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The Independent and Combined Associations of Physical Activity and Sedentary Behavior with Obesity in Adults: NHANES 2003-06

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Abstract

Objective—To examine the combined influence of moderate-to-vigorous physical activity (MVPA) and sedentary behavior on obesity in US adults.

Design and Methods—Cross-sectional analyses were undertaken on a nationally representative sample of 5,083 adults from the April 2003 and June 2005 National Health and Nutrition Examination Survey. Self-reported TV time was divided into low, moderate, and high categories. Accelerometer-derived total sedentary and MVPA minutes divided into low, moderate, and high tertiles. The independent associations between MVPA, TV, and total sedentary time and obesity were examined using logistic regression. Participants were then cross tabulated into nine MVPA–sedentary behavior groups, and logistic regression was used to examine the combined influence of MVPA and sedentary behavior on the odds of being obese.

Results—MVPA was consistently inversely associated with obesity, regardless of sedentary behavior [odds ratio (OR) = 1.80-4.00]. There were inconsistent positive associations between TV time and risk of obesity in men, but not between total sedentary time and risk of obesity in either men or women.

Conclusions—Obesity was more strongly related to MVPA than either TV time or total sedentary time in US adults. Small differences in daily MVPA (5-10 min) were associated with relatively large differences in risk of obesity.

Introduction

For many years the relationship between moderate-to-vigorous physical activity (MVPA) and obesity has been recognized. Increased MVPA is thought to operate on energy balance ("energy in-energy out") through multiple pathways, including its positive effect on energy

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expenditure (1) and a possible suppressive effect on appetite (2). In addition, some studies have suggested that MVPA has a positive influence on basal metabolic rate (3).

Time spent watching television (TV) has often been scrutinized to examine the link between sedentary behaviors and obesity. It is often postulated that TV time may impact weight status via simple displacement of MVPA (4), and indirectly, via altered energy intake. For example, TV viewing has been associated with snacking behavior (5) and fast-food consumption (6). However, these links are tenuous—a recent systematic review identified six large-scale prospective studies examining the relationship between TV time and BMI/ weight status, of which two studies showed a relationship, one study reported mixed findings, and three studies found no relationship (7).

Time spent watching TV has often been used as a proxy of sedentary behavior more generally (7). However, research examining this assumption has shown that TV time and total sedentary time are actually only weakly correlated, suggesting that measurement of overall sedentary time is also important (8).

In recent years increasing attention has been paid to the detrimental effects of overall sedentary behavior. Numerous studies have linked sedentary time with adverse health outcomes, including excess adiposity (9-11). The persistence of these relationship, even when analyses have accounted for MVPA, suggests that sedentary behavior may not simply be a lack of MVPA, but rather has unique negative physiological and health effects (12). The mechanisms underpinning these are currently debatable, but it is thought, for example, that postural stasis may trigger a chain of unhealthy molecular sequelae impacting physiological outcomes (13). Interestingly, Ekelund et al.'s (14) longitudinal study of 393 adults suggested reverse causation may in fact be occurring, with baseline BMI able to predict sedentary behavior 5.6 years later, but baseline sedentary behavior unrelated to BMI at follow up.

There is limited information comparing the relative influence of MVPA and sedentary behavior on adult obesity status. Studies to date which have examined both factors have been limited by use of nonrepresentative samples (e.g., male health professionals (15) and female nurses (16)), reliance on self-reported measures (15-18), and focus on fragments of daily activity (15-18) such as leisure time activity participation, rather than capturing total daily activity patterns. To our knowledge, only one study has examined the independent associations between objectively measured daily MVPA and sedentary behavior and adiposity. This study, conducted by Healy et al. (19), examined 169 Australian adults, and found that both low MVPA and high sedentary time were associated with higher waist circumference when examined separately, but that only sedentary time was associated with waist circumference once analyses were adjusted to account for the contrasting behavior. It is unclear whether these findings are representative of the wider adult population.

Little is known about the influence of MVPA and sedentary behaviors in combination on adult obesity. Liao et al. (20) examined weight status, MVPA and screen time in 2,832 Japanese adults and found that failure to meet physical activity and screen time guidelines was associated with an increased risk of being overweight (odds ratio = 1.50) in men but not

in women. However, the study relied on self-reported weight and behavior data and only scrutinized screen time without considering sedentary behavior more broadly. Furthermore, the relevance of its findings to Western countries is unclear given the cultural and biological differences between Japan and Western countries [e.g., the prevalence of obesity and overweight in Japan are ~3 and 20%, respectively, versus 34 and 33% in the United States (21)].

Therefore, this current analysis aimed to examine the separate, independent and combined associations of MVPA and sedentary behavior and obesity status in a large representative sample of US adults aged 20 years and older who took part in the April 2003 and June 2005 National Health and Nutrition Examination Survey (NHANES) surveys. Given that screen time and total sedentary time are not equivalent, analyses were conducted using both measures of sedentary behavior.

Methods and Procedures

Design and participants

NHANES is a large cross-sectional study, which uses a complex, multistage probability design to obtain a representative sample of the USA civilian noninstitutionalized population. Participants were visited in their homes and completed an interviewer-administered questionnaire. In addition, a subsample attended a specifically designed Mobile Examination Center to undertake a physical examination. The National Center for Health Statistics Ethics Review Board approved the protocols. Full details of the methods can be found at http://www.cdc.gov/nchs/nhanes.htm.

Of the 10,020 individuals aged ≥20 years who participated in the NHANES April 2003 and June 2005 waves, 5,546 had valid accelerometer data. Of these, 261 pregnant women were excluded, as well as 202 participants who had missing values for key outcomes and continuous covariates. Thus the total sample included herein was n = 5,083.

Accelerometry

In April 2003 and June 2005, the NHANES protocol asked all ambulatory participants to wear an Actigraph 7164 accelerometer (Actigraph, LLC, Fort Walton Beach, FL) on their right hip during waking hours (except water activities) for 7 consecutive days. Full details of the NHANES accelerometry protocol have been published elsewhere (22).

An automated program available from the National Cancer Institute website was used to carry out quality control procedures, derive wear time, and summarize minute-by-minute data (http://riskfactor.cancer.gov/tools/nhanes_pam/create.html). Specifically, nonwear time was defined on the basis of 60 consecutive minutes of 0 counts per minute (cpm), with allowance for up to 2 min of <100 cpm, similar to Healy et al. (9). The data were censored so that intensity counts ≥20,000 in a single minute were considered invalid. The average of the valid intensity counts immediately before and after such invalid minute(s) were imputed to replace the invalid minute(s). If the last minute of the day was invalid, then the last valid minute was used. Days with at least 10 h wear time were considered valid. Because we were

interested in behavior patterns, only participants with at least four valid days, including at least 1 valid weekend day, were included in the current analyses.

For each participant, MVPA time was calculated as the mean number of daily minutes ≥2 020 counts per minute (23). Mean daily sedentary time was calculated as the average of the number of valid minutes per day < 100 counts per minute as used in past NHANES analysis (24).

Self-reported TV time

The amount of time spent watching TV or videos on a typical day in the last 30 days was measured by self-report in the household interview questionnaire. This item has been shown to have fair test–retest reliability (ICC = 0.32) when measured over a 16 day period (25), though its validity does not appear to have been scrutinized (26). Response categories were none, <1, 1, 2, 3, 4, and ≥5 h.

Height and weight

Participants' height and weight were measured by trained health technicians during the physical examination using standardized procedures (27). BMI was calculated from height and weight (kg m $^{-2}$), and participants were categorized as obese (≥30 kg m $^{-2}$), and not obese <30 kg m $^{-2}$) according to National Institutes of Health (NIH) guidelines (28).

Covariates

Age in years was recorded at the time of the screening interview. Socio-demographic variables were recorded in the household questionnaires. Ethnicity was categorized as Mexican American, Other Hispanic, Non-Hispanic White, Non-Hispanic Black and Other (including mixed ethnicities). Household income was grouped into 13 categories ($0 to $ 4,999, $5,000 to $9,999, $10,000 to $14,999, $15,000 to $19,999, $20,000 to $24,999, $25,000 to $34,999, $35,000 to $44,999, $45,000 to $54,999, $55,000 to $64,999, $65,000 to $74,999, ≥$75,000, "over $20,000," "under $20,000" and missing). Highest educational level attained was collapsed into the following categories: "less than 9th grade," "9th to 12th grade with no high school diploma," "high school diploma or equivalent," "post high school" and "college graduate or higher."

Smoking status was categorized on the basis of serum-cotinine levels as nonsmoker (<10 ng dL $^{-1}$), light (10 to <100 ng dL $^{-1}$), moderate (100 to <300 ng dL $^{-1}$), and heavy (≥300 ng dL $^{-1}$). Participants completed two 24 h diet recalls, which were coupled with US Department of Agriculture food composition data to determine mean daily total energy intake (kcal) and mean saturated fat as a percentage of total energy intake. Mean daily alcohol intake was collapsed into sex-specific categories on the basis of US dietary guidelines: none, light (men < 28 g day $^{-1}$; women < 14 g day $^{-1}$), moderate (men 28 to < 56 g day $^{-1}$; women 14 to < 28 g day $^{-1}$), and heavy (men ≥56 g day $^{-1}$; women ≥28 g day $^{-1}$). To retain the maximum number of participants in analyses, missing categorical data were recoded into "missing" categories.

Statistical analyses

To obtain population-representative findings, analyses were conducted using SAS version 9.2 (SAS Institute, Cary, NC) using sample weights for the combined 2003/4 and 2005/6 NHANES cycles which account for the complex survey design (including oversampling), survey non-response, and poststratification. Analyses were stratified by sex, on the basis that interactions between sex and the three exposures (MVPA, total sedentary time and TV time) in their association with obesity were significant or borderline significant ($P = 0.01$ for MVPA × sex, $P = 0.11$ for sedentary × sex, and $P = 0.12$ for TV × sex). Because MVPA and total sedentary time were=related to age in this sample (MVPA minutes and age: Spearman's rho = –0.56; accelerometer sedentary minutes and age: rho = 0.30), these variables were adjusted for age by regressing daily minutes of MVPA and total sedentary time against age. The residuals were used in subsequent analyses and represented age-adjusted MVPA and age-adjusted total sedentary time. This was not done for TV time, which was a categorical variable and was only weakly related to age (rho = 0.19).

Participants' age-adjusted MVPA and age-adjusted total sedentary time were divided into sex-specific low, moderate and high tertiles for age-adjusted MVPA and age-adjusted total sedentary time. Because of the categorical classification of TV time, three approximately equal groups were created such that the low group watched ≥1 h, the moderate watched exactly 2 h and the high watched ≥3 h of TV per day. Logistic regression was used to calculate the odds ratios for being obese, for each group of behaviors separately (MVPA, TV time and total sedentary time). The associations between sedentary behaviors and MVPA and obesity were then determined using stratified logistic regression analyses (i.e., the analyses examining the relationship between MVPA and weight status were undertaken separately within low, moderate and high sedentary behavior groups, and the analyses examining the relationships between sedentary behaviors and weight status were undertaken separately within low, moderate and high MVPA groups).

Each participant was then allocated to one of nine categories of low, moderate or high MVPA combined with low, moderate, or high total sedentary time. The high MVPA low total sedentary time group was used as the reference category to examine their combined influence on obesity using logistic regression, and the results are displayed graphically. Finally, to determine the independent effects of MVPA and sedentary behaviors on odds of obesity, both behaviors were included in the same model and significance is reported in Figure 1.

For all regression analyses, ethnicity, household income, educational attainment, smoking status and dietary variables (average daily energy intake, saturated fat as a percentage of total energy, and alcohol intake) were used as covariates, since obesity status is known to covary with each of these variables. Participants with missing categorical covariate data were retained in analyses; however sensitivity analyses in which analyses were repeated with such participants excluded, showed that the results were unchanged (analyses not shown). Interactions between MVPA and TV viewing, and between MVPA and sedentary time in their associations with obesity were examined, however they were not significant (*P*

> 0.4), therefore behavior interaction terms were not included in the models. Alpha was set at 0.05.

Results

A total of 5,083 NHANES participants met the inclusion criteria and were included in these analyses. Key sociodemographic and behavioral characteristics of the participants are reported in Table 1. For women and men, 32 and 31%, respectively were obese.

The separate associations of MVPA, TV time and total sedentary time with obesity status were examined using population-weighted logistic regression (adjusted for accelerometer wear time, age, education, income, ethnicity, energy intake, saturated fat as a percentage of total energy intake, alcohol intake and smoking status) as shown in Table 2. A graded association between decreasing MVPA and increasing risk of obesity was seen in both men and women (OR 1.62 to 2.84). Similarly, there was a consistent pattern for increasing TV time to be associated with increasing risk of obesity (OR 1.37 to 1.56) with the exception of the women's moderate TV time group. However, risk of obesity was unrelated to accelerometer measured total sedentary time.

The stratified associations of MVPA, TV time, and total sedentary time with obesity were then examined using logistic regression. Again, analyses were adjusted for sociodemographic and behavioral variables (accelerometer wear time, age, education, income, ethnicity, energy intake, saturated fat as a percentage of total energy intake, alcohol intake and smoking status). Complete results for these analyses are shown in Tables 3 and 4.

Higher TV time (stratified by MVPA) was sometimes, but not always, associated with increased risk of obesity in men (OR 1.71 to 2.12; Table 3). In women, TV time was not associated with risk of obesity once analyses were stratified by MVPA. In contrast, MVPA (stratified by TV time) was associated with the risk of obesity in men and women. In men, low MVPA was associated with increased risk of obesity (OR 2.19 to 3.36). In women, those who obtained either moderate or low levels of MVPA had increased risk of obesity (OR 1.80 to 2.47 and OR 2.48 to 3.67 for moderate and low MVPA, respectively) compared with the high MPVA tertile.

Table 4 shows that after stratification by MVPA, total sedentary time continued to have no association with risk of obesity in men or women. In contrast, MVPA (stratified by total sedentary time) was associated with increased risk of obesity. In men, low MVPA was consistently associated with increased risk of obesity (OR 2.82 to 3.28), and moderate MVPA was associated with risk of obesity. In women, both moderate and low MVPA was associated with increased risk of obesity (OR 1.37 to 2.55 for moderate MVPA and OR 2.39 to 4.00 for low MVPA).

The results for the logistic regression analyses examining the risk of obesity for combined MVPA and sedentary behaviors are depicted in Figure 1 (combined MVPA/TV time shown in top panels, and combined MVPA/total sedentary time shown in bottom panels). While the independent associations between TV time and risk of obesity were inconsistent in men and nonexistent in women (Table 3), when TV patterns were combined with MVPA behaviors, it

appears they acted synergistically to increase the risk of obesity. For example, the OR for risk of obesity were 3.42 and 3.99 for women and men respectively when low MVPA was combined with high TV time, which was higher than the odds ratios for either of these behaviors when examined independently. In contrast, there was little evidence of interplay between MVPA and total sedentary time on risk of obesity when these behaviors were examined in combination. As can be seen from the bottom panel of Figure 1, changes in the risk of obesity were due to differences in MVPA, with risk relatively "flat" across sedentary tertiles.

Discussion

This study employed an analytical approach that provides insight into two commonly recognized risk factors for adult obesity—physical activity and sedentary behavior. Low MVPA was consistently associated with higher risk of obesity, regardless of TV time or total sedentary behavior. The relationships between obesity status and sedentary behavior varied depending on how sedentary behavior was operationalized: there was an inconsistent pattern for risk of obesity to be greater with higher TV time in men but not in women. However, sedentary behavior defined on the basis of accelerometer sedentary minutes was not associated with obesity. When low MVPA was combined with high TV time, risk of obesity was heightened compared with risk of obesity associated with low MVPA or high TV time alone.

In contrast to our expectations at the outset of the study, total sedentary time was not associated with increased risk of obesity. This finding is inconsistent with two studies undertaken by Healy et al. (9,19) which found significant positive associations between sedentary time and waist circumference. Interestingly, the same sample (NHANES 2003-06) was used in the current study and in Healy et al. (9). Thus, it seems likely that difference in findings between studies was due to the different measures of adiposity examined (obesity status based on BMI in the current study versus waist circumference in Healy et al.'s studies). Alternatively, we considered whether the difference in findings relating to total sedentary time were due to differences in data handling: in the current study a cutoff was used to detect excess adiposity (30 kg m $^{-2}$) whereas in Healy's studies waist circumference was used as a continuous variable, which one might expect to be more sensitive in analyses. Accordingly, we re-examined the association between total sedentary time and BMI in our study sample, and found a low, but statistically significant correlation between BMI and sedentary time in women (Pearson's $r = 0.07$) but not in men (Pearson's $r = 0.03$, $P > 0.05$). The clinical significance of such a correlation is questionable, given that it infers that less than half of 1% of variability (0.07^2) in BMI could be explained by sedentary time.

A positive association between TV time and risk of obesity was identified in this study, which is consistent with previous studies (15-18). An advantage of the NHANES dataset is that eating behaviors are captured, thus we were able to control the analyses for total energy intake, saturated fat as a per cent of total energy intake and alcohol intake, which may have otherwise confounded analyses, given that snacking and alcohol consumption can co-occur with TV viewing (5). The presence of a relationship between TV time and risk of obesity (albeit inconsistent), independent of dietary factors, suggests that a portion of the

relationship between obesity and TV time is due to factors other than eating behavior. It appears on a small degree of displacement occurred in this sample, given the weak inverse relationship between TV time and MVPA minutes (rho = –0.17 men; rho = –0.20 women).

Across sexes, the risk of obesity associated with MVPA, TV time and sedentary behaviors was generally quite consistent. In some analyses (e.g., see Table 3) there was a pattern for increased risk of obesity to be associated with both low and moderate MVPA in women, and only low MVPA in men. It is possible that this is due to men's overall higher MVPA levels, i.e., the physical activity level of the men's low MVPA tertile was actually comparable to that of the moderate MVPA women's tertile (11.8 and 9.9 mean daily minutes, respectively). Thus it appears possible that MVPA in the vicinity of men's moderate MVPA tertile (20.4 min day $^{-1}$) may be protective against obesity. This is broadly consistent with the American College of Sports Medicine and the American Health Association physical activity guidelines, which equate to 150 min of MVPA per week to help prevent unhealthy weight gain (1).

That total sedentary time and risk of obesity were unrelated, yet TV time and risk of obesity were related, was surprising. Total sedentary time would be largely inclusive of TV time, thus the fact that there was a negative association between weight status and TV time, but not between weight status and total sedentary time, suggests that some non-TV components of sedentary time may in fact have a beneficial relationship with weight status. There is currently an upsurge in research investigating the health effects of sedentary behavior, so in time such work should shed light on the nuanced relationships found in this study. Certainly, differing associations between various types of sedentary behaviors and health outcomes have been reported in other studies, for example, Bertrais et al.'s (29) study of 3,834 French adults found that increased risk of metabolic syndrome was significantly associated with screen-based sedentary time, but not time spent reading.

It seems possible that socioeconomic factors may be complicating the relationship between sedentary time and obesity. On one hand, higher SES has been linked to a lower prevalence of obesity in US women, and UK men and women (30,31). Yet, on the other hand, higher socioeconomic status occupations are associated with increased sitting time (32), which one might expect would increase the risk of obesity. Thus it is possible that these factors may be interacting to wash out the relationship between total sedentary time and obesity. However, this seems unlikely given the very large sample on which analyses were based, and that our analyses were adjusted for a range of recognized potential confounders, including markers of socioeconomic status and occupation (household income and educational attainment).

A strength of the current study was the large, nationally representative dataset. Physical activity and total sedentary time were measured objectively using accelerometers. The comprehensive nature of the NHANES dataset allowed us to statistically control for numerous covariates, including ethnicity, socioeconomic status, and diet (including saturated fat and alcohol intake), which if not included, may have confounded results. Limitations of the study should also be acknowledged. The study is cross-sectional, therefore it is not possible to discern whether differences in activity patterns are the cause or

the outcome of weight status. In addition, TV time was self-reported, and thus may be susceptible to recall and social desirability bias.

In recent years there has been increased interest in the public health benefit of small changes to behaviors or “nudges” (33). Findings from the current analysis support the idea that relatively modest increases in physical activity might improve BMI status. For example, the difference in mean MVPA time between low and moderate MVPA tertiles in men and women was an average of 6 min day $^{-1}$. Yet this small difference in MVPA was associated with markedly lower risk for obesity in the moderate MVPA groups compared with the low MVPA groups. This is consistent with other studies that have shown considerable improvement in weight status and health biomarkers associated with small activity changes, such as taking the stairs rather than the elevator (34).

In conclusion, this study extends our understanding of relationships between MVPA, sedentary behavior and obesity in men and women. The results highlight the complex relationships, including independent and interacting relationships, where low MVPA and high TV combined are associated with heightened risk of obesity. While both MVPA and TV time were related to obesity, MVPA emerged as the more significant influence, with relatively small differences in MVPA associated with considerable differences in risks of obesity. Given the inconsistent patterns seen between TV time and total sedentary time and obesity, additional work is needed to better understand these relationships and underlying mechanisms. In the meantime, we recommend that epidemiological and clinical research regarding sedentary behavior should capture both of these measures.O

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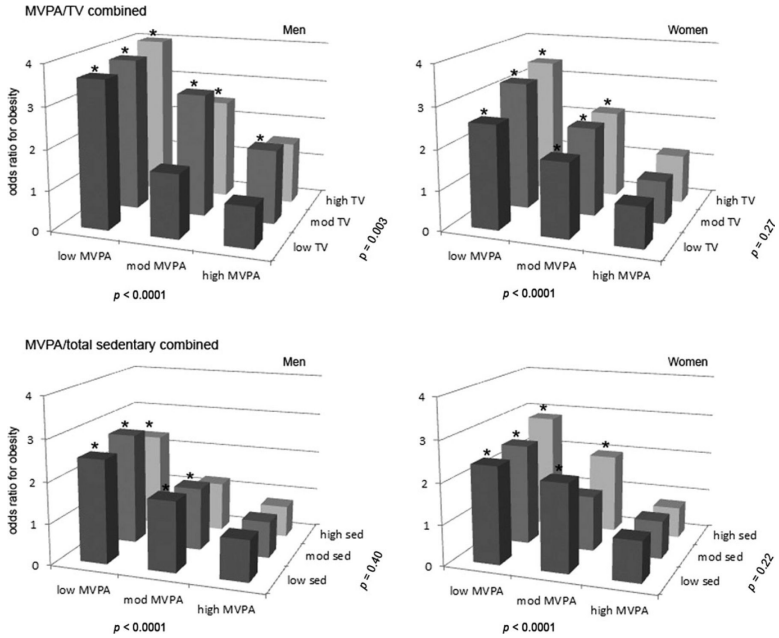

FIGURE 1.

The odds of being obese among combined MVPA and sedentary behavior categories for men and women. * denotes significant difference ($P < 0.05$) from reference category (high MVPA low sedentary behavior).

TABLE 1

Population weighted descriptive characteristics of the NHANES sample used in this study

		Women (*n* = 2,460, 48.4%)	Men (*n* = 2,623)
Socio-demographic			
Age (%)	20-39 years	27.9	32.6
	40-59 years	41.9	42.5
	60+ years	30.3	24.9
Ethnicity (%)	Mexican American	6.4	8.3
	Other Hispanic	3.4	2.6
	Non-Hispanic White	75.1	75.9
	Non-Hispanic Black	9.8	8.6
	Other	5.4	4.6
Educational attainment (%)	Less than 9^{th} grade	5.4	6.8
	9^{th}-12^{th} grade with no high school diploma	9.2	9.5
	High school diploma or equivalent	25.8	24.7
	Some post high school	33.3	30.8
	College graduate or higher	26.2	28.2
	Missing[a]	0.02	0.04
Household income (%)	$ 0 to $ 4,999	0.8	1.2
	$ 5,000 to $ 9,999	3.4	1.9
	$10,000 to $14,999	5.6	3.8
	$15,000 to $19,999	5.4	4.6
	$20,000 to $24,999	6.7	5.6
	$25,000 to $34,999	12.3	11.2
	$35,000 to $44,999	9.9	9.8
	$45,000 to $54,999	9.8	11.2
	$55,000 to $64,999	8.2	7.9
	$65,000 to $74,999	5.9	7.0
	$75,000 and Over	27.3	31.6
	Over $20,000	1.2	1.0
	Under $20,000	0.2	0.2
	Missing[a]	3.5	2.9
BMI (kg/m^2) mean ± SE		28.2 ± 0.21	28.2 ± 0.16
Overweight (%)		30.1	41.1
Obese (%)		32.2	31.4
Behaviors			
Accelerometer daily MVPA minutes mean ± SE		16.8 ± 0.5	29.3 ± 0.7
MVPA tertiles minutes mean ± SE	Low	6.1 ± 0.2	11.8 ± 0.3
	Moderate	9.9 ± 0.4	20.4 ± 0.7
	High	34.5 ± 0.8	55.7 ± 0.8

		Women (*n* = 2,460, 48.4%)	**Men (*n* = 2,623)**
Accelerometer daily sedentary minutes mean ± SE		487.3 ± 1.8	493.3 ± 3.3
Total sedentary time tertiles minutes mean ± SE	Low	378.85 ± 2.6	367.5 ± 2.3
	Moderate	485.8 ± 1.6	491.9 ± 1.8
	High	597.1 ± 2.7	620.2 ± 4.0
Self-reported TV time (%)	Low	35.7	32.4
	Moderate	28.4	28.8
	High	35.9	38.8
Total energy intake (kcal) mean ± SE		1783.5 ± 14.8	2542.3 ± 18.7
Saturated fat as % of total energy mean ± SE		11.1 ± 0.1	11.2 ± 0.1
Alcohol intake (%)	None	72.1	57.6
	Light	14.8	23.7
	Moderate	7.0	11.0
	Heavy	6.0	7.6
Smoking status (%)	Non	80.2	67.9
	Light	3.2	6.6
	Moderate	9.9	14.7
	Heavy	4.6	8.5
	Missing[a]	2.2	2.2

TABLE 2

Separate associations between MPVA, TV time and total sedentary time and obesity status

		Men		Women	
		n	**OR (95% CI)**	***n***	**OR (95% CI)**
MVPA minutes	High	790	1.0 (reference)	730	1.0 (reference)
	Moderate	997	**1.62 (1.19-2.22)**	930	**1.94 (1.50-2.52)**
	Low	836	**2.69 (2.04-3.56)**	800	**2.84 (2.16-3.73)**
TV minutes	Low	780	1.0 (reference)	777	1.0 (reference)
	Moderate	713	**1.56 (1.21-2.02)**	682	1.22 (0.89-1.67)
	High	1130	**1.51 (1.23-1.86)**	1001	**1.37 (1.07-1.76)**
Sed minutes	Low	907	1.0 (reference)	859	1.0 (reference)
	Moderate	879	1.18 (0.88-1.59)	794	1.00 (0.78-1.27)
	High	837	1.21 (0.89-1.63)	807	1.33 (0.98-1.81)

OR = Odds ratio.

Covariates (included in all models): ethnicity, education, household income, total energy intake, saturated fat as percentage of total energy, alcohol intake, smoking status, accelerometer wear time (MVPA and Sedentary time models only) and age (TV time model only).

TABLE 3

Stratified associations between MVPA and TV time and obesity

		OR (95% CI)				OR (95% CI)	
MVPA	**TV**	**Men**	**Women**	**TV**	**MVPA**	**Men**	**Women**
High	Low	1.0 (reference)	1.0 (reference)	High	High	1.0 (reference)	1.0 (reference)
	Moderate	**1.71 (1.16-2.53)**	1.04 (0.65-1.66)		Moderate	1.59 (0.97-2.60)	**1.80 (1.20-2.69)**
	High	1.53 (0.90-2.60)	1.20 (0.72-2.01)		Low	**2.62 (1.65-4.16)**	**2.85 (1.69-4.80)**
Moderate	Low	1.0 (reference)	1.0 (reference)	Moderate	High	1.0 (reference)	1.0 (reference)
	Moderate	**2.12 (1.14-3.95)**	1.32 (0.82-2.13)		Moderate	1.73 (0.96-3.13)	**2.47 (1.47-4.16)**
	High	**1.73 (1.23-2.43)**	1.31 (0.92-1.87)		Low	**2.19 (1.35-3.55)**	**3.67 (1.98-6.82)**
Low	Low	1.0 (reference)	1.0 (reference)	Low	High	1.0 (reference)	1.0 (reference)
	Moderate	1.12 (0.73-1.71)	1.30 (0.74-2.29)		Moderate	1.56 (0.96-2.56)	**1.86 (1.28-2.71)**
	High	1.11 (0.78-1.60)	1.31 (0.89-1.93)		Low	**3.36 (2.13-5.32)**	**2.48 (1.86-3.31)**

OR = Odds ratio.

Covariates: accelerometer wear time, age, ethnicity, education, household income, total energy intake, saturated fat as percentage of total energy, alcohol intake and smoking status.

TABLE 4

Stratified associations between MVPA and total sedentary time and obesity

		OR (95% CI)				OR (95% CI)	
MVPA	**Sedentary**	**Men**	**Women**	**Sedentary**	**MVPA**	**Men**	**Women**
High	Low	1.0 (reference)	1.0 (reference)	High	High	1.0 (reference)	1.0 (reference)
	Moderate	0.98 (0.55-1.74)	1.04 (0.55-1.96)		Moderate	1.55 (0.73-3.26)	**2.55 (1.54-4.20)**
	High	0.95 (0.39-2.31)	0.89 (0.38-2.05)		Low	**2.87 (1.49-5.52)**	**4.00 (2.48-6.45)**
Moderate	Low	1.0 (reference)	1.0 (reference)	Moderate	High	1.0 (reference)	1.0 (reference)
	Moderate	0.84 (0.53-1.34)	0.65 (0.36-1.16)		Moderate	1.72 (0.98-3.01)	1.37 (0.76-2.46)
	High	0.63 (0.30-1.05)	1.14 (0.67-1.95)		Low	**3.28 (1.86-5.79)**	**2.39 (1.50-3.81)**
Low	Low	1.0 (reference)	1.0 (reference)	Low	High	1.0 (reference)	1.0 (reference)
	Moderate	1.08 (0.62-1.87)	0.92 (0.63-1.34)		Moderate	**2.13 (1.30-3.46)**	**2.23 (1.19-4.16)**
	High	0.95 (0.49-1.84)	0.91 (0.59-1.42)		Low	**2.82 (1.62-4.90)**	**2.52 (1.41-4.51)**

OR = Odds ratio.

Covariates: accelerometer wear time, age, ethnicity, education, household income, total energy intake, saturated fat as percentage of total energy, alcohol intake and smoking status.