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Obesity

Relationships Between Time Use and Obesity in a Representative Sample of Americans

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Objective: To provide a nationally representative analysis of time use in America for insight into behaviors associated with obesity.

Methods: This study utilized 28,503 observations of individuals aged 22 to 70 from the American Time Use Survey, a continuous cross-sectional survey on time use in America. Linear and logistic regressions were performed to analyze sociodemographic characteristics, determine activity participation levels and time spent in activities, understand nonlinear associations between activity time and BMI, and appreciate differences in activity timing between BMI categories.

Results: Short and long sleep and work were associated with increased BMI. On weekdays, individuals with obesity were more likely to be working at night and sleeping during the day. They were less likely to participate in sports/exercise/recreation, but those that participated did so for amounts of time not different than normal-BMI individuals. Those with obesity were more likely to watch television almost all hours of the day. Further differences are detailed for health-related, sedentary, and household activities.

Conclusions: Both short and long sleep, as well as the timing of sleep and work activity, are associated with obesity. Motivation to exercise nonzero amounts may be an appropriate target for intervention. Television is chief among sedentary activities in their association with obesity.

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Introduction

After remaining relatively stable from 1960 to 1980, the prevalence of obesity in the U.S. has increased dramatically in the past 30 years; recent population studies estimate that two-thirds of Americans have overweight or obesity (1). Obesity is a risk factor for a variety of chronic conditions including type 2 diabetes, hypertension, and high cholesterol, and the direct and indirect costs of obesity have been estimated to be as high as $147 billion annually (2,3). Considering the significant physiological and financial costs of obesity, uncontrolled weight gain poses a serious problem in the U.S. As such, research has focused on elucidating the mechanisms underlying the recent increase in the prevalence of obesity and obesity-related disorders and has implicated increased consumption of calorically dense foods and increasingly sedentary lifestyles as significant factors (4,5).

Given the significant implication of lifestyle factors, time use analyses can offer insight into which behaviors in particular might be associated with obesity. In the American Time Use Survey (ATUS), respondents report their activities on a minute-by-minute basis during a 24-h period. The ATUS data set has not yet been utilized to *comprehensively* study the relationships between obesity and time use. The United States Department of Agriculture (USDA), which sponsored the Eating and Health Module that collected data on body mass index (BMI), described how Americans spend their time eating food but did not analyze relationships between obesity and *all* uses of time (6). Similarly, studies have looked at the relationships between obesity and specific activities such as exercising and viewing television (7). Further, studies frequently have utilized metabolic equivalents to group activities based on energy expenditure in order to analyze how individuals in different BMI categories might participate differently in energy expensive activities (8). This article is unique in that it provides an analysis of activities that account for 99.1% of available time.

Our study had four objectives. We first measured sociodemographic associations with obesity. Second, we aimed to understand how activity participation and activity time differ in individuals who are overweight or who have obesity compared with individuals with normal weight.

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Third, we examined nonlinear associations between BMI and activity time for each activity. Finally, we assessed how the *timing* of activity participation differed across individuals in different BMI categories.

Methods

American Time Use Survey

The ATUS is a continuous cross-sectional survey on time use in America; it is sponsored by the Bureau of Labor Statistics and administered by the U.S. Census Bureau. ATUS aims to provide nationally representative estimates of how Americans, aged 15 and older, spend their time. It involves a computer-assisted telephone interview in which survey participants are asked how they spent their time from 4 a.m. the previous day to 4 a.m. the day of the interview. Details of ATUS and its survey and sampling methods are readily available in the literature and in the ATUS User Guide (9).

ATUS codes activities using a three-tier coding system that utilizes 17 first-tier categories; we combined first-, second-, and third-tier levels of details to create 40 activities which, together, account for 99.1% of time use within the 24-h period. Detail of these activities and respective coding can be found in Supporting Information Table 1 and the ATUS Coding Lexicon (http://www.bls.gov/tus/lexicons.htm).

While ATUS has been administered continuously since 2003, only data collected from January 2006 to December 2008 (which included the Eating and Health Module, sponsored by the USDA) were used in this study. The Eating and Health Module collected self-reported height and weight measurements, which enabled the calculation of BMI. Further details of this module can be found in the ATUS Eating and Health Module documentation. We limited our original sample ($n = 37{,}832$) to respondents aged 22 to 70 years (2,195 excluded) with complete BMI data (7,625 excluded) for a final sample of 28,403 observations.

Data analysis

Data analyses were conducted using SAS (v. 9.3, SAS Institute, Carey, NC). Appropriate ATUS weights and replicate weights were obtained from the Eating and Health Module to calculate representative estimates. Details for the use of weights and replicate weights, and the appropriate adjustments necessary for variance estimation, are provided in the ATUS documentation. World Health Organization classifications were used to group respondents into categories (normal and underweight combined: BMI <25 kg/m^2; overweight: 25 kg/m$^2 \leq$ BMI <30 kg/m^2; obesity: BMI ≥ 30 kg/m^2). As there were very few observations with BMI <18.5 kg/m^2 ($n = 374$), we folded these observations into the normal-BMI category.

We first assessed the relationships of BMI with sociodemographic variables and with survey region and year. Separate linear regression models with BMI as the outcome were estimated for each sociodemographic category; a further regression was estimated that included all sociodemographic variables. These results are presented in Table 1 as "univariate" and "controlled for all covariates," respectively. All subsequent analyses were controlled using covariates found to be significant from the analysis controlled for all covariates.

The distribution of time spent participating in many activities revealed a large cluster at zero; however, nonzero activity times consistently followed a normal distribution. Given such a distribution, a two-part model was utilized to separately analyze the decision to participate in a given activity (activity time >0) and the decision on amount of time to spend participating (10-12). In the two-part model, first a logistic regression was estimated with indicator variables for the overweight and obesity categories to determine odds ratios for activity participation compared with the normal-BMI category. Then, utilizing observations with nonzero activity time, a linear regression was estimated to determine differences between BMI categories in the time spent participating. Other methods were also explored to analyze such data; Tobit specification has been shown to produce biased estimates for our particular type of data, and OLS was not appropriate due to the aforementioned distribution of the data (13). These relationships were also analyzed by splitting the data set into working and nonworking days (for employed observations) and weekdays and weekends (for unemployed observations), but no substantially different results were found with this approach (data not shown). Both models were adjusted for age, race, sex, family income, education, employment characteristics, and census region. Analyses were conducted separately for weekdays and weekends/holidays as behavior varies considerably between these two segments of the week; results are presented in Tables 2 and 3.

Linear regression was utilized to assess how BMI may be nonlinearly associated with activity time. Observations were placed into categories of activity time, and a linear regression was estimated with BMI as the outcome and indicator predictor variables for each activity time category; the time category with lowest BMI was utilized as reference. The model was adjusted for age, race, gender, family income, educational attainment, employment characteristics, and census region, and the analysis was separated for weekdays and weekends/holidays. Significant results are presented in Figure 1.

Finally, we investigated whether individuals with obesity and overweight participated in particular activities at different times of day than individuals with normal weight. For each activity, a logistic regression with a binary outcome variable for activity participation was run for every 30-min interval of the 24-h day. The models were adjusted for age, race, sex, family income, educational attainment, employment characteristics, and census region and were estimated separately for weekdays and weekends/holidays. Odds ratios for participation were calculated (with normal-BMI group serving as reference) for each 30-min time interval. Results are presented in Figure 2.

Results

Sociodemographic, geographic, and temporal characteristics

Individual associations between BMI and various sociodemographic, geographic, and temporal characteristics, as well as associations after including all these variables in one model, are presented in Table 1. In the model adjusted for all covariates, younger age; female sex; Asian race; higher levels of education; family income >\$75 k; self-employment; and residence in the West or Northeast census regions were all associated with a lower BMI relative to reference categories whereas age 50 to 59 years; Black, Hispanic, or "other" race; and not being in the labor force were associated with a higher BMI.

TABLE 1 Sociodemographic characteristics

Variable	Pop %	% Norm	% Ovwt	% Obesity	Univariate BMI estimate	BMI controlled for all covariates
Population	100	34.5	36.7	28.8	27.67 (27.58 to 27.77)	*29.11 (28.64 to 29.58)*
Age (yr)						
22–29	17.6	43.9	33.4	22.7	**−1.41 (−1.71 to −1.10)**	**−1.67 (−1.99 to −1.34)**
30–39	21.6	37.4	34.7	27.9	**−0.37 (−0.63 to −0.12)**	**−0.35 (−0.61 to −0.10)**
40–49	24.5	32.8	37.2	30.0	27.89 (27.71 to 28.06)	Reference
50–59	21.4	28.9	40.1	31.0	**0.29 (0.05 to 0.53)**	**0.37 (0.10 to 0.63)**
60–70	14.8	29.8	37.9	32.3	**0.36 (0.10 to 0.62)**	0.32 (−0.05 to 0.70)
Sex						
Male	51.1	26.0	43.8	30.2	28.13 (28.01 to 28.26)	Reference
Female	48.9	43.4	29.3	27.3	**−0.94 (−1.09 to −0.79)**	**−1.11 (−1.26 to −0.96)**
Race/ethnicity						
White	70.0	36.0	36.9	27.1	27.43 (27.31 to 27.54)	Reference
Black	11.5	24.2	36.6	39.2	**2.01 (1.70 to 2.32)**	**1.67 (1.35 to 2.00)**
Hispanic	12.9	28.8	38.4	32.8	**0.82 (0.58 to 1.06)**	**0.62 (0.36 to 0.89)**
Asian	3.6	61.9	28.3	9.8	**−3.07 (−3.51 to −2.64)**	**−2.37 (−2.84 to −1.90)**
Other	2.1	27.2	35.1	37.7	**1.12 (0.42 to 1.81)**	**1.08 (0.39 to 1.76)**
Education						
Less than high school	10.9	26.5	38.6	34.8	**0.34 (0.02 to 0.67)**	−0.10 (−0.45 to 0.25)
High school graduate	48.1	30.1	36.6	33.3	28.32 (28.18 to 28.47)	Reference
College graduate	30.1	40.4	36.6	23.1	**−1.51 (−1.71 to −1.32)**	**−1.07 (−1.27 to −0.87)**
Master's degree or higher	10.9	45.2	36.0	18.8	**−2.12 (−2.39 to −1.85)**	**−1.63 (−1.92 to −1.34)**
Marital status						
Married	62.7	33.4	37.7	28.9	27.68 (27.57 to 27.79)	Reference
Divorced/separated	13.2	32.7	36.5	30.8	**0.37 (0.15 to 0.60)**	−0.31 (−0.70 to 0.08)
Widowed	2.6	29.9	35.0	35.1	**1.09 (0.61 to 1.58)**	0.28 (−0.30 to 0.87)
Never married	21.6	39.2	34.2	26.5	**−0.37 (−0.62 to −0.11)**	−0.13 (−0.54 to 0.27)
Presence of spouse or unmarried partner						
Spouse or unmarried partner present	66.6	33.5	37.8	28.7	27.64 (27.53 to 27.75)	Reference
No spouse or unmarried partner present	33.4	36.4	34.6	29.0	0.10 (−0.10 to 0.30)	0.06 (−0.31 to 0.42)
Presence of household children						
No children	58.9	34.2	37.0	28.8	27.70 (27.57 to 27.83)	Reference
1 child	16.2	35.7	35.1	29.2	−0.06 (−0.29 to 0.18)	0.22 (−0.04 to 0.49)
2 children	15.9	35.5	37.4	27.1	**−0.24 (−0.45 to −0.04)**	0.10 (−0.16 to 0.36)
3 or more children	9.1	32.4	36.6	31.0	0.22 (−0.07 to 0.50)	0.28 (−0.06 to 0.63)
Family income						
<$25,000	15.9	32.5	33.3	34.2	**0.37 (0.10 to 0.65)**	0.13 (−0.16 to 0.42)
$25,000 < $50,000	23.3	30.8	37.3	31.9	28.11 (27.93 to 28.28)	Reference

TABLE 1. (continued).

Variable	Pop %	% Norm	% Ovwt	% Obesity	Univariate BMI estimate	BMI controlled for all covariates
$50,000 < $75,000	18.2	32.8	37.7	29.5	**−0.32 (−0.60 to −0.05)**	−0.08 (−0.36 to 0.20)
$75,000 < $100,000	12.2	36.4	38.0	25.6	**−0.87 (−1.18 to −0.57)**	**−0.43 (−0.74 to −0.11)**
$100,000 < $150,000	10.3	37.3	38.5	24.2	**−1.13 (−1.42 to −0.85)**	**−0.55 (−0.84 to −0.27)**
≥$150,000	6.6	44.9	39.6	15.5	**−2.23 (−2.55 to −1.92)**	**−1.45 (−1.78 to −1.11)**
No family income information available	13.6	36.3	34.5	29.2	**−0.45 (−0.78 to −0.13)**	**−0.44 (−0.77 to −0.11)**
Employment						
Private sector employee	51.2	34.4	37.6	28.0	27.56 (27.45 to 27.68)	Reference
Government employee	11.0	33.0	38.3	28.6	0.10 (−0.15 to 0.36)	**0.25 (0.00 to 0.51)**
Self-employed or employed without pay	8.2	34.5	43.0	22.5	**−0.64 (−0.93 to −0.34)**	**−0.77 (−1.06 to −0.48)**
Employed but absent from work	2.8	34.2	36.4	29.5	0.27 (−0.23 to 0.76)	0.27 (−0.23 to 0.77)
Full-time college or university student	3.1	47.0	27.4	25.6	**−0.98 (−1.65 to −0.31)**	0.04 (−0.61 to 0.69)
Unemployed	3.4	34.2	35.3	30.5	0.41 (−0.09 to 0.90)	−0.04 (−0.55 to 0.46)
Retired	7.7	28.5	39.2	32.2	**0.69 (0.40 to 0.98)**	−0.04 (−0.41 to 0.33)
Not in labor force	12.7	36.5	29.1	34.4	**0.86 (0.55 to 1.18)**	**0.53 (0.20 to 0.85)**
Multiple job status						
Not working multiple jobs	92.6	34.4	36.7	28.9	27.69 (27.59 to 27.79)	Reference
Working multiple jobs	7.4	35.5	36.6	27.9	−0.18 (−0.50 to 0.13)	0.14 (−0.17 to 0.45)
Census region						
South	36.1	32.5	36.2	31.3	27.97 (27.81 to 28.13)	Reference
West	21.5	37.2	36.8	26.0	**−0.75 (−1.01 to −0.49)**	**−0.35 (−0.60 to −0.11)**
Midwest	24.4	33.0	37.3	29.7	−0.13 (−0.36 to 0.10)	0.10 (−0.13 to 0.33)
Northeast	18.0	37.0	37.0	26.0	**−0.57 (−0.83 to −0.31)**	**−0.24 (−0.49 to 0.02)**
Season						
Winter	24.7	33.8	36.7	29.5	27.80 (27.61 to 27.98)	Reference
Spring	25.1	34.6	37.0	28.3	−0.13 (−0.38 to 0.12)	−0.19 (−0.43 to 0.06)
Summer	25.3	34.4	36.9	28.6	−0.16 (−0.41 to 0.10)	−0.18 (−0.43 to 0.07)
Fall	24.9	34.9	36.3	28.7	−0.19 (−0.44 to 0.05)	−0.24 (−0.48 to 0.00)
Survey year						
2006	33.0	35.1	36.5	28.5	27.63 (27.46 to 27.79)	Reference
2007	33.2	34.5	36.7	28.8	0.06 (−0.16 to 0.28)	0.07 (−0.15 to 0.30)
2008	33.8	33.8	37.0	29.1	0.08 (−0.15 to 0.31)	0.15 (−0.08 to 0.37)

This table details the sociodemographic associations with obesity. The first column indicates the percentage of the total population falling within each category of each sociodemographic variable. The second, third, and fourth columns show the percentage of each category of sociodemographic variable that falls into either normal-BMI, overweight BMI, or obese-BMI categories, respectively. The fifth column is an unadjusted estimate of the difference in BMI for each category within a sociodemographic variable compared with the reference category from the same variable; these were obtained from linear regression of only the indicated sociodemographic variable on BMI and are presented with their 95% confidence intervals. The absolute BMI value (with 95% confidence interval) is included for the reference category. The rightmost column is much the same but is the result of one regression of all sociodemographic variables on BMI and is thus an adjusted estimate. Statistically significant estimates are shown in bold.

TABLE 2 Weekday activity participation and time

Activity (% participating)		OR of participating (ref: normal BMI)		Minutes spent on activity (if participating)		
		Overweight	Obesity	Normal (ref.)	Overweight	Obesity
Sleeping	99.9%	0.75 (0.18 to 3.12)	7.81 (0.42 to 143.92)	461 (452 to 471)	**−6.6 (−12.5 to −0.7)**	−3.6 (−9.8 to 2.6)
Sleeplessness	5.3%	0.98 (0.80 to 1.22)	1.03 (0.81 to 1.32)	65 (45 to 85)	8.1 (−7.7 to 23.9)	−0.9 (−15.4 to 13.5)
Grooming	83.2%	1.06 (0.92 to 1.21)	1.06 (0.91 to 1.25)	43 (41 to 45)	−0.6 (−2.0 to 0.8)	**−1.7 (−3.2 to −0.1)**
Health-related self-care	5.5%	1.09 (0.86 to 1.39)	**1.91 (1.49 to 2.43)**	59 (1 to 116)	**60.3 (12.2 to 108.5)**	−15.6 (−49.1 to 17.9)
Personal activities	0.7%	1.46 (0.76 to 2.78)	1.70 (0.87 to 3.31)	96 (31 to 161)	27.7 (−40.8 to 96.3)	−17.2 (−75.7 to 41.4)
Housework	35.3%	**0.88 (0.79 to 0.98)**	**0.88 (0.78 to 0.99)**	55 (44 to 66)	−0.2 (−7.3 to 6.8)	−0.5 (−8.6 to 7.6)
Food and drink preparation, presentation, and cleanup	55.2%	0.95 (0.85 to 1.07)	**0.83 (0.75 to 0.92)**	35 (30 to 39)	−2.2 (−5.5 to 1.0)	−3.7 (−7.6 to 0.1)
Interior maintenance, repair, and decoration	9.0%	0.99 (0.84 to 1.17)	0.94 (0.77 to 1.15)	139 (108 to 169)	−2.3 (−26.2 to 21.6)	−6.9 (−32.1 to 18.3)
Lawn, garden, and houseplants	9.0%	0.93 (0.78 to 1.11)	0.83 (0.70 to 1.00)	93 (70 to 117)	1.0 (−15.7 to 17.8)	−8.9 (−24.5 to 6.7)
Animals and pets	15.6%	0.94 (0.81 to 1.08)	0.87 (0.74 to 1.02)	31 (24 to 38)	−2.6 (−7.5 to 2.4)	**−9.6 (−14.2 to −5.1)**
Household management	29.6%	1.03 (0.92 to 1.16)	1.07 (0.95 to 1.21)	31 (24 to 38)	**5.7 (1.4 to 10.0)**	4.6 (−0.3 to 9.5)
Caring for and helping household children	27.2%	1.12 (0.99 to 1.24)	1.09 (0.97 to 1.23)	57 (44 to 70)	−2.6 (−10.2 to 4.9)	−2.2 (−10.4 to 6.1)
Caring for household adults	5.6%	1.24 (0.98 to 1.58)	1.23 (0.97 to 1.56)	29 (−11 to 69)	−3.5 (−21.3 to 14.2)	15.5 (−14.3 to 45.3)
Caring for and helping non-household children	5.1%	1.30 (0.99 to 1.68)	1.15 (0.90 to 1.48)	63 (27 to 100)	10.0 (−12.3 to 32.3)	−6.3 (−30.2 to 17.6)
Caring for non-household adults	7.4%	1.13 (0.95 to 1.33)	1.16 (0.95 to 1.41)	56 (31 to 81)	−8.2 (−24.0 to 7.6)	−9.1 (−30.1 to 12.0)
Working	65.2%	1.03 (0.87 to 1.23)	1.02 (0.85 to 1.22)	520 (507 to 533)	2.1 (−7.0 to 11.2)	4.0 (−5.6 to 13.5)
Job search and interviewing	1.6%	0.76 (0.46 to 1.24)	1.03 (0.63 to 1.68)	102 (6 to 198)	−40.7 (−85.5 to 4.1)	**−51.6 (−99.2 to −4.0)**
Taking class	2.6%	0.86 (0.56 to 1.31)	0.69 (0.47 to 1.01)	170 (105 to 236)	−11.5 (−48.5 to 25.5)	31.0 (−11.9 to 74.0)
Research/homework	2.9%	0.67 (0.45 to 1.00)	0.69 (0.46 to 1.05)	170 (97 to 243)	−21.4 (−68.9 to 26.1)	−9.6 (−55.5 to 36.3)
Consumer purchases	40.4%	1.00 (0.90 to 1.11)	1.06 (0.95 to 1.18)	33 (26 to 40)	3.5 (−0.8 to 7.9)	3.2 (−1.6 to 8.0)
Professional and personal care services	10.4%	0.99 (0.84 to 1.17)	1.04 (0.87 to 1.24)	21 (7 to 36)	**14.9 (5.9 to 23.8)**	4.5 (−4.3 to 13.3)
Household services	2.3%	0.84 (0.62 to 1.13)	0.98 (0.73 to 1.32)	16 (−7 to 39)	2.8 (−10.9 to 16.4)	8.2 (−8.0 to 24.3)
Government services and civic obligations	1.0%	1.18 (0.74 to 1.89)	1.50 (0.93 to 2.45)	47 (−10 to 104)	−4.5 (−42.5 to 33.5)	0.6 (−29.6 to 30.9)
Eating and drinking	95.9%	1.09 (0.84 to 1.41)	0.97 (0.74 to 1.29)	65 (62 to 68)	−2.4 (−4.9 to 0.1)	**−2.5 (−4.9 to −0.1)**
Socializing and communicating	35.3%	1.04 (0.94 to 1.16)	1.04 (0.93 to 1.16)	71 (58 to 83)	−0.4 (−7.9 to 7.1)	3.9 (−3.3 to 11.2)
Relaxing, thinking	22.0%	0.99 (0.87 to 1.12)	1.05 (0.91 to 1.21)	64 (48 to 80)	2.5 (−6.6 to 11.6)	−3.1 (−11.9 to 5.7)
Tobacco and drug use	2.8%	1.04 (0.77 to 1.40)	0.76 (0.55 to 1.04)	22 (14 to 30)	0.3 (−8.3 to 8.9)	−4.0 (−10.9 to 2.9)
Television and movies	79.1%	1.11 (0.97 to 1.27)	**1.17 (1.03 to 1.33)**	171 (160 to 183)	1.5 (−5.5 to 8.5)	**15.1 (7.3 to 22.9)**
Listening to the radio	3.1%	0.80 (0.59 to 1.07)	0.74 (0.54 to 1.01)	56 (19 to 93)	2.6 (−17.8 to 22.9)	−6.5 (−26.8 to 13.8)
Playing games	6.3%	1.10 (0.87 to 1.39)	**1.52 (1.21 to 1.92)**	118 (80 to 157)	6.0 (−20.6 to 32.6)	5.9 (−19.4 to 31.2)
Computer use for leisure (excluding games)	9.4%	0.95 (0.81 to 1.11)	1.05 (0.87 to 1.27)	79 (57 to 101)	2.0 (−8.7 to 12.7)	**16.9 (3.5 to 30.2)**
Arts and crafts as a hobby	1.3%	1.11 (0.66 to 1.88)	**1.97 (1.09 to 3.57)**	169 (91 to 247)	−48.7 (−106.7 to 9.3)	−23.6 (−80.3 to 33.1)
Reading for personal interest	24.0%	0.99 (0.88 to 1.11)	0.91 (0.81 to 1.03)	54 (39 to 69)	6.0 (−2.5 to 14.5)	6.1 (−3.1 to 15.2)
Arts and entertainment (other than sports)	2.1%	1.10 (0.79 to 1.53)	1.04 (0.72 to 1.49)	228 (173 to 284)	**−51.1 (−79.3 to −23.0)**	**−54.5 (−85.0 to −24.0)**

TABLE 2. (continued).

Activity (% participating)		OR of participating (ref: normal BMI)		Minutes spent on activity (if participating)		
		Overweight	Obesity	Normal (ref.)	Overweight	Obesity
Participating in sports, exercise, and recreation	17.0%	**0.78 (0.69 to 0.89)**	**0.52 (0.45 to 0.61)**	111 (92 to 130)	1.6 (−7.4 to 10.5)	4.6 (−7.3 to 16.5)
Attending sports/recreational events	0.8%	**2.92 (1.59 to 5.35)**	1.01 (0.51 to 2.00)	196 (116 to 276)	**47.5 (11.1 to 83.8)**	43.3 (−4.9 to 91.4)
Religious and spiritual activities	5.2%	0.91 (0.73 to 1.14)	0.91 (0.74 to 1.12)	51 (29 to 73)	4.0 (−12.6 to 20.7)	−4.7 (−16.9 to 7.6)
Volunteer activities	6.5%	1.01 (0.84 to 1.22)	0.90 (0.73 to 1.10)	158 (119 to 196)	−7.1 (−32.2 to 18.0)	−21.9 (−45.1 to 1.4)
Telephone calls	14.2%	0.91 (0.79 to 1.05)	0.91 (0.78 to 1.06)	21 (12 to 30)	1.1 (−4.3 to 6.6)	0.8 (−5.7 to 7.3)
Travel	90.5%	1.07 (0.90 to 1.28)	0.93 (0.78 to 1.11)	80 (74 to 87)	**3.8 (0.5 to 7.0)**	2.0 (−1.9 to 5.9)

Each activity category is listed along with the percentage of the overall sample that spent nonzero amounts of time in said activity. The difference in the likelihood individuals in the overweight or obesity BMI categories participated in an activity (nonzero amounts of time spent) compared with individuals in the normal-BMI category is presented as odds ratios (OR) with their respective 95% confidence intervals. The average number of minutes spent on an activity by participating individuals in the normal-BMI category is also presented. The difference in the average number of minutes spent by individuals in the overweight and obesity BMI categories compared with individuals in the normal-BMI category and the corresponding 95% confidence intervals are also presented for each activity category. All models are adjusted for age, race, gender, family income, educational attainment, employment characteristic, and census region. Significant results are presented in bold.

Activity participation, duration, and timing

Sleep. There were no substantial differences among BMI categories in participation or time spent sleeping, but overweight individuals experienced almost 20 fewer minutes of sleeplessness on weekends/holidays than individuals with normal weight (Tables 2 and 3). There exists a U-shaped relationship between BMI and sleep duration such that BMI was lowest when sleep duration was approximately 8 h per day and increased as sleep duration became both shorter and longer. On weekends/holidays, 5 to 7 h of sleep was associated with higher BMI than 8 to 9 h (Figure 1A).

Individuals with obesity, relative to individuals with normal weight, were less likely to be asleep on weekdays between 9:30 p.m. and 5:30 a.m. and on weekends/holidays from 10:30 p.m. to midnight but were more likely to be asleep on weekdays between 8:00 a.m. and 10:00 a.m. and 1:00 p.m. and 3:00 p.m. and on weekends/holidays between noon and 4:00 p.m. (Figure 2A). No significant or substantial differences in sleep time or timing were found between normal-weight and overweight BMI categories.

Work. There were no differences appreciated between BMI categories in the odds of participating in work or in the amount of time working. The relationship between work time and BMI is nonlinear, particularly on weekends/holidays where 3 to 4 h of work was associated with lower BMI than any lesser or greater amount of work (Figure 1B). There were no differences in the timing of work between the overweight and normal-BMI categories, but individuals with obesity were more likely to be working between 3:30 a.m. and 7:00 a.m. (Figure 2C) on weekdays than normal-BMI individuals. It was also observed that individuals with obesity spent half the time searching and interviewing for jobs on weekdays compared with individuals in the normal-BMI category.

Food/drink preparation and consumption. Individuals with obesity were less likely to participate in food and drink preparation than individuals with normal weight on weekdays (Table 2). No differences were observed between categories in either the timing of, or the amount of time spent, eating or drinking (Figure 2D).

Self-care. Individuals with obesity were more likely than individuals with normal weight to participate in health-related self-care, and overweight individuals spent over 1 h more on weekdays than individuals with normal weight on health-related self-care and also spent an additional 15 min (almost double the time) on professional and personal care services (Tables 2 and 3).

Sports, exercise, and recreation. Overweight individuals and individuals with obesity were less likely to participate in sports, exercise, and recreation on weekdays and weekends/holidays compared with individuals with normal weight; however, those who did participate did not differ from individuals with normal weight in the amount of time spent participating. Overweight individuals were more likely to attend sports/recreation events during the week and spent an additional 47 min (almost 25% more) on this activity than individuals with normal weight (Table 2).

Sedentary activities. Both on weekends/holidays and weekdays, individuals with obesity were more likely to watch television/movies and spent an average of 15 more minutes on this activity than individuals with normal weight (Table 2). There was a positive and generally linear association between time spent viewing television/

TABLE 3 Weekend activity participation and time

Activity (% participating)		OR of participating (ref: normal BMI)		Minutes spent on activity (if participating)		
		Overweight	Obesity	Normal (ref.)	Overweight	Obesity
Sleeping	99.9%	1.75 (0.31 to 9.86)	0.79 (0.18 to 3.43)	549 (538 to 560)	−3.5 (−10.7 to 3.7)	−2.6 (−10.1 to 4.9)
Sleeplessness	4.3%	0.89 (0.67 to 1.18)	1.04 (0.78 to 1.40)	63 (38 to 88)	**−19.7 (−36.8 to −2.7)**	−6.4 (−23.2 to 10.4)
Grooming	72.0%	1.00 (0.88 to 1.13)	0.96 (0.83 to 1.10)	44 (42 to 47)	0.1 (−1.7 to 1.8)	−1.0 (−3.0 to 1.0)
Health-related self-care	4.5%	1.03 (0.78 to 1.37)	1.27 (0.98 to 1.65)	186 (86 to 285)	25.8 (−26.6 to 78.2)	−4.5 (−55.1 to 46.1)
Personal activities	0.8%	0.72 (0.41 to 1.24)	0.64 (0.36 to 1.16)	252 (86 to 418)	−22.8 (−97.3 to 51.8)	−39.1 (−91.2 to 13.0)
Housework	40.7%	0.97 (0.87 to 1.08)	**0.88 (0.79 to 0.99)**	107 (96 to 119)	0.8 (−7.5 to 9.1)	−2.2 (−10.6 to 6.2)
Food and drink preparation, presentation, and cleanup	52.6%	0.98 (0.89 to 1.08)	0.98 (0.87 to 1.10)	51 (43 to 58)	0.2 (−5.1 to 5.5)	−2.2 (−7.1 to 2.8)
Interior maintenance, repair, and decoration	12.5%	1.04 (0.91 to 1.18)	0.94 (0.79 to 1.11)	164 (134 to 194)	−10.2 (−28.7 to 8.4)	−2.1 (−23.5 to 19.4)
Lawn, garden, and houseplants	13.1%	0.91 (0.79 to 1.04)	**0.77 (0.65 to 0.91)**	204 (176 to 232)	−19.0 (−38.4 to 0.4)	−7.8 (−32.9 to 17.2)
Animals and pets	13.7%	0.93 (0.81 to 1.06)	**0.83 (0.71 to 0.96)**	61 (49 to 72)	−9.2 (−18.4 to 0.1)	**−13.9 (−22.2 to −5.6)**
Household management	25.4%	0.90 (0.80 to 1.00)	0.96 (0.84 to 1.11)	39 (29 to 49)	4.5 (−2.4 to 11.5)	−0.5 (−7.2 to 6.3)
Caring for and helping household children	22.6%	1.11 (0.99 to 1.23)	**1.13 (1.00 to 1.29)**	83 (67 to 98)	−5.2 (−14.1 to 3.6)	**−11.4 (−21.0 to −1.7)**
Caring for household adults	4.2%	1.00 (0.78 to 1.28)	**1.51 (1.17 to 1.95)**	39 (0 to 78)	−3.8 (−24.8 to 17.1)	−2.2 (−24.3 to 19.9)
Caring for and helping non-household children	5.2%	1.21 (0.97 to 1.52)	1.14 (0.87 to 1.49)	73 (40 to 106)	−1.2 (−24.5 to 22.2)	−5.8 (−27.0 to 15.3)
Caring for non-household adults	9.7%	1.02 (0.85 to 1.23)	0.98 (0.81 to 1.17)	102 (70 to 134)	2.5 (−15.0 to 20.0)	−0.9 (−18.7 to 16.9)
Working	26.6%	1.03 (0.90 to 1.18)	1.01 (0.88 to 1.16)	418 (384 to 452)	8.4 (−11.4 to 28.3)	18.7 (−4.8 to 42.2)
Job search and interviewing	0.6%	0.98 (0.50 to 1.92)	1.53 (0.73 to 3.23)	60 (−41 to 160)	−36.1 (−99.4 to 27.2)	−10.4 (−70.3 to 49.4)
Taking class	0.9%	0.63 (0.39 to 1.01)	0.67 (0.43 to 1.07)	54 (−27 to 134)	−20.7 (−76.1 to 34.6)	−3.9 (−57.5 to 49.7)
Research/homework	2.4%	0.94 (0.67 to 1.31)	0.82 (0.55 to 1.23)	269 (179 to 360)	14.1 (−38.7 to 67.0)	−45.0 (−92.3 to 2.2)
Consumer purchases	47.5%	1.07 (0.97 to 1.17)	1.04 (0.93 to 1.16)	70 (61 to 78)	−1.6 (−6.4 to 3.3)	**−7.2 (−12.3 to −2.1)**
Professional and personal care services	4.6%	1.03 (0.83 to 1.27)	1.14 (0.90 to 1.44)	29 (8 to 51)	9.5 (−4.3 to 23.2)	**16.2 (0.1 to 32.3)**
Household services	1.7%	0.94 (0.69 to 1.28)	0.76 (0.53 to 1.09)	66 (29 to 103)	4.4 (−21.3 to 30.1)	1.4 (−18.2 to 21.0)
Government services and civic obligations	0.2%	0.45 (0.16 to 1.25)	0.59 (0.19 to 1.83)	−75 (−269 to 119)	8.1 (−123.4 to 139.7)	−28.8 (−85.3 to 27.6)
Eating and drinking	95.6%	1.09 (0.86 to 1.38)	0.98 (0.76 to 1.26)	71 (67 to 76)	−1.6 (−4.5 to 1.3)	−2.4 (−5.7 to 0.9)
Socializing and communicating	44.5%	1.09 (0.98 to 1.22)	0.97 (0.86 to 1.10)	135 (116 to 154)	3.3 (−5.8 to 12.4)	−0.2 (−10.7 to 10.2)
Relaxing, thinking	16.5%	1.01 (0.90 to 1.13)	1.00 (0.86 to 1.15)	91 (67 to 115)	7.0 (−7.9 to 21.9)	6.8 (−12.1 to 25.7)
Tobacco and drug use	1.5%	0.75 (0.49 to 1.16)	**0.46 (0.28 to 0.75)**	8 (−12 to 28)	−9.0 (−31.1 to 13.0)	−15.9 (−35.5 to 3.6)
Television and movies	81.3%	1.10 (0.96 to 1.25)	**1.30 (1.14 to 1.48)**	259 (246 to 273)	0.3 (−9.4 to 10.1)	**17.3 (7.7 to 27.0)**
Listening to the radio	3.1%	0.79 (0.59 to 1.07)	**0.71 (0.52 to 0.97)**	61 (14 to 108)	6.8 (−21.7 to 35.2)	0.7 (−33.3 to 34.7)
Playing games	8.1%	1.02 (0.85 to 1.23)	1.23 (0.99 to 1.53)	137 (98 to 176)	21.0 (−0.5 to 42.4)	**27.6 (2.1v53.1)**
Computer use for leisure (excluding games)	8.5%	1.03 (0.85 to 1.26)	1.21 (0.95 to 1.54)	99 (75 to 123)	−0.8 (−17.8 to 16.1)	0.8 (−16.9 to 18.6)
Arts and crafts as a hobby	1.3%	1.27 (0.82 to 1.98)	**1.59 (1.08 to 2.34)**	165 (53 to 278)	−16.0 (−69.2 to 37.2)	1.9 (−59.6 to 63.4)
Reading for personal interest	24.2%	**0.84 (0.75 to 0.93)**	**0.75 (0.66 to 0.85)**	79 (63 to 94)	**−11.2 (−18.4 to −4.0)**	−4.2 (−12.2 to 3.8)

TABLE 3. (continued).

Activity (% participating)		OR of participating (ref: normal BMI)		Minutes spent on activity (if participating)		
		Overweight	Obesity	Normal (ref.)	Overweight	Obesity
Arts and entertainment (other than sports)	5.9%	1.04 (0.81 to 1.32)	1.11 (0.88 to 1.40)	166 (121 to 211)	6.1 (−15.5 to 27.6)	−19.3 (−45.7 to 7.0)
Participating in sports, exercise, and recreation	16.5%	**0.77** (**0.68** to **0.87**)	**0.58** (**0.48** to **0.71**)	153 (127 to 178)	11.6 (−2.9 to 26.2)	1.5 (−14.5 to 17.5)
Attending sports/recreational events	1.6%	0.87 (0.62 to 1.24)	0.98 (0.64 to 1.51)	218 (146 to 289)	−7.8 (−50.4 to 34.8)	−0.3 (−62.3 to 61.7)
Religious and spiritual activities	15.0%	1.03 (0.90 to 1.16)	1.04 (0.91 to 1.19)	116 (97 to 136)	4.9 (−3.9 to 13.7)	**14.8** (**3.0** to **26.6**)
Volunteer activities	7.0%	1.00 (0.84 to 1.20)	1.21 (0.98 to 1.50)	185 (144 to 226)	−3.4 (−27.0 to 20.2)	2.0 (−24.9 to 29.0)
Telephone calls	12.7%	1.07 (0.92 to 1.24)	0.97 (0.83 to 1.13)	26 (18 to 35)	3.7 (−1.3 to 8.8)	**6.0** (**0.1** to **11.9**)
Travel	84.9%	1.15 (0.99 to 1.32)	1.00 (0.87 to 1.16)	82 (75 to 89)	0.9 (−4.2 to 6.1)	−1.2 (−6.4 to 4.1)

Each activity category is listed along with the percentage of the overall sample that spent nonzero amounts of time in said activity. The difference in the likelihood individuals in the overweight or obesity BMI categories participated in an activity (nonzero amounts of time spent) compared with individuals in the normal-BMI category is presented as odds ratios (OR) with their respective 95% confidence intervals. The average number of minutes spent on an activity by participating individuals in the normal-BMI category is also presented. The difference in the average number of minutes spent by individuals in the overweight and obesity BMI categories compared with individuals in the normal-BMI category and the corresponding 95% confidence intervals are also presented for each activity category. All models are adjusted for age, race, gender, family income, educational attainment, employment characteristic, and census region. Significant results are presented in bold.

movies and BMI (Figure 1D). Further, relative to individuals with normal weight, individuals with obesity were more likely to watch television almost all hours of the day during the week and weekends except between 3:00 p.m. and 10:00 a.m. and 10:00 p.m. and midnight on weekdays and between 1:00 a.m. and 8:00 a.m. and 1:00 and 3:00 p.m. during weekends/holidays (when there were no differences between groups) (Figure 2B). Individuals with excess weight and individuals with normal weight did not differ in the timing of television/movie viewing.

In general, individuals with overweight or obesity were found to be more likely to participate in and/or spend more time on arts and crafts, playing games, and utilizing the computer for leisure, but they were less likely to read for personal interest on weekends/holidays and spent less time on arts and entertainment during the week.

Household activities. During the week, individuals with overweight or obesity were less likely to participate in housework and individuals with obesity spent a third of the time caring for pets compared with individuals with normal weight. During the weekends/holidays, individuals with obesity were less likely to participate in housework, lawn care, or animal and pet care than individuals with normal weight (Table 2). On weekends/holidays, individuals with obesity were more likely to participate in care for household children and household adults. It was also observed that individuals with obesity spent an additional 15 min on religious and spiritual activities on weekends/holidays, compared with normal-BMI individuals (who spent 116 min).

Discussion

In addition to the overconsumption of calorically dense foods and an increasingly sedentary lifestyle, reduced sleep duration has been identified as a lifestyle factor associated with the increased prevalence of obesity and obesity-related disorders (14,15). Prospective cohort studies have demonstrated that habitual short sleep duration is associated with increased future weight gain/obesity (16,17). Paradoxically, some cross-sectional studies have also revealed a relationship between long sleep duration and risk for obesity (18,19). Our analysis supports this U-shaped relationship where higher BMI is associated with both short and long amounts of sleep. Importantly, the average sleep times did not differ between those with obesity and normal weight; this suggests that comparisons of average sleep time may not be appropriate due to the association of obesity with *both long and short* sleep. Causality or its direction cannot be determined from our data, but our results support the growing body of literature providing biologic plausibility for a causal role of short sleep in the genesis of weight gain (20,21). The role of long sleep is less clear, but reverse causation is a strong possibility as obesity has been identified as a significant risk factor for excessive daytime sleepiness (22).

While the literature is replete with studies about length of sleep and its impact on health, fewer studies analyze the *timing* of sleep. Our results show that on weekdays, those with obesity are significantly less likely to be sleeping at night and significantly more likely to be sleeping during the day relative to individuals with normal weight. This is consistent with studies showing that daytime sleepiness is a

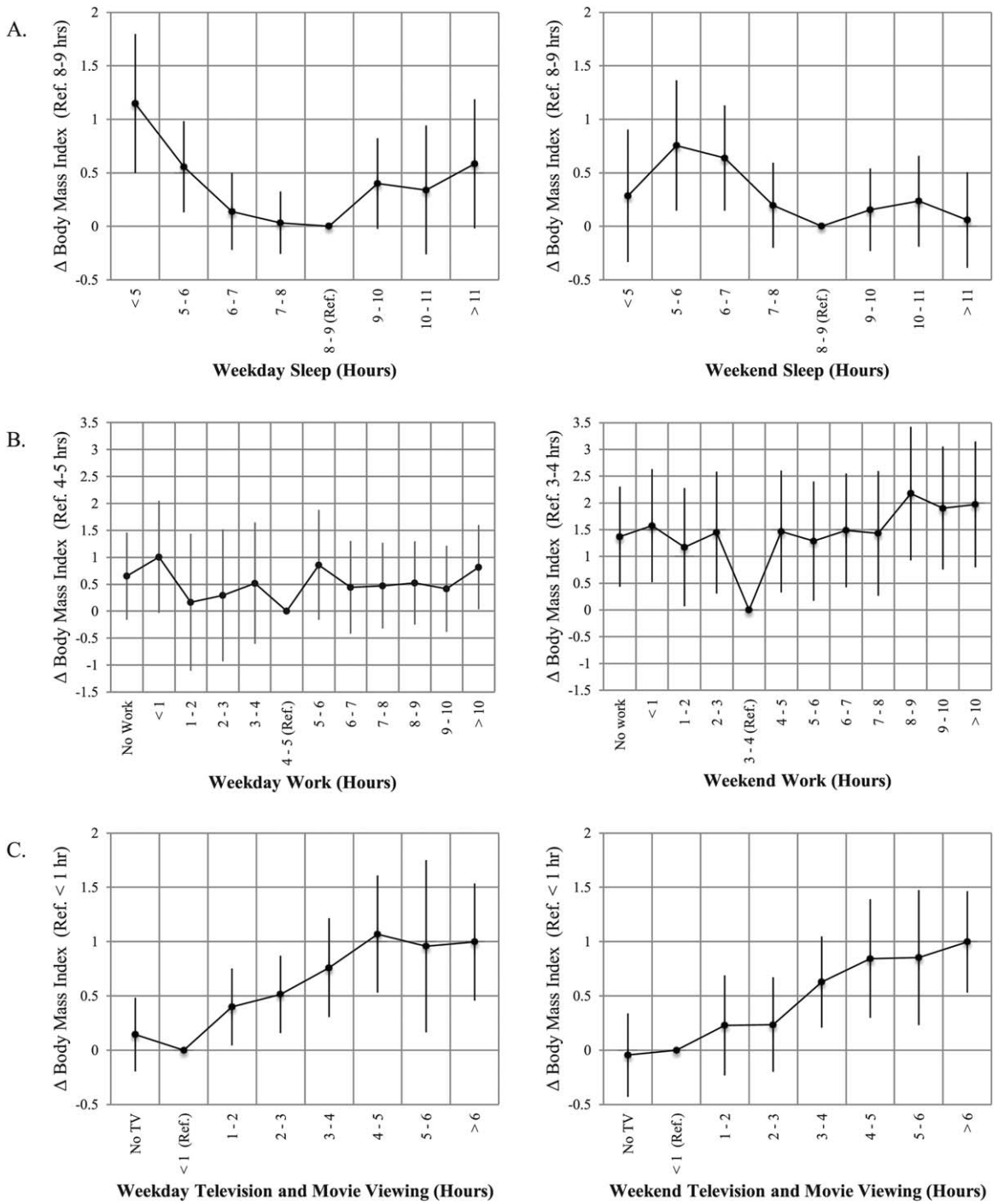

Figure 1 Analysis for nonlinear trends. Activities were analyzed for differences in BMI between a reference time category (chosen as the category with lowest BMI) and remaining time categories. Error bars represent 95% confidence intervals. Models were adjusted for age, race, gender, education, family income, employment characteristics, and census region.

comorbid characteristic of those with obesity. Sleep disorders prevalent among people with obesity (i.e., sleep apnea) may contribute to this pattern of behavior, but it has been shown that obesity, independent of sleep apnea, is still associated with daytime sleepiness (23).

The significance of the results regarding the timing of sleep is emphasized by our analysis of work time and timing. Work and employment activity are the activities that take the most amount of time away from sleep (9). Our study finds that individuals with obesity are more likely to work during hours typically devoted to sleep

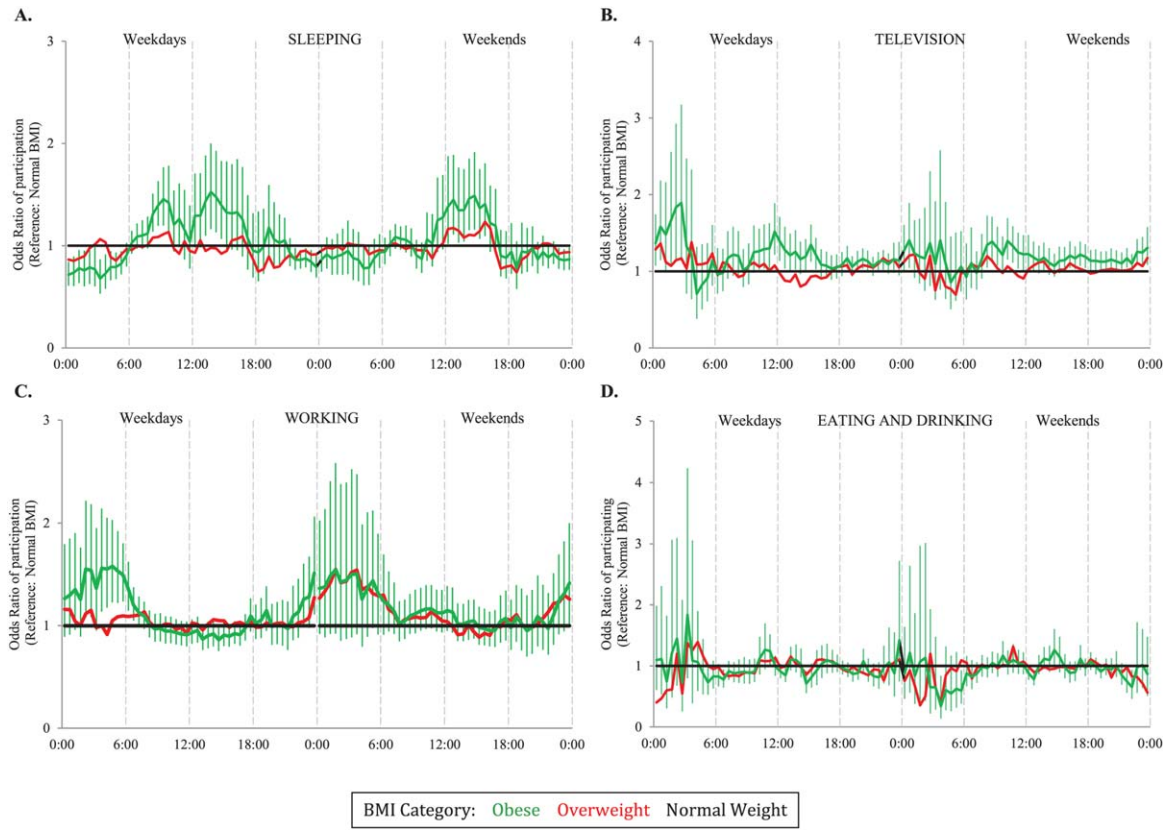

Figure 2 Activity timing analysis. Each point and corresponding 95% confidence interval (error bars) represents the odds ratio for participation in the given activity at the corresponding half-hour time interval. The green line represents individuals with obesity, whereas the red line represents individuals who are overweight; both are in reference to normal-BMI individuals, who are represented by the dark black line at value = 1. Error bars were not included for the overweight population as the overwhelming majority of time intervals showed no statistically significant difference in participation for overweight individuals compared with normal-BMI individuals. Each regression was adjusted for age, race, gender, income, education, employment characteristics, and census region. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

(2:00 a.m. to 7:00 a.m.). This finding contributes to the growing body of literature linking shift work, short sleep, and obesity; though the existing evidence is insufficient, this study contributes by providing these findings in nationally representative data (24,25). In America, shift work among nurses is linked with increased BMI, and shift work among truck drivers is associated with poor sleep quality (26,27). Furthermore, night-shift work is associated with increased risk for hypertension, diabetes, and metabolic syndrome in America, particularly in the African American population (28,29). The mechanism behind the association between shift work and obesity is unclear, but a study has shown a simulated night shift was associated with a predilection for high-fat-content foods and another study proposes poor sleep quality as a mediator (30,31). Our findings extend the evidence describing the relationship between night shift and obesity in showing that obesity is significantly associated with night-work behavior in nationally representative data adjusted for age, race, gender, income, education, employment characteristics, and census region. Our analysis further shows that work hours longer than 3 to 4 h on weekends/holidays are associated with higher BMI; this supports literature showing long work hours, particularly during weekend/holiday days, are associated with adverse mental and cardiovascular health outcomes (32). Given the significant financial and physiological costs of obesity and short sleep, this relationship should be explored in further detail and further mechanisms should be elucidated.

Given that energy expenditure plays an important role in weight management, we examined time spent on both sedentary and active behaviors. It has been estimated that on an average day, only one in four American adults participate in sports, exercise, or recreational activities; among those who do participate, sessions typically last more than 10 min per session and accumulate to over 60 min per day (33). We found individuals with obesity are less likely to participate in sports, exercise, and recreation, but those who participated engaged in these activities for nontrivial amounts of time. In fact, the time spent on these activities did not differ between BMI groups. Previous studies have shown that individuals with overweight or obesity are less physically active than individuals with normal weight and spend less time engaged in moderate or higher intensity activity, but our separation of the study sample into participants and nonparticipants for each activity elucidates that the number of nonparticipants might skew average exercise time (34). Our findings suggest that participation in these activities differs between BMI groups, but among those who do engage, participation time does not differ. This is supported by literature finding that individuals who are trying to lose or maintain weight are more likely to be regularly

active than those not trying to lose or maintain weight (35). Our findings suggest that the *motivation* to exercise is a meaningful target for lifestyle change.

Associations between sedentary activities, particularly television viewing, and obesity are well established (36). We found that individuals with obesity watch significantly more television than individuals with normal weight and are more likely to watch television during both weekdays and weekend/holiday days. In addition to television viewing, we also observed significant differences between BMI groups in game playing, arts and crafts, arts and entertainment, reading for personal interest, and engaging in religious activities. These findings are particularly interesting given models were controlled for age, race, sex, income, education, employment characteristics, and census region.

Eating and drinking habits are also naturally worth considering. The existing literature finds that individuals with overweight or obesity spend less time eating and drinking than individuals with normal weight; this relationship was observed in our results when models were only adjusted for age, race, gender, family income, and education but did not persist when also controlled for employment characteristics and census region (37). Further, no associations were found in the timing of eating and drinking activities across the groups; this is inconsistent with evidence exhibiting associations between weight loss effectiveness and the timing of caloric intake (38).

Our findings that individuals with obesity and overweight are less likely to participate in housework activities support a growing body of literature that suggests the decrement in household management energy expenditure may have contributed to the increased prevalence of obesity (39). Other household activities, such as caring for adults and children, housework, food preparation, caring for pets, and lawn and garden work, also exhibit different participation rates and time spent by BMI category and warrant further analysis.

Given the cross-sectional nature of the ATUS data it is difficult to infer causality. While we limited bias by utilizing statistical methods most appropriate to the data and question at hand and by adjusting each analysis with all covariates significantly associated with obesity, unaccounted characteristics of the excluded observations without BMI data subject the study to potential bias. Further, the survey questions lend themselves to digit preference bias; self-report for certain activities tends to be rounded to convenient numbers, leading to response clusters around 15-, 30-, and 60-min intervals (40). Moreover, certain activities have low participation rates or may not be partaken in every day; the exact minute estimates for amount of time spent are thus not as meaningful as are the *differences* between BMI groups. For example, ATUS tends to overestimate sleep time; the usefulness of the findings is thus likely limited to differences between groups, rather than elucidating exact amount of time spent (9).

While previous analyses have been conducted on individual or a few activities, we were able to comprehensively analyze time use and its relationship to obesity. Importantly, the U-shaped relationship between sleep time and BMI and between work time and BMI, as well as the finding that individuals with obesity are more likely to work during the night and sleep during the day, underlines the significance of the relationships among sleep, work, and BMI. Further investigation into the nature of these interactions is warranted. Our finding that individuals with obesity are less likely to participate in sports, recreation, or physical activity than individuals with normal BMI, but spend similar times if they do participate, also warrants further investigation as it more clearly defines the nature of physical activity participation by those with obesity. The findings suggest that the motivation to exercise at all might be a more effective target for lifestyle change than amount of exercise. The findings for eating and drinking, television viewing, and household activities further suggest the importance of daily activities and lifestyle in health promotion. We hope in presenting the data for the remainder of our comprehensive analysis, there is opportunity for further investigation into the other significant associations found. O

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