with options of none, less than 1 hour, 1 hour, 2 hours, 3 hours, 4 hours, or 5 hours or more per day. Because of the categorical nature of these data, for primary analyses, participants' responses were further categorized into less than 2 vs 2 h/d or more for sitting watching television or videos and less than 1 vs 1 h/d or more for computer use. These cutoffs, previously used in other studies,[17,18] also approximated the median values in the present study population. Both the NHANES questions have shown evidence of test-retest reliability in measuring television or video watching (intraclass correlation coefficient, 0.32) and computer use (intraclass correlation coefficient, 0.69) in the US adult sample.[19] In addition, similar questions assessing parental reports of children's television watching and computer use have yielded high reliability coefficients (intraclass correlation or Pearson *r* ranged from 0.60

to 0.80) in the youth sample.[20] Of note, the nature of television or video watching and computer use behaviors have changed over time, such as video watching shifting from television to personal devices, reading shifting from books to computers and personal devices, which are in part captured by the NHANES as "sit[ting] and watch[ing] television or videos."

Total sitting time was assessed among adolescents and adults, but not children, from the 2007-2008 cycle through the 2015-2016 cycle. Participants were asked "(in a typical week), how much time (minutes) do you usually spend sitting (or reclining) on a typical day (including time spent sitting at a desk, sitting with friends, traveling in a car or bus, or train, reading, playing cards, watching television, or using a computer)?" Responses were converted to hours per day.[19] A similar total sitting question: "During the last 7 days, how much time did you usually spend sitting on a week-day/weekend day?" was used in the International Physical Activity Questionnaire—and has been validated (criterion validity Spearman's ρ >0.45) in the US adult sample with high repeatability (test-retest Spearman ρ >0.71).[21] Participants who reported more than 16 hours (approximately the average waking hours per day)[13] of daily total sitting time were considered implausible values and were excluded.

Assessment of Sociodemographic and Lifestyle Characteristics

Self-reported sociodemographic characteristics included sex, annual household income (<$25 000, $25 000-$74 999, and ≥$75 000), and educational attainment (< high school, high school, and >high school for adults only). In addition, prior research demonstrated distinct patterns according to racial/ethnic group in television watching behavior among children and adolescents[22,23] and in total sitting time among adolescent and adults.[13] In the present analyses, race/ethnicity were defined as non-Hispanic white, non-Hispanic black, Hispanic, and other (includes races other than non-Hispanic white, non-Hispanic black, or Hispanic, including multiracial)[16] according to participant self-report (proxy reported for children and adolescents aged 5-16 years). Weight and height were measured during the physical examination at the mobile examination center, and body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Among children and adolescents, BMI-to-age percentile cutoffs (Center for Disease Control and Prevention) were used: normal (5th-84th percentile), overweight (85th-94th percentile), and obese (≥95th percentile).[24] For adults, BMI was classified into normal (18.5-24.9), overweight (25.0-29.9), and obese (≥30.0). Underweight participants (<5th percentile for children and adolescents and <18.5 for adults) were excluded due to potential underlying health conditions. Leisure-time physical activity was assessed using separate questions within each age group. Children's leisure-time physical activity was defined using a binary variable dichotomized by cycle-specific median cutoffs to represent inactive and active, respectively. Among adolescents and adults, no vs any moderate or vigorous physical activity at leisure time was used to define inactive vs active participants. Smoking status was assessed in adults only, as never, former, or current smokers (eMethods in the Supplement).

Statistical Analyses

Survey analysis procedures were used to account for sample weights, stratification, and clustering of the complex sampling design to ensure nationally representative estimates.[15] Estimates on crude weighted prevalence and 95% CIs of sitting watching television or videos (≥2 h/d) and computer use outside school or work (≥1 h/d), and crude weighted means and 95% CIs of total sitting time (h/d) were calculated by cycle and age group. Crude linear trends in sedentary behaviors were evaluated using linear regression models across survey cycles and to estimate regression coefficients (β) and 95% CIs for every 2-year change. *P* for trends were estimated using the survey cycle as a continuous variable. Absolute differences in the estimated prevalence of screen-based behaviors were calculated by comparing the 2015-2016 cycle with the corresponding baseline cycle (children, 2001-2002; adolescents and adults, 2003-2004). Among adolescents and adults, the absolute difference in total sitting time (h/d) between the 2015-2016 and 2007-2008 cycles was calculated. Additionally, crude trends in screen-based sedentary behaviors (≥3 and ≥4 h/d for television or video and ≥2 and ≥3 h/d for computer) were visually illustrated.

Logistic regressions were used to model prevalence of screen-based behaviors and estimate odds ratios (ORs), while linear regressions were used to model total sitting time and estimate regression coefficients to evaluate age-adjusted, and multivariable-adjusted linear trends. Sociodemographic and lifestyle correlates for sedentary behaviors over time were identified using multivariable regression models adjusting for sex, race/ethnicity, weight, annual household income, leisure-time physical activity for all participants and educational attainment and smoking status for adults. Individuals with missing covariates were excluded, and sensitivity analyses were conducted using indicators for missingness. Overall and race/ethnicity-specific predicted margins on the prevalence or means were estimated for each cycle standardizing to the joint sample distribution of the model covariates. Due to insufficient sample size, the race/ethnicity category "other" (other than non-Hispanic white, non-Hispanic black, and Hispanic) was excluded in subgroup analyses. Similarly, due to the small number of adults 65 years or older, their trends in sedentary behaviors were presented separately from younger adults (20-64 years) but grouped together in multivariable regression models. All statistical tests were 2-sided and statistical significance was set at $P < .05$. *P* values were not adjusted for multiple testing and should be interpreted as exploratory. Data were analyzed using Stata version 14.0 (Stata Corp).

Results

After excluding 669 underweight participants (1.2%), 3720 (6.5%) with limitations on physical function, 718 (1.3%) with missing data on sedentary behavior, and 61 (0.1%) with reported total sitting time longer than 16 h/d, a total of 51 896

Table 1. Sample Size for Daily Sedentary Behaviors in the US Population by Sociodemographic and Lifestyle Characteristics, NHANES 2015-2016[a]

	No. of Participants by Age Group (Weighted %)[b]		
	5-11 y	12-19 y	≥20 y
Overall	1415 (100)	1141 (100)	4542 (100)
Sex			
Female	707 (51.6)	557 (49.5)	2311 (50.4)
Male	708 (48.4)	584 (50.5)	2231 (49.6)
Race/ethnicity			
Non-Hispanic white	385 (50.9)	297 (51.6)	1408 (63.3)
Non-Hispanic black	316 (13.7)	264 (14.7)	946 (11.2)
Hispanic	515 (25.6)	397 (23.8)	1417 (15.9)
Other[c]	199 (9.8)	183 (9.9)	771 (9.6)
Annual household income, $			
<25 000	353 (18.0)	252 (15.1)	961 (13.6)
25 000-<75 000	556 (36.3)	500 (39.8)	1805 (37.2)
≥75 000	383 (37.9)	293 (39.1)	1288 (40.7)
Weight status[d]			
Normal	841 (62.1)	597 (53.5)	1234 (27.7)
Overweight	286 (19.9)	285 (25.0)	1445 (31.5)
Obese	218 (13.5)	229 (19.3)	1652 (36.5)
Leisure-time physical activity[e]			
Active	813 (56.1)	883 (79.5)	2441 (60.4)
Inactive	602 (43.9)	258 (20.5)	2101 (39.6)
Educational attainment[f]			
<High school			969 (12.8)
High school			949 (19.8)
>High school			2624 (67.4)
Smoking status[f]			
Never			2806 (59.5)
Former			948 (23.3)
Current			781 (17.1)

[a] Participant characteristics were presented according to age group: 5-11 years, 12-19 years, ≥20 years. Sample size was weighted to be nationally representative, with the 10.7% in the child group, 11.4% in the adolescent group, and 77.9% in the adult group representing the US population.

[b] No. of participants within each age group may not sum to equal the unweighted number due to missing data. Weighted percentage may not sum to 100% due to missing data.

[c] "Other" includes race/ethnicity other than non-Hispanic white, non-Hispanic black, or Hispanic, including multiracial.

[d] Weight status was defined by body mass index, calculated as weight in kilograms divided by height in meters squared. The US Centers for Disease Control and Prevention (CDC) growth chart was used for children aged 5 through 11 years and adolescents aged 12 through 19 years: underweight was defined as less than the 5th percentile; normal weight, from the 5th to less than the 85th percentile; overweight, from the 85th to less than the 95th percentile; and obese, the 95th percentile and higher. Standard BMI cutoffs (normal weight, <25; overweight, 25-29.9; obese, ≥30) were used for adults 20 years or older.

[e] Leisure-time physical activity level was defined by lower than (inactive) or higher than (active) the median cutoff of times per week of play or exercise involving hard breathing (2001-2008) or days of physical activity that amounted to at least 60 minutes in the past 7 days (2009-2016) for participants aged 5 through 11 years; and by engaging in no (inactive) or any (active) moderate or vigorous recreational physical activity over the past 30 days (2001-2006) or in a typical week (2007-2016) for participants aged 12 through 19 years and 20 years or higher.

[f] Information on educational attainment and smoking status was collected only among participants 20 years or older.

individuals (mean age, 37.2 years [SE, 0.19 years]; 25 968 [50%] female) were analyzed, including 10 359 children, 9639 adolescents, and 31 898 adults. The sample size per cycle ranged from 1139 to 1430 children; 1097 to 1990 adolescents; and 4008 to 4724 adults. Unweighted sample sizes in the 2015-2016 cycle overall and for each age group by sociodemographic and lifestyle characteristics are presented in **Table 1** and eTable 2 in the Supplement. For the weighted sample size, see eTable3 in the Supplement. Participants with missing covariates (12.4% children, 14.0% adolescents, 12.4% adults) were excluded in the multivariable analyses.

Screen-Based Sedentary Behaviors

Sitting Watching Television or Videos

In the 2015-2016 cycle, a substantial proportion of the population spent at least 2 h/d sitting watching television or videos. The estimated prevalence among children was 62% (95% CI, 57% to 67%); adolescents, 59% (95% CI, 54% to 65%); adults overall, 65% (95% CI, 61% to 69%). Among adults aged 20 to 64 years, the estimated prevalence was 62% (95% CI, 58% to 66%) and among those 65 years or older, 84% (95% CI, 81% to 88%; **Table 2**), with a large proportion spending 2 to 3 h/d (**Figure 1**). Across all age groups, 28% to 38% of the

Table 2. Crude Weighted Trends in Sedentary Behaviors Among the US Population, NHANES 2001-2016[a,b]

Age, y	Trends in Sedentary Behaviors NHANES Cycle Years 2001-2002	2003-2004	2005-2006	2007-2008	2009-2010	2011-2012	2013-2014	2015-2016	β (95% CI)[c]	*P* for Trend[c]	2015-2016 vs First Cycle, Difference (95% CI)[d]
Sitting Watching Television or Videos ≥2 h/d, Weighted % (95% CI)											
5-11	65.5 (59.1 to 72.0)	72.6 (68.1 to 77.2)	61.0 (56.3 to 65.7)	63.2 (57.8 to 68.7)	61.8 (54.5 to 69.1)	63.6 (59.2 to 68.0)	57.6 (53.7 to 61.4)	62.2 (57.1 to 67.2)	−1.1 (−1.9 to −0.4)	.004	−3.4 (−11.2 to 4.5)
12-19		64.2 (59.4 to 68.9)	57.5 (53.7 to 61.3)			63.2 (57.5 to 69.0)	60.6 (57.5 to 63.7)	59.4 (53.7 to 65.0)	−0.2 (−1.1 to 0.6)	.60	−4.8 (−11.8 to 2.3)
≥20		64.7 (61.8 to 67.6)	64.1 (62.1 to 66.1)			66.9 (64.2 to 69.5)	65.9 (64.0 to 67.9)	65.1 (61.4 to 68.8)	0.2 (−0.3 to 0.8)	.38	0.4 (−4.1 to 4.9)
20-64		62.3 (59.1 to 65.4)	61.8 (59.4 to 64.2)			63.8 (61.2 to 66.4)	63.2 (61.1 to 65.3)	61.5 (57.6 to 65.5)	0.1 (−0.5 to 0.6)	.82	−0.7 (−5.6 to 4.1)
≥65		80.6 (77.2 to 84.0)	79.1 (74.2 to 84.1)			86.2 (82.6 to 89.8)	82.4 (80.3 to 84.4)	84.1 (80.6 to 87.5)	0.8 (0.1 to 1.4)	.03	3.5 (−1.2 to 8.1)
Computer Use Outside School or Work ≥1 h/d, Weighted % (95% CI)											
5-11	42.9 (39.7 to 46.0)	36.8 (30.1 to 43.5)	33.2 (28.4 to 38.0)	41.4 (36.3 to 46.5)	39.7 (34.0 to 45.4)	47.1 (40.0 to 54.3)	54.2 (50.4 to 57.9)	55.9 (48.8 to 63.0)	2.6 (1.8 to 3.4)	<.001	13.0 (5.6 to 20.5)
12-19		52.6 (47.1 to 58.0)	54.8 (50.7 to 59.0)			62.4 (57.7 to 67.1)	64.1 (59.2 to 68.9)	57.4 (53.2 to 61.6)	1.4 (0.5 to 2.3)	.002	4.8 (−1.8 to 11.4)
≥20		29.3 (27.0 to 31.5)	32.0 (28.6 to 35.3)			50.1 (45.7 to 54.6)	49.0 (46.3 to 51.8)	50.4 (47.7 to 53.1)	3.9 (3.4 to 4.4)	<.001	21.2 (17.8 to 24.5)
20-64		31.3 (28.7 to 34.0)	33.6 (30.4 to 36.8)			52.1 (47.6 to 56.5)	49.9 (47.5 to 52.4)	49.9 (47.1 to 52.6)	3.6 (3.1 to 4.1)	<.001	18.5 (14.9 to 22.2)
≥65		15.4 (12.3 to 18.5)	21.1 (15.2 to 27.0)			38.1 (31.4 to 44.8)	43.6 (36.7 to 50.5)	53.4 (46.4 to 60.5)	6.1 (5.1 to 7.2)	<.001	38.0 (30.7 to 45.4)
Total Sitting Time (h/d), Weighted Mean (95% CI)											
12-19				7.0 (6.7 to 7.4)	7.2 (6.7 to 7.6)	7.9 (7.5 to 8.4)	8.4 (8.0 to 8.7)	8.2 (7.9 to 8.4)	0.3 (0.3 to 0.4)	<.001	1.1 (0.7 to 1.5)
≥20				5.5 (5.2 to 5.7)	5.6 (5.5 to 5.7)	6.2 (6.0 to 6.5)	7.0 (6.7 to 7.2)	6.4 (6.2 to 6.6)	0.3 (0.3 to 0.4)	<.001	1.0 (0.7 to 1.3)
20-64				5.5 (5.2 to 5.7)	5.7 (5.5 to 5.8)	6.3 (6.0 to 6.5)	7.0 (6.8 to 7.2)	6.5 (6.2 to 6.7)	0.3 (0.3 to 0.4)	<.001	1.0 (0.6 to 1.3)
≥65				5.3 (4.9 to 5.6)	5.3 (5.0 to 5.7)	6.0 (5.7 to 6.4)	6.8 (6.4 to 7.1)	6.1 (5.8 to 6.4)	0.3 (0.2 to 0.4)	<.001	0.9 (0.4 to 1.3)

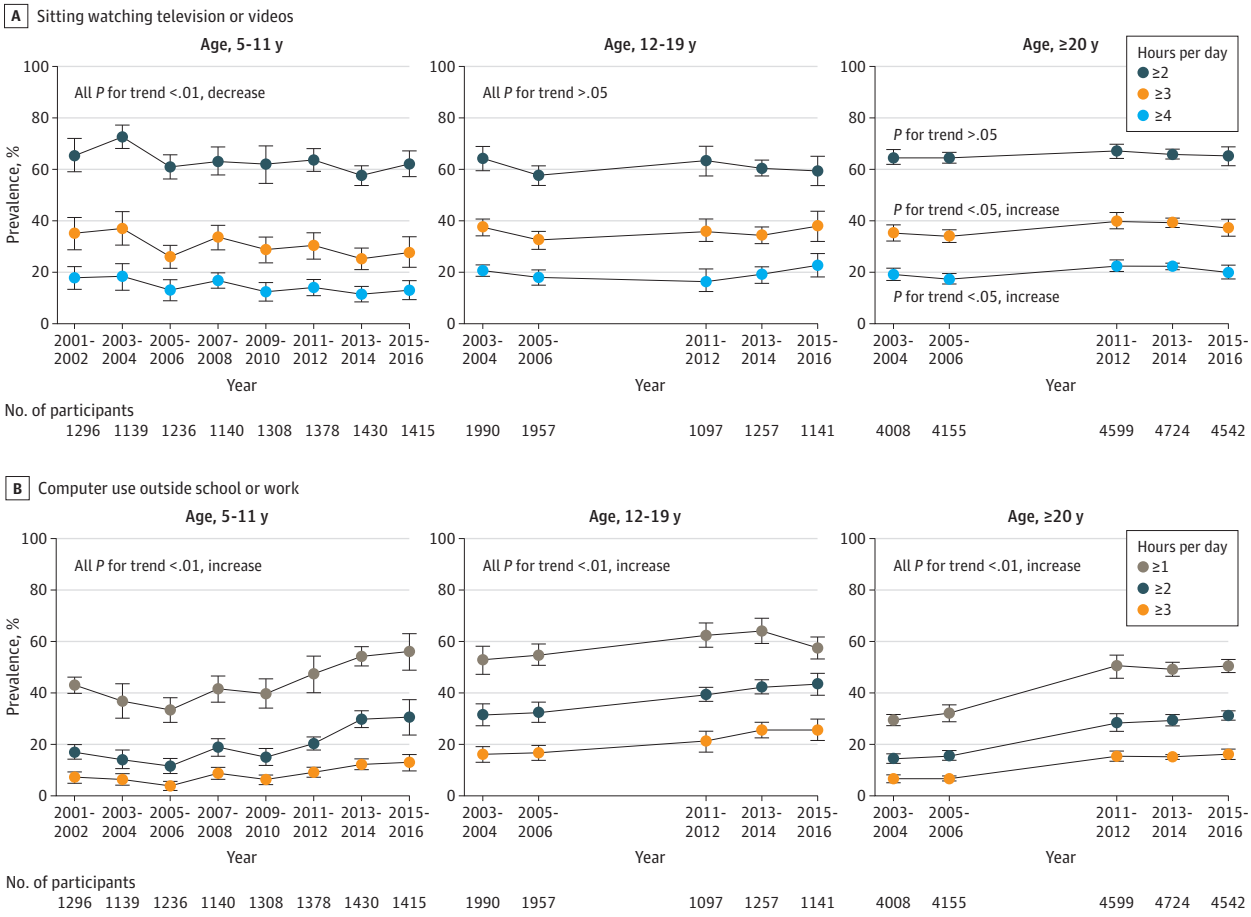
[a] Sample sizes for individual cells ranged from 747 to 4724 and can be found in eTable 3 in the Supplement.

[b] Weighted estimates and 95% CIs were estimated for each survey cycle. All estimates were weighted to be nationally representative.

[c] The estimate β, 95% CI, and *P* for trend were calculated using linear regression that included the National Health and Nutrition Examination Survey (NHANES) 2-year cycle as a continuous variable. The estimate β can be interpreted as the average percentage point change in prevalence every 2 years.

[d] A decrease corresponds to difference below zero.

Figure 1. Crude Weighted Trends in Screen-Based Sedentary Behaviors Among the US Population, NHANES 2001-2016



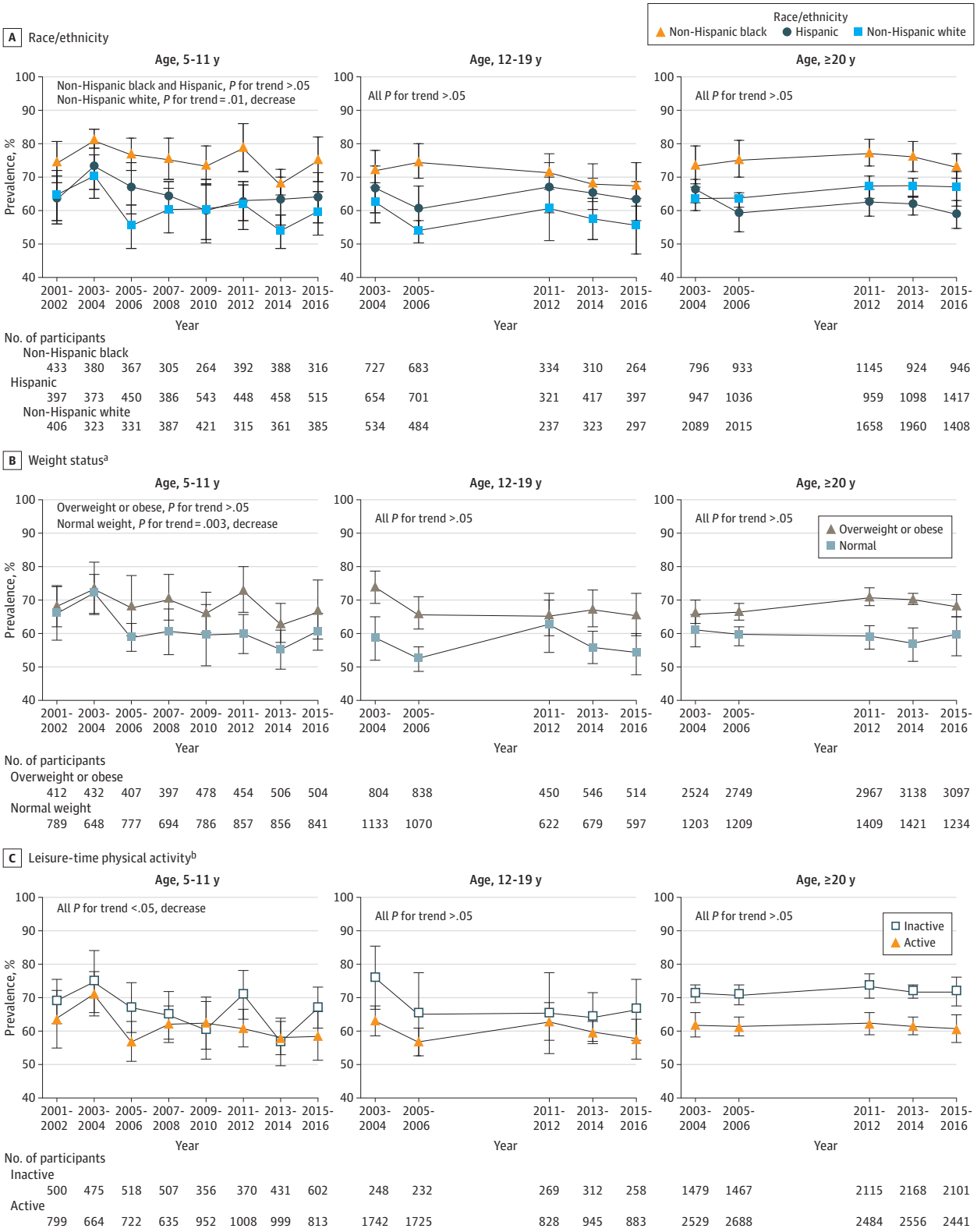
Data were weighted to be nationally representative. Error bars indicate 95% CIs; NHANES, National Health and Nutrition Examination Survey.

US population spent 3 h/d or more, and 13% to 23% spent 4 h/d or more sitting watching television or videos.

Compared with the 2001-2002 or 2003-2004 cycles, the 2015-2016 estimated prevalence of sitting watching television or videos (≥2 h/d) was stable over time among adolescents (*P* for trend = .60) and adults 20 years or older (*P* for trend = .38), primarily among younger adults aged 20 through 64 years (*P* for trend = .82). For prevalence estimates, see Table 2; for sample size, see eTable 3 in the Supplement. In children, a statistically significant decline was noted since 2001 (*P* for trend = .004). However, this decline was driven largely by a decrease among non-Hispanic white children (*P* for trend = .01). For prevalence estimates, see **Figure 2** and eTable 4 in the Supplement. In contrast, a significant increase appeared in adults older than 65 years (*P* for trend = .03). For prevalence estimates see Table 2. Overall and racial/ethnic-specific estimated prevalence and trends remained similar after age and multivariable adjustment. For overall and racial/ethnic-specific prevalence estimates and *P* for trend values, see eTable 5 in the Supplement.

Significantly higher estimated prevalence was consistently observed across all ages after multivariable adjustment among males, non-Hispanic black, obese, or physically inactive participants. Compared with females, the OR for boys aged 5-11 years was 1.12 (95% CI, 1.01-1.26); for boys aged 12-19 years, 1.17 (95% CI, 1.02-1.34); and for adult men, 1.14 (95% CI, 1.06-1.23). Compared with their non-Hispanic white counterparts, the OR for non-Hispanic black children was 1.81 (95% CI, 1.56-2.09); for non-Hispanic black adolescents, 1.64 (95% CI, 1.39-1.94); and for non-Hispanic adults, 1.63 (95% CI, 1.43-1.86). Compared with their normal-weight counterparts, the OR for obese children was 1.59 (95% CI, 1.32-1.90); for obese adolescents, 1.80 (95% CI, 1.45-2.22); and for adults who were obese, 1.59 (95% CI, 1.43-1.76). Compared with their physically active counterparts, the OR for inactive children was 1.25 (95% CI, 1.07-1.45); for inactive adolescents, 1.24 (95% CI, 1.00-1.53); and for adults who were inactive, 1.36 (95% CI, 1.25-1.48) (**Table 3** and Figure 2). Additionally, children and adults from lower-income families tended to watch more television or videos (both *P* for trend <.005). For comparative absolute prevalence estimates in the 2015-2016 cycle, see eTable 6 in the Supplement, and the estimated ORs and *P* for trends for the 2015-2016 cycle, see eTable 7 in the Supplement.

Figure 2. Crude Weighted Trends in Sitting Watching Television or Videos (≥ 2 h/d) According to Race/Ethnicity, Weight Status, and Physical Activity, NHANES 2001-2016



[a] For weight status definitions, see the Table 1 footnotes.

[b] For leisure-time physical activity definitions, see the Table 1 footnotes.

Data were weighted to be nationally representative. Error bars indicate 95% CIs.

Table 3. Weighted Logistic Regression Models of Screen-Based Sedentary Behaviors, Adjusted for Sociodemographic and Lifestyle Characteristics, NHANES 2001-2016[a]

	Odds Ratio (95% CI)[b]					
	Sitting Watching Television or Videos ≥2 h/d			Computer Use Outside School or Work ≥1 h/d		
	5-11 y	12-19 y	≥20 y	5-11 y	12-19 y	≥20 y
No.	9228	6759	19 306	9228	6759	19 306
Age[c]	1.05 (1.02-1.09)	1.02 (0.98-1.06)	1.02 (1.02-1.02)	1.17 (1.13-1.20)	1.04 (1.00-1.07)	0.98 (0.98-0.98)
Sex						
Female	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
Male	1.12 (1.01-1.26)	1.17 (1.02-1.34)	1.14 (1.06-1.23)	1.84 (1.64-2.06)	1.36 (1.18-1.57)	1.09 (1.01-1.18)
Race/ethnicity						
Non-Hispanic white	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
Non-Hispanic black	1.81 (1.56-2.09)	1.64 (1.39-1.94)	1.63 (1.43-1.86)	2.26 (1.93-2.64)	1.08 (0.90-1.29)	1.07 (0.95-1.20)
Hispanic	1.05 (0.92-1.20)	1.21 (1.00-1.46)	0.86 (0.78-0.96)	0.90 (0.78-1.04)	0.79 (0.68-0.93)	0.65 (0.58-0.73)
Other[d]	0.99 (0.80-1.22)	0.90 (0.70-1.17)	0.86 (0.74-1.00)	1.37 (1.08-1.73)	1.79 (1.39-2.32)	1.17 (1.02-1.34)
Annual household income, $						
<25 000	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
25 000-<75 000	0.96 (0.82-1.12)	1.10 (0.93-1.30)	0.97 (0.87-1.08)	1.29 (1.14-1.47)	1.12 (0.95-1.31)	1.10 (0.98-1.25)
≥75 000	0.61 (0.52-0.71)	0.95 (0.76-1.18)	0.81 (0.71-0.92)	1.15 (0.97-1.37)	1.60 (1.30-1.97)	1.19 (1.04-1.37)
P for trend[e]	<.001	.76	.001	.37	<.001	.06
Weight status[f]						
Normal	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
Overweight	1.08 (0.93-1.26)	1.40 (1.21-1.62)	1.20 (1.09-1.31)	1.04 (0.88-1.22)	0.99 (0.83-1.18)	1.13 (1.01-1.26)
Obese	1.59 (1.32-1.90)	1.80 (1.45-2.22)	1.59 (1.43-1.76)	1.01 (0.86-1.20)	1.24 (1.07-1.42)	1.28 (1.16-1.40)
P for trend[g]	<.001	<.001	<.001	.62	.01	<.001
Leisure-time physical activity[h]						
Active	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
Inactive	1.25 (1.07-1.45)	1.24 (1.00-1.53)	1.36 (1.25-1.48)	1.26 (1.11-1.42)	1.27 (1.09-1.48)	0.95 (0.87-1.04)
Educational attainment[i]						
<High school			1 [Reference]			1 [Reference]
High school			1.24 (1.09-1.41)			1.91 (1.63-2.24)
>High school			0.93 (0.82-1.06)			3.00 (2.57-3.50)
Smoking status[i]						
Never			1 [Reference]			1 [Reference]
Former			1.11 (0.99-1.24)			1.11 (0.99-1.24)
Current			1.44 (1.28-1.62)			1.02 (0.91-1.15)
Cycle						
2001-2002	1 [Reference]			1 [Reference]		
2003-2004	1.24 (0.85-1.79)	1 [Reference]	1 [Reference]	0.78 (0.58-1.03)	1 [Reference]	1 [Reference]
2005-2006	0.81 (0.57-1.15)	0.73 (0.59-0.90)	0.98 (0.84-1.14)	0.65 (0.51-0.82)	1.04 (0.78-1.38)	1.13 (0.95-1.33)
2007-2008	0.85 (0.60-1.22)			0.94 (0.75-1.19)		
2009-2010	0.81 (0.54-1.22)			0.88 (0.68-1.16)		
2011-2012	0.93 (0.65-1.33)	0.96 (0.71-1.29)	1.13 (0.96-1.33)	1.30 (0.95-1.77)	1.42 (1.07-1.89)	2.62 (2.20-3.11)
2013-2014	0.70 (0.49-1.00)	0.83 (0.67-1.02)	1.09 (0.94-1.27)	1.65 (1.35-2.02)	1.47 (1.06-2.02)	2.41 (2.10-2.77)
2015-2016	0.85 (0.58-1.24)	0.75 (0.58-0.97)	1.08 (0.88-1.33)	1.88 (1.41-2.52)	1.11 (0.84-1.47)	2.54 (2.17-2.97)
P for trend[j]	.02	.29	.12	<.001	.03	<.001

[a] Participant characteristics were presented by age group: 5-11 years, 12-19 years and 20 years old or older. All estimates were weighted to be nationally representative.

[b] For categorical variables, the odds ratios (ORs) represent the change in odds expected in each category compared with the reference group.

[c] The ORs in this row represent the change in odds expected from a 1-year increase in age within this age group.

[d] "Other" includes race/ethnicity other than non-Hispanic white, non-Hispanic black, and Hispanic, including multiracial.

[e] *P* for trend over annual household income was calculated using the median value of each category as a continuous variable.

[f] For weight status definitions, see the Table 1 footnotes.

[g] Calculated using BMI as a continuous variable.

[h] For leisure-time physical activity definitions, see the Table 1 footnotes.

[i] Information on educational attainment and smoking status was collected only among participants 20 years or older.

[j] *P* for trend over survey cycle was calculated using the National Health and Nutrition Examination Survey (NHANES) 2-year survey cycle as a continuous variable.

Computer Use Outside School or Work

In the 2015-2016 cycle, 56% (95% CI, 49% to 63%) of children, 57% (95% CI, 53% to 62%) of adolescents, 50% (95% CI, 47% to 53%) of adults aged 20 through 64 years, and 53% (95% CI, 46% to 61%) of adults 65 years or older spent at least 1 h/d using the computer outside of school or work (Table 2). Among them, the majority used a computer for 1 to 3 hours daily (Figure 1). Overall, outside school or work, 30% to 43% of the US population used a computer for 2 h/d or more, and 13% to 25% used a computer for 3 or more hours each day.

In contrast to the generally stable trends in sedentary television or video viewing time, computer use outside school or work (≥1 hour/d) significantly increased among all age groups from 2001 or 2003 to 2016 (for prevalence estimates, see Table 2; for sample size, see eTable 3), primarily driven by the increasing proportion of the population that used 2 h/d or more (Figure 1). The estimated prevalence of 1 h/d or more of leisure-time computer use increased from 43% (95% CI, 40% to 46%) to 56% (95% CI, 49% to 63%) between 2001 and 2016 for children (*P* for trend <.001; difference, 13% [95% CI, 5.6% to 21%]). Between 2003 and 2016, the estimated prevalence of computer use outside school or work of 1 h/d or more increased from 53% (95% CI, 47% to 58%) to 57% (95% CI, 53% to 62%) for adolescents (*P* for trend = 0.002; difference, 4.8% [95% CI, −1.8% to 11%]). Among adults, the estimated prevalence increased from 29% (95% CI, 27% to 32%) to 50% (95% CI, 48% to 53%) between 2003 and 2016 (*P* for trend <.001; difference, 21% [95% CI, 18% to 25%]), with a greater increment among those 65 years or older, from 15% (95% CI, 12% to 19%) to 53% (95% CI, 46% to 61%, *P* for trend <.001) for a difference of 38% (95% CI, 31% to 45%). Age and multivariable adjustment revealed similar overall and racial/ethnic-specific trends of computer use (eTable 5 in the Supplement).

Correlates of higher estimated prevalence of computer use outside school or work (≥1 h/d) were noted with less consistent patterns across age groups over time (for estimated ORs and *P* for trend, see Table 3; for 2015-2016 cycle, see eTable 7 in the Supplement). For instance, males of all ages, children who were non-Hispanic black, children and adolescents who were physically inactive, adolescents and adults with higher BMI, and adolescents from families with higher household income reported higher estimated prevalence of computer use (for estimated ORs and *P* for trend, see Table 3; and for the 2015-2016 cycle, see eTable 7 in the Supplement).

Total Sitting Time

From 2007 to 2016, the crude total sitting time increased in both adolescents and adults (*P* for trend <.001 for all). Total sitting time increased from 7.0 to 8.2 h/d among adolescents (difference, 1.1 [95% CI, 0.7 to 1.5]), from 5.5 to 6.5 h/d among younger adults (difference, 1.0 [95% CI, 0.6 to 1.3]), and from 5.3 to 6.1 h/d among older adults (difference, 0.9 [95% CI, 0.4 to 1.3]) (Table 2, for sample size see eTable 3 in the Supplement). Overall and racial/ethnic trends in total sitting time remained significant after multivariable adjustment (*P* for trend <.001 for all) (eTable 8 in the Supplement). Prolonged total sitting was observed in adults with higher household income, educational attainment, or BMI (for coefficients and *P* values for each variable see eTable 9 in the Supplement, and for the 2015-2016 cycle see eTable 10 in the Supplement).

Discussion

In this nationally representative sample of the US population, the estimated prevalence of sitting watching television or videos for 2 h/d or more remained high and stable from 2001 through 2016, except for a decline in non-Hispanic white children and an increase in adults 65 years or older. Meanwhile, the estimated prevalence of computer use during leisure time of 1 h/d or more significantly increased among all age groups with more pronounced increase among adults. Between 2007 and 2016, the estimated total sitting time increased by nearly 1 h/d among adolescents and adults. Although these trends were comparable among most subgroups, males, non-Hispanic blacks, obese or physically inactive individuals reported significantly higher estimated prevalence of prolonged sitting watching television.

In 2018, the Global Action Plan on Physical Activity (2018-2030) for the first time adopted sedentary behavior reduction as one of the strategies for global chronic disease prevention and control.[25] The second edition of *Physical Activity Guidelines for Americans* published in November 2018 further highlighted several knowledge gaps for making specific recommendations to reduce sedentary behaviors and its associated health risks.[8] In particular, understanding the landscape of sedentary behaviors is a critical step before population-wide strategies can be developed and implemented. Although increases in leisure screen-time and sedentary time spent in occupation and commuting have been documented in parts of Europe and Australia,[26-28] US-based studies have thus far been limited to children,[10] with smaller and inconsistent reports among adolescents.[11,12] The majority of data among adults have utilized a single cross-sectional sample[13,18,29,30]; thus, trends in US sedentary behaviors have not been well described. Present analyses provide a contemporary understanding of sedentary behaviors across all age groups in the United States from 2001 to 2016.

Although the estimated prevalence remained generally stable, 60% of the US population spent 2 h/d or more sitting watching television, which is comparable with a recent cross-sectional report from the American Time Use Survey.[31] For all ages, substantially higher prevalence of sitting watching television or videos was observed among male, non-Hispanic black, obese, or physically inactive individuals. A few prior reports have noted that TV watching was more common among children who were non-Hispanic black or obese,[23,32] and for black adolescents.[22] In line with these findings, differences according to sex, race/ethnicity, weight status, and physical activity levels were consistent not only over time but also from early childhood through late adulthood. Because television viewing, the most well-studied sedentary behavior, was associated with increased risk of major chronic diseases[3,5] and all-cause mortality,[5] these observed differences in television viewing time across the life course may

contribute significantly to the existing disparities in these diseases and mortality.[33] Moreover, Matthews et al[34] demonstrated that black adults were at higher risk of all-cause mortality associated with prolonged television viewing than were white adults. Additional studies are warranted to further understand whether certain groups with prolonged sitting may be affected disproportionally.

Of note, the substantial rise in total sitting time among adolescents and adults appears to be attributable to sedentary behaviors other than television or video watching, which was likely driven in part by the observed increases in computer use. Although patterns were less consistent, persistent sociodemographic and lifestyle correlates of computer use appeared since early childhood. Taken together, these findings strengthened the case for understanding patterns of early childhood sedentary behaviors, the trajectory of sitting behaviors across the life course, and their influence on disease outcomes.[35]

The study's strengths include the utilization of a large, nationally representative survey with a rigorous protocol and extensive quality control, the investigation into trends of both screen-based sedentary behaviors and total screen time, and the thorough examination of potential sociodemographic and lifestyle correlates.

Limitations

This study has several limitations. First, self-reported sedentary behaviors may not reflect the true amount of sitting. Nevertheless, self-reported television or computer time and total sitting time have been widely used in epidemiological studies,[3,5,19] and measurement errors were unlikely to affect findings on the secular trends over time. Additionally, estimates on television and computer time were comparable with cross-sectional reports from the Bureau of Labor Statistics' American time use survey,[31] and the total sitting time was similar to that estimated using accelerometry in a prior NHANES study (7.7 h/d).[13] Second, sedentary time using other devices such as phones and tablets were not captured. However, the NHANES questionnaire specifically asks about time "sit[ting] and watch[ing] TV or videos," which may at least partially capture video watching time on personal devices as these behaviors became more ubiquitous. In fact, the majority of national surveys[36] and large epidemiological studies[5] have not yet assessed sedentary time spent on handheld devices. Nevertheless, present conservative estimates have revealed substantial increment in total sitting time over the years. Additionally, reading on a computer may have substituted for reading a book; thus, computer use may have captured the reading time that was previously spent reading books, which was sedentary as well. Third, NHANES was not able to separate sitting playing computer video games from those with a physical activity component. However, based on limited reports from the industry, only 8% to 18% (among different demographic groups) of the US population are regular gamers with 48% of all gamers dedicated to console rather than computer gaming.[37] Hence, assessing time spent on computer use may misclassify related sedentary time but to a minimal extent. Altogether, measuring and understanding the shift in sedentary behaviors and their contributions to disease risk are critical and urgent in reducing the progressive increase in the early-onset of multiple chronic illnesses[38,39] as well as disparities nationwide.

Conclusions

In this nationally representative survey of the US population from 2001 through 2016, the estimated prevalence of sitting watching television or videos for at least 2 hours per day generally remained high and stable. The estimated prevalence of computer use during leisure-time increased among all age groups, and the estimated total sitting time increased among adolescents and adults.

ARTICLE INFORMATION

Accepted for Publication: March 18, 2019.

Author Affiliations: Cancer Epidemiology and Prevention Research, CancerControl Alberta, Alberta Health Services, Calgary, Canada (Yang); Department of Community Health Sciences, Cumming School of Medicine, University of Calgary, Calgary, Alberta, Canada (Yang); Department of Oncology, Cumming School of Medicine, University of Calgary, Calgary, Alberta, Canada (Yang); Department of Epidemiology, Center for Public Health, Medical University of Vienna, Vienna, Austria (Yang); Division of Public Health Sciences, Department of Surgery, Washington University School of Medicine, St Louis, Missouri (C. Cao, Zheng, Park, Colditz, Y. Cao); Department of Epidemiology and Biostatistics, Memorial Sloan Kettering Cancer Center, New York, New York (Kantor); Division of Gastroenterology, Department of Medicine, Massachusetts General Hospital, Boston (Nguyen); Clinical and Translational Epidemiology Unit, Massachusetts General Hospital and Harvard Medical School, Boston (Nguyen); Department of Colorectal Surgery, the Sixth Affiliated Hospital, Sun Yat-sen University, Guangzhou, China (Zheng); Guangdong Provincial Key Laboratory of Colorectal and Pelvic Floor Diseases, the Sixth Affiliated Hospital, Sun Yat-sen University, Guangzhou, China (Zheng); Department of Epidemiology, Harvard T. H. Chan School of Public Health, Boston, Massachusetts (Giovannucci); Department of Nutrition, Harvard T.H. Chan School of Public Health, Boston, Massachusetts (Giovannucci); Division of Cancer Epidemiology and Genetics, National Cancer Institute, Bethesda, Maryland (Matthews); Siteman Cancer Center, Washington University School of Medicine, St Louis, Missouri (Colditz, Y. Cao).

Author Contributions: Dr Yang and Mr Cao had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Dr Yang and Mr Cao contributed equally. Drs Matthews, Colditz, and Cao contributed equally.
Concept and design: Yang, C. Cao, Matthews, Colditz, Y. Cao.
Acquisition, analysis, or interpretation of data: All authors.
Drafting of the manuscript: Yang, C. Cao, Y. Cao.
Critical revision of the manuscript for important intellectual content: All authors.
Statistical analysis: Yang, C. Cao, Y. Cao.
Administrative, technical, or material support: Y. Cao.
Supervision: Matthews, Colditz, Y. Cao.

Conflict of Interest Disclosures: Dr Kantor reported receiving grants from the National Cancer Institute. Dr Colditz reported receiving grants from the National Cancer Institute. No other disclosures were reported.

Funding/Support: Dr Kantor's effort on this project is supported by grant P30CA008748 from the National Cancer Institute. Dr Colditz is supported by grant P30CA091842 from the National Cancer Institute and Biostatistics Shared Resource, a component of the Cancer Center Support grant.

Role of the Funder/Sponsor: The study sponsors had no role in the study design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; or decision to submit the manuscript for publication.

REFERENCES

1. Gortmaker SL, Must A, Sobol AM, Peterson K, Colditz GA, Dietz WH. Television viewing as a cause of increasing obesity among children in the United States, 1986-1990. *Arch Pediatr Adolesc Med*. 1996; 150(4):356-362. doi:10.1001/archpedi.1996.02170290022003

2. Biswas A, Oh PI, Faulkner GE, et al. Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults: a systematic review and meta-analysis. *Ann Intern Med*. 2015;162(2):123-132. doi:10.7326/M14-1651

3. Schmid D, Leitzmann MF. Television viewing and time spent sedentary in relation to cancer risk: a meta-analysis. *J Natl Cancer Inst*. 2014;106(7): dju098. doi:10.1093/jnci/dju098

4. Wilmot EG, Edwardson CL, Achana FA, et al. Sedentary time in adults and the association with diabetes, cardiovascular disease and death: systematic review and meta-analysis. *Diabetologia*. 2012;55(11):2895-2905. doi:10.1007/s00125-012-2677-z

5. Patterson R, McNamara E, Tainio M, et al. Sedentary behaviour and risk of all-cause, cardiovascular and cancer mortality, and incident type 2 diabetes: a systematic review and dose response meta-analysis. *Eur J Epidemiol*. 2018;33 (9):811-829. doi:10.1007/s10654-018-0380-1

6. Ekelund U, Steene-Johannessen J, Brown WJ, et al; Lancet Physical Activity Series 2 Executive Committee; Lancet Sedentary Behaviour Working Group. Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? a harmonised meta-analysis of data from more than 1 million men and women. *Lancet*. 2016;388(10051):1302-1310. doi:10.1016/S0140-6736(16)30370-1

7. Ussery EN, Fulton JE, Galuska DA, Katzmarzyk PT, Carlson SA. Joint prevalence of sitting time and leisure-time physical activity among US adults, 2015-2016. *JAMA*. 2018;320(19):2036-2038. doi:10.1001/jama.2018.17797

8. US Department of Health and Human Services. *Physical Activity Guidelines for Americans*. 2nd ed. Washington, DC: US Dept of Health and Human Services; 2018.

9. Piercy KL, Troiano RP, Ballard RM, et al. The physical activity guidelines for Americans. *JAMA*. 2018;320(19):2020-2028. doi:10.1001/jama.2018.14854

10. Bassett DR, John D, Conger SA, Fitzhugh EC, Coe DP. Trends in physical activity and sedentary behaviors of United States youth. *J Phys Act Health*. 2015;12(8):1102-1111. doi:10.1123/jpah.2014-0050

11. Iannotti RJ, Wang J. Trends in physical activity, sedentary behavior, diet, and BMI among US adolescents, 2001-2009. *Pediatrics*. 2013;132(4): 606-614. doi:10.1542/peds.2013-1488

12. Nelson MC, Neumark-Stzainer D, Hannan PJ, Sirard JR, Story M. Longitudinal and secular trends in physical activity and sedentary behavior during adolescence. *Pediatrics*. 2006;118(6):e1627-e1634. doi:10.1542/peds.2006-0926

13. Matthews CE, Chen KY, Freedson PS, et al. Amount of time spent in sedentary behaviors in the United States, 2003-2004. *Am J Epidemiol*. 2008; 167(7):875-881. doi:10.1093/aje/kwm390

14. Cohen SS, Matthews CE, Signorello LB, Schlundt DG, Blot WJ, Buchowski MS. Sedentary and physically active behavior patterns among low-income African-American and white adults living in the southeastern United States. *PLoS One*. 2013;8(4):e59975. doi:10.1371/journal.pone.0059975

15. Curtin LR, Mohadjer LK, Dohrmann SM, et al. The National Health and Nutrition Examination Survey: Sample Design, 1999-2006. *Vital Health Stat 2*. 2012;(155):1-39.

16. Hales CM, Fryar CD, Carroll MD, Freedman DS, Ogden CL. Trends in obesity and severe obesity prevalence in US youth and adults by sex and age, 2007-2008 to 2015-2016. *JAMA*. 2018;319(16): 1723-1725. doi:10.1001/jama.2018.3060

17. Tremblay MS, LeBlanc AG, Kho ME, et al. Systematic review of sedentary behaviour and health indicators in school-aged children and youth. *Int J Behav Nutr Phys Act*. 2011;8(1):98. doi:10.1186/1479-5868-8-98

18. Sisson SB, Church TS, Martin CK, et al. Profiles of sedentary behavior in children and adolescents: the US National Health and Nutrition Examination Survey, 2001-2006. *Int J Pediatr Obes*. 2009;4(4): 353-359. doi:10.3109/17477160902934777

19. Healy GN, Clark BK, Winkler EA, Gardiner PA, Brown WJ, Matthews CE. Measurement of adults' sedentary time in population-based studies. *Am J Prev Med*. 2011;41(2):216-227. doi:10.1016/j.amepre.2011.05.005

20. Atkin AJ, Gorely T, Clemes SA, et al. Methods of Measurement in epidemiology: sedentary behaviour. *Int J Epidemiol*. 2012;41(5):1460-1471. doi:10.1093/ije/dys118

21. Craig CL, Marshall AL, Sjöström M, et al. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc*. 2003;35(8):1381-1395. doi:10.1249/01.MSS.0000078924.61453.FB

22. Robinson TN, Killen JD. Ethnic and gender differences in the relationships between television viewing and obesity, physical activity, and dietary fat intake. *J Health Educ*. 1995;26(suppl 2):S91-S98. doi:10.1080/10556699.1995.10603155

23. Crespo CJ, Smit E, Troiano RP, Bartlett SJ, Macera CA, Andersen RE. Television watching, energy intake, and obesity in US children: results from the third National Health and Nutrition Examination Survey, 1988-1994. *Arch Pediatr Adolesc Med*. 2001;155(3):360-365. doi:10.1001/archpedi.155.3.360

24. Kuczmarski RJ, Ogden CL, Guo SS, et al. 2000 CDC growth charts for the United States: methods and development. *Vital Health Stat 11*. 2002;(246): 1-190.

25. World Health Organization. Global action plan on physical activity 2018–2030: more active people for a healthier world. https://www.who.int/ncds/prevention/physical-activity/global-action-plan-2018-2030/en/. Published 2018. Accessed March 19, 2019.

26. Chau JY, Merom D, Grunseit A, Rissel C, Bauman AE, van der Ploeg HP. Temporal trends in non-occupational sedentary behaviours from Australian Time Use Surveys 1992, 1997 and 2006. *Int J Behav Nutr Phys Act*. 2012;9:76. doi:10.1186/1479-5868-9-76

27. Aadahl M, Andreasen AH, Hammer-Helmich L, Buhelt L, Jørgensen T, Glümer C. Recent temporal trends in sleep duration, domain-specific sedentary behaviour and physical activity. A survey among 25-79-year-old Danish adults. *Scand J Public Health*. 2013;41(7):706-711. doi:10.1177/1403494813493151

28. van der Ploeg HP, Venugopal K, Chau JY, et al. Non-occupational sedentary behaviors: population changes in the Netherlands, 1975-2005. *Am J Prev Med*. 2013;44(4):382-387. doi:10.1016/j.amepre.2012.11.034

29. Harrington DM, Barreira TV, Staiano AE, Katzmarzyk PT. The descriptive epidemiology of sitting among US adults, NHANES 2009/2010. *J Sci Med Sport*. 2014;17(4):371-375. doi:10.1016/j.jsams.2013.07.017

30. Whitt-Glover MC, Taylor WC, Floyd MF, Yore MM, Yancey AK, Matthews CE. Disparities in physical activity and sedentary behaviors among US children and adolescents: prevalence, correlates, and intervention implications. *J Public Health Policy*. 2009;30(suppl 1):S309-S334. doi:10.1057/jphp.2008.46

31. Bureau of Labor Statistics. American time use survey—2017 results. https://www.bls.gov/news.release/pdf/atus.pdf. Published June 28, 2018. Accessed February 15, 2019.

32. Andersen RE, Crespo CJ, Bartlett SJ, Cheskin LJ, Pratt M. Relationship of physical activity and television watching with body weight and level of fatness among children: results from the Third National Health and Nutrition Examination Survey. *JAMA*. 1998;279(12):938-942. doi:10.1001/jama.279.12.938

33. Wong MD, Shapiro MF, Boscardin WJ, Ettner SL. Contribution of major diseases to disparities in mortality. *N Engl J Med*. 2002;347(20):1585-1592. doi:10.1056/NEJMsa012979

34. Matthews CE, George SM, Moore SC, et al. Amount of time spent in sedentary behaviors and cause-specific mortality in US adults. *Am J Clin Nutr*. 2012;95(2):437-445. doi:10.3945/ajcn.111.019620

35. Walsh JJ, Barnes JD, Cameron JD, et al. Associations between 24 hour movement behaviours and global cognition in US children: a cross-sectional observational study. *Lancet Child Adolesc Health*. 2018;2(11):783-791. doi:10.1016/S2352-4642(18)30278-5

36. Bureau of Labor Statistics. American time use survey questionnaire 2011-17. https://www.bls.gov/tus/tuquestionnaire.pdf. June 2018. Accessed October 26, 2018.

37. Essential facts about the computer and video game industry. Accessed http://www.theesa.com/wp-content/uploads/2017/09/EF2017_Design_FinalDigital.pdf. Published 2017. Accessed February 10, 2019.

38. Wilmot E, Idris I. Early onset type 2 diabetes: risk factors, clinical impact and management. *Ther Adv Chronic Dis*. 2014;5(6):234-244. doi:10.1177/2040622314548679

39. Siegel RL, Fedewa SA, Anderson WF, et al. Colorectal cancer incidence patterns in the United States, 1974-2013. *J Natl Cancer Inst*. 2017;109(8). doi:10.1093/jnci/djw322