

# Television Watching and Other Sedentary Behaviors in Relation to Risk of Obesity and Type 2 Diabetes Mellitus in Women

Frank B. Hu, MD, PhD

Tricia Y. Li, MD

Graham A. Colditz, MD, DrPH

Walter C. Willett, MD, DrPH

JoAnn E. Manson, MD, DrPH

CURRENT PUBLIC HEALTH CAMPAIGNS to reduce obesity and type 2 diabetes have largely focused on increasing exercise levels, but have paid little attention to the reduction of sedentary behaviors. Television (TV) watching is a major sedentary behavior in the United States. In a survey conducted in 1997, an adult male spent approximately 29 hours per week watching TV, and an adult female spent 34 hours per week.<sup>1</sup> In recent decades, in parallel with increasing obesity, there has been a steady increase in the number of homes with multiple TV sets, videocassette recorders (VCRs), cable TV, and remote controls, as well as the number of hours spent watching TV.<sup>1</sup>

Compared with other sedentary activities such as sewing, playing board games, reading, writing, and driving a car, TV watching results in a lower metabolic rate.<sup>2</sup> Constant exposure to food advertising leads to increased food and calorie intake and unhealthy eating patterns.<sup>3-5</sup> It is well established that prolonged TV watching is associated with obesity in children.<sup>6-8</sup> However, the role of TV watching compared with other sedentary behaviors, such as sitting at work or reading, in the development of obesity and type 2 diabetes among adults

**Context** Current public health campaigns to reduce obesity and type 2 diabetes have largely focused on increasing exercise, but have paid little attention to the reduction of sedentary behaviors.

**Objective** To examine the relationship between various sedentary behaviors, especially prolonged television (TV) watching, and risk of obesity and type 2 diabetes in women.

**Design, Setting, and Participants** Prospective cohort study conducted from 1992 to 1998 among women from 11 states in the Nurses' Health Study. The obesity analysis included 50277 women who had a body mass index (BMI) of less than 30 and were free from diagnosed cardiovascular disease, diabetes, or cancer and completed questions on physical activity and sedentary behaviors at baseline. The diabetes analysis included 68497 women who at baseline were free from diagnosed diabetes mellitus, cardiovascular disease, or cancer.

**Main Outcome Measures** Onset of obesity and type 2 diabetes mellitus.

**Results** During 6 years of follow-up, 3757 (7.5%) of 50277 women who had a BMI of less than 30 in 1992 became obese (BMI  $\geq 30$ ). Overall, we documented 1515 new cases of type 2 diabetes. Time spent watching TV was positively associated with risk of obesity and type 2 diabetes. In the multivariate analyses adjusting for age, smoking, exercise levels, dietary factors, and other covariates, each 2-h/d increment in TV watching was associated with a 23% (95% confidence interval [CI], 17%-30%) increase in obesity and a 14% (95% CI, 5%-23%) increase in risk of diabetes; each 2-h/d increment in sitting at work was associated with a 5% (95% CI, 0%-10%) increase in obesity and a 7% (95% CI, 0%-16%) increase in diabetes. In contrast, standing or walking around at home (2 h/d) was associated with a 9% (95% CI, 6%-12%) reduction in obesity and a 12% (95% CI, 7%-16%) reduction in diabetes. Each 1 hour per day of brisk walking was associated with a 24% (95% CI, 19%-29%) reduction in obesity and a 34% (95% CI, 27%-41%) reduction in diabetes. We estimated that in our cohort, 30% (95% CI, 24%-36%) of new cases of obesity and 43% (95% CI, 32%-52%) of new cases of diabetes could be prevented by adopting a relatively active lifestyle ( $<10$  h/wk of TV watching and  $\geq 30$  min/d of brisk walking).

**Conclusions** Independent of exercise levels, sedentary behaviors, especially TV watching, were associated with significantly elevated risk of obesity and type 2 diabetes, whereas even light to moderate activity was associated with substantially lower risk. This study emphasizes the importance of reducing prolonged TV watching and other sedentary behaviors for preventing obesity and diabetes.

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**Author Affiliations:** Departments of Nutrition (Drs Hu, Li, and Willett) and Epidemiology (Drs Hu, Colditz, Willett, and Manson), Harvard School of Public Health; the Channing Laboratory (Drs Hu, Colditz, Willett, and Manson); and the Division of Preventive Medicine (Dr Manson), Department of Medicine, Harvard Medical

School and Brigham and Women's Hospital, Boston, Mass.

**Corresponding Author and Reprints:** Frank B. Hu, MD, PhD, Department of Nutrition, Harvard School of Public Health, 665 Huntington Ave, Boston, MA 02115 (e-mail: Frank.hu@channing.harvard.edu).

has not been well studied, especially among women. We therefore examined prospectively the relationship between several common sedentary behaviors and incidence of obesity and type 2 diabetes in a large cohort of women.

## METHODS

### Study Participants

The Nurses' Health Study cohort was established in 1976 when 121 700 female registered nurses aged 30 to 55 years and residing in 1 of 11 US states responded to mailed questionnaires regarding their medical history and health practices; details have been published elsewhere.<sup>9</sup> For this study, we excluded women with diagnosed cardiovascular disease ( $n=3102$ ), cancer ( $n=9917$ ), or diabetes ( $n=4373$ ) in 1992. The final sample for the diabetes analysis consisted of 68 497 women. For the obesity analysis, we also excluded women who were already obese (body mass index [BMI]  $\geq 30$ ) in 1992 or earlier cycles, leaving 50 277 women in the final analysis.

### Assessment of Sedentary Behaviors and Physical Activity

In 1992, participants were asked to report their average weekly time spent sitting at home while watching TV or VCR, sitting at work or away from home or while driving, and other sitting at home (eg, reading, meal times, at desk). They were also asked to report time spent standing or walking around at home or at work. The responses included 9 categories (ranging from 0 h/wk to  $>90$  h/wk). In the current analyses, 5 categories were coded consistently across all the 5 items (0-1, 2-5, 6-20, 21-40, and  $>40$  h/wk).

In 1992, 1994, and 1996, participants were asked the amount of time they spent on average per week on each of the following physical activities: walking, jogging, running, bicycling, calisthenics/aerobics/aerobic dance/rowing machine, lap swimming, squash/racquetball, and tennis. They were also asked about their usual walking pace, specified as easy/casual ( $<2$  miles per hour [mph]), normal (2-2.9 mph), brisk (3-3.9 mph), or very brisk/striding ( $\geq 4$

mph). From this information, weekly energy expenditure in metabolic equivalent hours (MET-hours) was calculated.<sup>2</sup> For example, brisk walking requires an energy expenditure of about 4 METs and is considered to be a moderate-intensity activity. In this cohort, walking is the most common type of activity (60% of all women reported that they walked  $\geq 1$  h/wk). Because the results using baseline and updated physical activity measures were similar, we reported only baseline analyses.

The reproducibility and validity of the physical activity questionnaire has been described elsewhere.<sup>10</sup> In a representative sample ( $n=147$ ) of participants in the Nurses' Health Study II cohort, the 2-year test-retest correlation for activity was 0.59. The correlation between physical activity reported on 1-week recalls and that reported on the questionnaire was 0.79. The correlation between activity reported in diaries and that reported on the questionnaire was 0.62. In a separate study on a population aged 20 to 59 years recruited from a university community ( $n=103$ ), the correlation between physical activity score on a very similar questionnaire and maximum oxygen consumption was 0.54.<sup>11</sup> In a parallel cohort of men, average hours of TV watching were significantly associated with higher levels of leptin and low-density lipoprotein cholesterol and lower levels of high-density lipoprotein cholesterol and apolipoprotein A1.<sup>12</sup>

### Assessment of Obesity

Body weight was self-reported in the biennial questionnaires. Self-reported weights were highly correlated with measured weights ( $r=0.96$ ; mean difference, 1.5 kg).<sup>13</sup> In 1976, the nurses were asked to report their height to the closest inch. Body mass index (BMI) is calculated as weight in kilograms divided by the square of height in meters. Incidence of obesity is defined as the transition from non-obese (BMI  $<30$ ) in 1992 to a BMI of 30 or more at the end of follow-up in 1998. Thus, only individuals with a BMI of less than 30 across all time points (between 1976 and 1992) were included in the obesity analysis ( $n=50 277$ ).

### Diagnosis of Diabetes

A supplementary questionnaire regarding symptoms, diagnostic tests, and hypoglycemic therapy was mailed to women who indicated on any biennial questionnaire that they had been diagnosed with diabetes. A case of diabetes was considered confirmed if at least 1 of the following was reported on the supplementary questionnaire: (1) classic symptoms plus elevated glucose levels (a fasting plasma glucose concentration  $\geq 140$  mg/dL [7.7 mmol/L] or a randomly measured concentration of at least 200 mg/dL [11.1 mmol/L]); (2) at least 2 elevated plasma glucose concentrations on different occasions in the absence of symptoms (levels as above or  $\geq 200$  mg/dL [11.1 mmol/L] after  $\geq 2$  hours of oral glucose tolerance testing); and (3) treatment with oral hypoglycemic agents or insulin. Our criteria for diabetes classification are consistent with those proposed by the National Diabetes Data Group.<sup>14</sup>

The validity of this diagnostic procedure has been verified in a subsample of this study population.<sup>15</sup> In addition, another substudy assessing the prevalence of undiagnosed diabetes suggested a very low rate of false-negative results.<sup>16</sup>

### Statistical Analysis

Person-time for each participant was calculated from the date of return of the 1992 questionnaires to the date of confirmed type 2 diabetes (for diabetes analysis only), the year of first reported obesity (for obesity analysis only), death from any cause, or June 1, 1998, whichever came first. Incidence rates of obesity or type 2 diabetes were obtained by dividing the number of cases by person-years in each category of average time spent on each sedentary behavior (eg, TV watching). Relative risks (RRs) were computed as the incidence rate in a specific category of TV watching divided by that in the reference category, with adjustment for 5-year age categories. Tests for linear trend across increasing categories of average time spent watching TV were conducted by treating the categories as a continuous variable and as-

signing the middle score for the category as its value.

We used Cox regression to adjust estimated incidence rate ratios simultaneously for potential confounding variables. In the multivariate analyses of onset of obesity, we adjusted for age (<50, 50-54, 55-59, 60-64, ≥65 years), smoking (never, past, current 1-14, 15-24, and ≥25 cigarettes/d), alcohol consumption (0, 0.1-4.9, 5-14.9, ≥15 g/d), and physical activity (METs in quintiles). We further adjusted for dietary variables including total energy intake, total fat, glycemic load, and cereal fiber (all in quintiles). For multivariate analyses of diabetes, our covariates included age, smoking, alcohol consumption, and family history of diabetes. Further analyses

adjusted for dietary intakes of polyunsaturated fat, glycemic load, cereal fiber, and *trans* fat (all in quintiles).<sup>17</sup>

We calculated the population-attributable risk to estimate the percentages of obesity and type 2 diabetes cases in this population that are attributable to the joint effects of 2 risk factors (either >10 h/wk of TV watching or <30 min/d walking or equivalent energy expenditure).<sup>18</sup>  $P=.05$  was considered significant. Statistical analysis was performed using SAS statistical software, version 8.2 (SAS Institute Inc, Cary, NC).

## RESULTS

Women who spent more time watching TV were more likely to smoke and drink alcohol and less likely to exer-

cise (TABLE 1). However, the correlation between TV watching and physical activity levels was minimal ( $r=-0.03$ ). These women also had higher intake of total energy, total and saturated fats, red meat, processed meat, refined grain products, snacks, sweets/desserts, and lower intakes of fish, vegetables, fruits, and whole grains.

During 6 years of follow-up (282 141 person years), 3757 women who were not obese at baseline (7.5%) became obese in 1998. Time spent watching TV was positively associated with risk of obesity (TABLE 2). The age-adjusted RRs across categories of TV watching (0-1, 2-5, 6-20, 21-40, >40 h/wk) were 1.0, 1.23, 1.42, 1.68, and 2.00, respectively ( $P$  for trend, <.001). Further ad-

**Table 1.** Baseline (1992) Characteristics According to Average Hours Spent Watching Television in 68 497 Women in the Nurses' Health Study\*

	Hours Spent Watching Television per week				
	0-1 (n = 4814)	2-5 (n = 16 799)	6-20 (n = 35 884)	21-40 (n = 9536)	>40 (n = 1464)
Age, y	56 (6.7)	57 (7.1)	57 (7.0)	60 (6.9)	61 (6.8)
Family history of diabetes, No. (%)	1107 (23)	4032 (24)	8971 (25)	2479 (26)	366 (25)
Postmenopausal hormone use, No. (%)	1781 (37)	6048 (36)	13 277 (37)	3624 (38)	498 (34)
Current smokers, No. (%)	578 (12)	2352 (14)	5383 (15)	1716 (18)	307 (21)
Alcohol consumption, g/d	4.7 (4.3)	4.9 (9.1)	5.3 (9.4)	5.6 (10.5)	5.4 (10.3)
Body mass index	25 (4.7)	26 (4.8)	26 (4.9)	27 (5.3)	28 (6.0)
Physical activity, METs/wk	21 (25.1)	20 (25)	19 (23)	17 (21)	16 (21)
Glycemic load	115 (4.3)	115 (4.2)	117 (4.2)	118 (4.2)	118 (4.8)
Nutrient intake					
Total fat, energy percentage	30.6 (6.4)	31.0 (6.0)	31.6 (5.8)	32.3 (6.0)	32.4 (6.4)
<i>Trans</i> -fat, energy percentage	1.40 (0.60)	1.44 (0.57)	1.51 (0.57)	1.59 (0.59)	1.57 (0.60)
Polyunsaturated fat, energy percentage	5.82 (1.66)	5.87 (1.67)	5.92 (1.57)	6.02 (1.65)	5.84 (1.69)
Monounsaturated fat, energy percentage	11.7 (2.8)	11.9 (2.6)	12.1 (2.5)	12.4 (2.6)	12.5 (2.8)
Saturated fat, energy percentage	10.3 (2.8)	10.5 (2.5)	10.7 (2.5)	11.0 (2.6)	11.2 (2.7)
Cereal fiber, g/d	5.74 (3.92)	5.50 (3.63)	5.56 (3.59)	5.49 (3.60)	5.18 (3.61)
Total calories, kcal/d	1710 (524)	1716 (515)	1760 (509)	1803 (512)	1804 (538)
Food intake, servings†					
Red meat	0.64 (0.51)	0.69 (0.51)	0.75 (0.52)	0.84 (0.58)	0.89 (0.69)
Fish	0.31 (0.32)	0.32 (0.31)	0.31 (0.27)	0.29 (0.24)	0.30 (0.28)
Vegetables	3.69 (2.29)	3.67 (2.25)	3.50 (2.02)	3.39 (2.00)	3.36 (2.41)
Fruit	2.28 (1.57)	2.21 (1.60)	2.09 (1.33)	1.98 (1.36)	1.93 (1.54)
Potato	0.34 (0.30)	0.35 (0.31)	0.38 (0.28)	0.40 (0.28)	0.40 (0.32)
Snack	0.64 (1.05)	0.65 (0.93)	0.72 (0.99)	0.79 (1.10)	0.75 (1.12)
Whole grain	1.54 (1.38)	1.41 (1.23)	1.37 (1.15)	1.37 (1.18)	1.25 (1.13)
Refined grain	1.05 (0.93)	1.07 (0.90)	1.15 (0.90)	1.24 (0.97)	1.27 (1.02)
Sweets	0.93 (1.08)	0.98 (1.11)	1.07 (1.15)	1.19 (1.29)	1.19 (1.37)

Abbreviation: METs, metabolic equivalents.

\*All dietary factors were assessed in 1990. Data are presented as mean (SD) unless otherwise indicated.

†Red meat includes pork, beef, lamb (main dish and mixed dish), hamburger, processed meat, hot dog, and bacon. Fish includes tuna, dark meat fish, and other fish. Vegetables include tomato, tofu, broccoli, string beans, onion, cabbage, cauliflower, sweet potato, brussels sprouts, peas, corn, squash, eggplant, carrot, spinach, kale, celery, lettuce, beets, and mixed vegetables. Fruits include prune, banana, watermelon, cantaloupe, apple, orange, grapefruit, strawberry, blueberry, and peach. Potato includes potato (baked, mashed, and fries). Snack includes potato/corn chips, crackers, and popcorn. Whole grain includes dark bread, brown rice, cereal, oatmeal, oat bran, wheat germ, and other grain and bran. Refined grain includes white rice, pasta, white bread, pancakes, waffles, muffins, and bagels. Sweets includes chocolate, candy, cookie, doughnuts, cake, coffee cake, and pie.

justment for exercise levels and other covariates did not appreciably alter the RRs. Sitting at work or away from home or driving was also significantly associated with elevated risk of obesity. In contrast, time spent standing or walking around at home was associated with a lower risk of obesity (multivariate RR comparing extreme categories, 0.77; 95% confidence interval [CI], 0.61-0.97; *P* for trend, <.001). Further adjustment for baseline BMI substantially attenuated the RRs. The multivariate RR comparing the extreme categories of TV watching was 1.29 (95% CI, 1.01-1.66). These results suggest that women who watched more TV were already on a trajectory to become obese at baseline.

During 6 years of follow-up (396 900 person-years), we documented 1515 newly diagnosed cases of type 2 diabetes. After adjustment for age, average time spent watching TV was significantly associated with increased risk of type 2 diabetes (TABLE 3). The RRs across categories of average hours spent watching TV per week were 1.0, 1.10, 1.30, 1.53, and 1.98 (*P* for trend, <.001). Further adjustment for dietary factors slightly attenuated the RRs. As expected, these RRs were substantially attenuated after further adjustment for BMI (RR comparing extreme categories, 1.17; 95% CI, 0.82-1.67), suggesting that the increased risk of diabetes associated with TV watching was largely mediated through obesity.

Sitting at work and other sitting at home (last category only) were both associated with significantly increased risk of diabetes in multivariate analyses adjusting for dietary and nondietary covariates (Table 3). Standing or walking around at home was associated with a modestly lower risk of diabetes.

To compare the predictive role of various sedentary behaviors and physical activity, we conducted a multivariate analysis including simultaneously these behaviors (in continuous form), physical activity (4 METs/d, equivalent to 1 h/d of brisk walking), and nondietary and dietary covariates. Among various sedentary behaviors, time spent watching TV was most strongly associated with obesity risk (FIGURE 1). For each 2-h/d

**Table 2.** Relative Risk of Obesity (1992-1998) According to Categories of Sedentary Behaviors

	No. of Hours					<i>P</i> for Trend
	0-1	2-5	6-20	21-40	>40	
<b>Sitting while watching television</b>						
No. of cases	226	872	2043	530	86	
Person-years	21 242	70 616	148 425	36 659	5198	
Age-adjusted RR (95% CI)	1.00	1.23 (1.06-1.42)	1.42 (1.24-1.63)	1.68 (1.43-1.96)	2.00 (1.56-2.57)	<.001
Multivariate RR (95% CI)*	1.00	1.24 (1.07-1.42)	1.44 (1.25-1.65)	1.67 (1.43-1.96)	1.97 (1.53-2.53)	<.001
Multivariate RR (95% CI)†	1.00	1.22 (1.06-1.42)	1.42 (1.24-1.63)	1.65 (1.41-1.93)	1.94 (1.51-2.49)	<.001
<b>Sitting at work or away from home or driving</b>						
No. of cases	240	1032	1812	530	143	
Person-years	21 947	88 720	127 931	35 198	8345	
Age-adjusted RR (95% CI)	1.00	0.98 (0.85-1.13)	1.08 (0.94-1.24)	1.08 (0.92-1.26)	1.24 (1.01-1.53)	.01
Multivariate RR (95% CI)*	1.00	1.03 (0.89-1.18)	1.14 (1.00-1.31)	1.14 (0.98-1.33)	1.28 (1.04-1.58)	.01
Multivariate RR (95% CI)†	1.00	1.02 (0.89-1.18)	1.13 (0.98-1.29)	1.13 (0.96-1.31)	1.25 (1.02-1.54)	.02
<b>Other sitting at home‡</b>						
No. of cases	141	1020	2158	352	86	
Person-years	9702	73 098	159 977	32 676	6688	
Age-adjusted RR (95% CI)	1.00	0.97 (0.81-1.15)	0.95 (0.80-1.13)	0.84 (0.69-1.02)	1.06 (0.81-1.38)	.23
Multivariate RR (95% CI)*	1.00	1.00 (0.84-1.19)	1.01 (0.85-1.20)	0.90 (0.74-1.10)	1.11 (0.85-1.45)	.49
Multivariate RR (95% CI)†	1.00	0.99 (0.83-1.18)	1.01 (0.85-1.20)	0.90 (0.74-1.10)	1.11 (0.85-1.45)	.52
<b>Standing or walking around at home</b>						
No. of cases	89	595	1711	887	475	
Person-years	5087	36 871	122 197	74 407	43 579	
Age-adjusted RR (95% CI)	1.00	0.94 (0.75-1.17)	0.79 (0.64-0.98)	0.69 (0.56-0.86)	0.67 (0.54-0.84)	<.001
Multivariate RR (95% CI)*	1.00	0.99 (0.79-1.23)	0.87 (0.70-1.08)	0.78 (0.62-0.97)	0.77 (0.61-0.96)	<.001
Multivariate RR (95% CI)†	1.00	0.99 (0.79-1.24)	0.87 (0.70-1.08)	0.78 (0.63-0.97)	0.77 (0.61-0.97)	<.001
<b>Standing or walking around at work</b>						
No. of cases	260	659	1309	1026	503	
Person-years	21 768	58 364	100 699	71 903	29 407	
Age-adjusted RR (95% CI)	1.00	0.87 (0.75-1.00)	0.90 (0.79-1.03)	0.88 (0.76-1.01)	1.05 (0.90-1.22)	.04
Multivariate RR (95% CI)*	1.00	0.91 (0.79-1.05)	0.97 (0.85-1.11)	0.93 (0.81-1.07)	1.12 (0.96-1.30)	.03
Multivariate RR (95% CI)†	1.00	0.91 (0.79-1.05)	0.96 (0.84-1.10)	0.92 (0.80-1.06)	1.11 (0.95-1.29)	.04

Abbreviations: CI, confidence interval; RR, relative risk.

\*Controlled for age, smoking, hormone use, alcohol consumption, and metabolic equivalents.

†Controlled for age, smoking, hormone use, alcohol consumption, metabolic equivalents, total fat, cereal fiber, glycemic load, and total calories.

‡Reading, mealtime, at desk.



increase in time spent watching TV, there was a 23% (95% CI, 17%-30%) increase in obesity risk. In contrast, other sitting at home or standing or walking around home was associated with a significantly lower risk of obesity. Each 1-h/d increase in brisk walking was associated with a 24% (95% CI, 19%-29%) reduction in obesity.

Watching TV was also most strongly associated with elevated risk of type 2 diabetes (Figure 1). Each 2-h/d increment in time spent watching TV was associated with a 14% (95% CI, 5%-23%) increase in diabetes risk. Standing or walking around at home was associated with a lower risk of diabetes (12% [95% CI, 7%-16%] risk reduction for each 2-h/d increment). Brisk walking was strongly associated with

a decreased risk of type 2 diabetes (34% [95% CI, 27%-41%] risk reduction for each 1-h/d increment).

To address the possibility that surveillance for diabetes may have varied according to physical activity levels, we did an analysis restricted to cases reporting at least 1 symptom of diabetes at diagnosis. Results from this subgroup were not appreciably different from those for the entire cohort. The multivariate RRs across categories of average hours spent watching TV per week were 1.0, 1.09, 1.30, 1.44, and 1.70.

In multivariate analyses, we observed independent effects of TV watching and exercise levels on obesity and type 2 diabetes (FIGURE 2). Compared with women who were in the most active (the highest tertile of METs/wk)

and the lowest TV watching category (<6 h/wk watching TV), those who were in the lowest of METs per week and most sedentary category ( $\geq 20$  h/wk watching TV) had a significantly increased risk of obesity (RR, 1.90; 95% CI, 1.61-2.24) and type 2 diabetes (RR, 2.89; 95% CI, 2.21-3.79).

We estimated that 30% (95% CI, 24%-36%) of new obesity cases and 43% (95% CI, 32%-52%) of type 2 diabetes cases could be attributable to the joint effects of 2 risk factors (either  $>10$  h/wk of TV watching or  $<30$  min/d walking or equivalent energy expenditure). Only 15% of participants in our cohort belonged to the joint low-risk group (defined as  $<10$  h/wk of TV watching and  $\geq 30$  min/d of walking or equivalent energy expenditure).

**Table 3.** Relative Risk of Type 2 Diabetes (1992-1998) According to Categories of Sedentary Behaviors

	No. of Hours					P for Trend
	0-1	2-5	6-20	21-40	>40	
Sitting while watching television						
No. of cases	81	315	810	258	51	
Person-years	27 966	97 533	208 138	54 970	8293	
Age-adjusted RR (95% CI)	1.00	1.10 (0.86-1.40)	1.30 (1.04-1.64)	1.53 (1.19-1.96)	1.98 (1.39-2.81)	<.001
Multivariate RR (95% CI)*	1.00	1.10 (0.86-1.41)	1.33 (1.06-1.68)	1.49 (1.16-1.92)	1.77 (1.24-2.52)	<.001
Multivariate RR (95% CI)†	1.00	1.09 (0.85-1.39)	1.30 (1.03-1.63)	1.44 (1.12-1.85)	1.70 (1.20-2.43)	<.001
Sitting at work or away from home or driving						
No. of cases	130	443	686	192	64	
Person-years	31 482	122 088	179 625	51 185	12 521	
Age-adjusted RR (95% CI)	1.00	0.91 (0.74-1.10)	1.00 (0.82-1.20)	1.01 (0.81-1.27)	1.37 (1.02-1.86)	.01
Multivariate RR (95% CI)*	1.00	1.00 (0.82-1.21)	1.12 (0.92-1.35)	1.13 (0.90-1.42)	1.51 (1.11-2.04)	.004
Multivariate RR (95% CI)†	1.00	0.99 (0.81-1.20)	1.10 (0.91-1.33)	1.12 (0.89-1.41)	1.48 (1.10-2.01)	.005
Other sitting at home‡						
No. of cases	65	361	852	170	67	
Person-years	14 490	102 965	223 445	46 089	9912	
Age-adjusted RR (95% CI)	1.00	0.79 (0.61-1.03)	0.85 (0.66-1.10)	0.80 (0.60-1.06)	1.44 (1.02-2.02)	.01
Multivariate RR (95% CI)*	1.00	0.87 (0.67-1.13)	1.12 (0.77-1.28)	1.13 (0.71-1.25)	1.51 (1.10-2.19)	.003
Multivariate RR (95% CI)†	1.00	0.87 (0.67-1.13)	0.98 (0.76-1.26)	0.94 (0.70-1.24)	1.54 (1.10-2.18)	.004
Standing or walking around at home						
No. of cases	37	264	697	335	182	
Person-years	7944	55 261	174 845	101 200	57 649	
Age-adjusted RR (95% CI)	1.00	1.02 (0.72-1.44)	0.86 (0.62-1.20)	0.71 (0.51-1.00)	0.66 (0.46-0.94)	<.001
Multivariate RR (95% CI)*	1.00	1.15 (0.81-1.62)	1.05 (0.76-1.47)	0.91 (0.64-1.27)	0.86 (0.60-1.22)	<.001
Multivariate RR (95% CI)†	1.00	1.13 (0.80-1.59)	1.03 (0.74-1.44)	0.88 (0.63-1.24)	0.83 (0.58-1.19)	<.001
Standing or walking around at work						
No. of cases	156	326	515	365	153	
Person-years	31 892	82 267	140 395	100 221	42 126	
Age-adjusted RR (95% CI)	1.00	0.83 (0.68-1.00)	0.79 (0.66-0.95)	0.82 (0.68-1.00)	0.82 (0.65-1.04)	.68
Multivariate RR (95% CI)*	1.00	0.92 (0.77-1.12)	0.94 (0.78-1.13)	0.93 (0.77-1.14)	0.95 (0.75-1.19)	.93
Multivariate RR (95% CI)†	1.00	0.92 (0.76-1.12)	0.93 (0.78-1.12)	0.93 (0.76-1.13)	0.94 (0.74-1.18)	.86

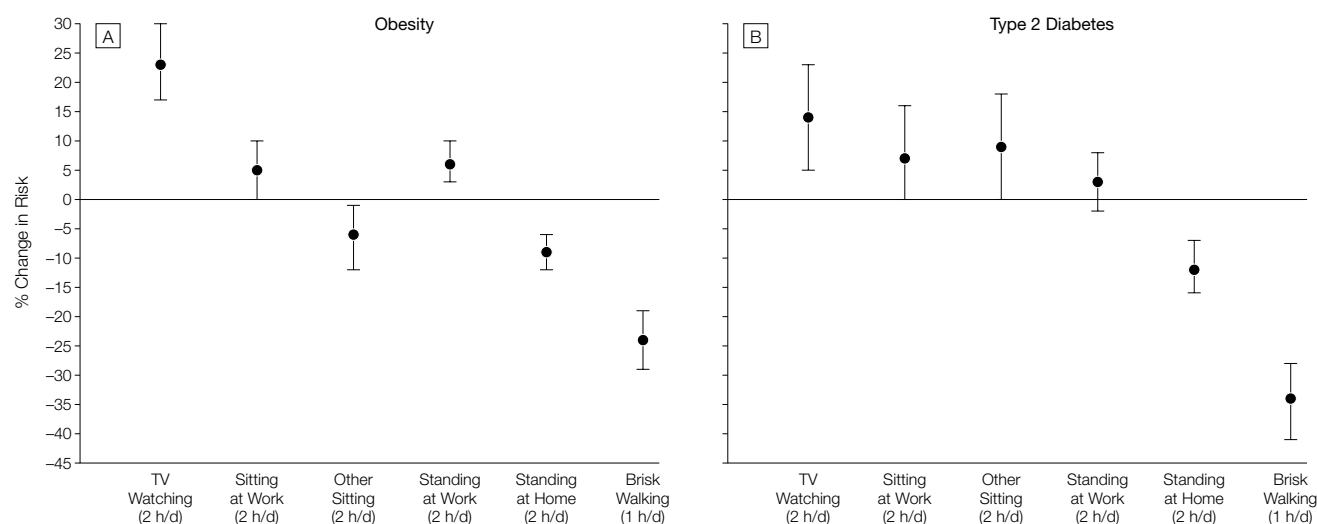
Abbreviations: CI, confidence interval; RR, relative risk.

\*Adjusted for age, hormone use, alcohol consumption, smoking, family history of diabetes, and physical activity.

†Adjusted for age, hormone use, alcohol consumption, smoking, family history of diabetes, physical activity, glycemic load, polyunsaturated fatty acid, cereal fiber, and *trans*-fat.

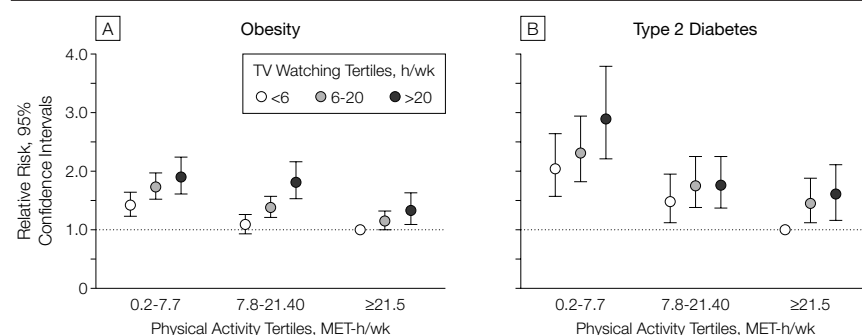
‡Reading, mealtime, at desk.

**Figure 1.** Percentage Changes in Risk of Developing Obesity Among Nonobese Women and in Risk of Developing Type 2 Diabetes Among Nondiabetic Women Associated With Television (TV) Watching, Other Sedentary Behaviors, and Walking



A, Adjusted for age, smoking, alcohol consumption, and dietary covariates. B, Adjusted for age, smoking, alcohol consumption, family history of diabetes, and dietary covariates. All sedentary behavior variables are included simultaneously in the model. Other sitting includes reading, mealtime, and at desk. Error bars indicate 95% confidence intervals.

**Figure 2.** Relative Risks of Developing Obesity Among Nonobese Women and of Developing Type 2 Diabetes Among Nondiabetic Women According to Joint Classification of Physical Activity Levels (Metabolic Equivalent Hours/Wk [MET-h/wk]) and Time Spent Watching Television (TV)



A, Adjusted for age, smoking, alcohol consumption, and dietary covariates. B, Adjusted for age, smoking, alcohol consumption, family history of diabetes, and dietary covariates.

## COMMENT

In this large prospective cohort of women, sedentary behaviors, especially TV watching, were significantly associated with risk of obesity and type 2 diabetes. Sedentary occupation reflected by long hours of sitting or standing at work was significantly associated with risk of obesity. In contrast, even light activities such as standing or walking around at home (which probably reflects household work) and brisk

walking were associated with a significantly lower risk of obesity and diabetes. Our study suggests that 30% of obesity cases and 43% of type 2 diabetes cases can be potentially prevented by following a relatively active lifestyle (<10 h/wk TV watching and ≥30 min/d of brisk walking).

Our results are consistent with previous studies of TV watching in relation to obesity and weight gain in children<sup>4,7</sup> and adults.<sup>19-22</sup> They are also

consistent with our previous analysis showing a positive association between prolonged TV watching and type 2 diabetes among men in the Health Professionals Follow-up Study.<sup>5</sup> Our findings extend the literature showing that moderate-intensity activity such as brisk walking is strongly protective against type 2 diabetes<sup>15,23-29</sup> and indicate a continuum in the relationship between physical activity levels and obesity and diabetes risk, and TV watching has the highest risk for obesity and diabetes among several sedentary behaviors.

There are at least 3 potential mechanisms for the observed positive association between TV watching and obesity and diabetes risk.<sup>30</sup> First, TV watching typically displaces physical activity and thus reduces energy expenditure.<sup>20,21</sup> In our study, women who spent more time watching TV tended to exercise less, but the effects of TV watching and exercise on the development of obesity and diabetes were largely independent. Second, TV watching results in increased food and total energy intake because individuals tend to eat while watching TV despite their low physical activity levels.<sup>3-5</sup> Also, participants who spent more time watching TV tended to follow an

unhealthy eating pattern.<sup>5</sup> Such an eating pattern is directly related to commercial advertisements and food cues appearing on TV<sup>31</sup> and has been associated with risk of obesity and diabetes.<sup>32</sup> Another potential mechanism is that TV viewing results in lower energy expenditure compared with other sedentary activities such as sewing, reading, writing, and driving a car.<sup>2</sup> The combinations of these factors may explain our findings that TV watching is more strongly associated with obesity than other sedentary behaviors.

Our findings could have important public health implications. The prevalence of obesity and type 2 diabetes has increased dramatically in the past several decades in the United States.<sup>33</sup> Although leisure-time physical activity levels are generally low in the United States, there is no evidence that recreational physical activity has declined in recent decades. However, sedentary lifestyle has become more prevalent and pervasive as reflected by the large numbers of TV sets, VCRs, and remote controls per household and increasing time spent watching TV in the past several decades.<sup>1</sup> We speculated that increasing sedentary behaviors, especially TV watching, may have contributed to the obesity epidemic in the United States. Given the strong relationship observed between sedentary lifestyle and obesity and diabetes risk, public health campaigns to reduce obesity and diabetes should not only promote increasing exercise levels, but also decreasing sedentary behaviors, especially prolonged TV watching. Substantial health benefits can be gained by even light to moderate activity such as doing household chores and by engaging in simple and convenient activities such as walking.

The major strengths of this study include its large sample size, prospective design, and detailed measures of physical activity, sedentary behaviors, and a multitude of dietary and nondietary covariates. However, the observational nature of this study cannot prove a causal relationship between TV watching and obesity because of the potential reciprocal relationship between TV watch-

ing behavior and obesity. This issue could be addressed in randomized clinical trials among adults. However, school-based intervention studies have already demonstrated that reductions in TV watching were effective in preventing obesity among children.<sup>8</sup>

In conclusion, our data provide strong evidence that sedentary behaviors, especially prolonged TV watching, are directly related to obesity and diabetes risk. In contrast, even light- to moderate-intensity activity substantially lowers the risk. While these findings lend further support to current guidelines that promote physical activity, they also suggest the importance of reducing sedentary behaviors in the prevention of obesity and type 2 diabetes.

**Author Contributions:** Study concept and design: Hu, Li, Colditz, Willett, Manson.

**Acquisition of data:** Hu, Colditz, Willett, Manson.

**Analysis and interpretation of data:** Hu, Li, Colditz, Willett, Manson.

**Drafting of the manuscript:** Hu.

**Critical revision of the manuscript for important intellectual content:** Hu, Li, Colditz, Willett, Manson.

**Statistical expertise:** Hu, Li, Colditz, Willett, Manson.

**Obtained funding:** Hu, Willett, Manson.

**Administrative, technical, or material support:** Hu, Colditz, Willett, Manson.

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## REFERENCES

1. Nielsen Report on Television. New York, NY: Nielsen Media Research; 1998.
2. Ainsworth BE, Haksell WL, Leon AS, et al. Compendium of physical activities. *Med Sci Sports Exerc.* 1993;25:71-80.
3. Lank NH, Vickery CE, Cotugna N, Shade DD. Food commercials during television soap operas. *J Community Health.* 1992;17:377-384.
4. Dietz WH, Jr, Gortmaker SL. Do we fatten our children at the television set? *Pediatrics.* 1985;75:807-812.
5. Hu FB, Leitzmann MF, Stampfer MJ, Colditz GA, Willett WC, Rimm EB. Physical activity and television watching in relation to risk for type 2 diabetes mellitus in men. *Arch Intern Med.* 2001;161:1542-1548.
6. Gortmaker SL, Must A, Sobol AM, et al. Television viewing as a cause of increasing obesity among children in the United States, 1986-1990. *Arch Pediatr Adolesc Med.* 1996;150:356-362.
7. Andersen RE, Crespo CJ, Barlett SJ, Cheskin LC, Pratt M. Relationship of physical activity and television watching with body weight and level of fatness among children. *JAMA.* 1998;279:938-942.
8. Robinson TN. Reducing children's television viewing to prevent obesity. *JAMA.* 1999;282:1561-1567.
9. Colditz GA, Willett WC, Stampfer MJ, et al. Weight as a risk factor for clinical diabetes in women. *Am J Epidemiol.* 1990;132:501-513.
10. Wolf AM, Hunter DJ, Colditz GA, et al. Reproducibility and validity of a self-administered physical activity questionnaire. *Int J Epidemiol.* 1994;23:991-999.
11. Jacobs DR Jr, Ainsworth BE, Hartman TJ, Leon AS. A simultaneous evaluation of 10 commonly used physical activity questionnaires. *Med Sci Sports Exerc.* 1993;25:81-91.
12. Fung TT, Hu FB, Yu J, et al. Leisure-time physical activity, television watching, and plasma biomarkers of obesity and cardiovascular disease risk. *Am J Epidemiol.* 2000;152:1171-1178.
13. Willett W, Stampfer MJ, Bain C, et al. Cigarette smoking, relative weight, and menopause. *Am J Epidemiol.* 1983;117:651-658.
14. National Diabetes Data Group. Classification and diagnosis of diabetes mellitus and other categories of glucose intolerance. *Diabetes.* 1979;28:1039-1057.
15. Manson JE, Rimm EB, Stampfer MJ, et al. Physical activity and incidence of non-insulin-dependent diabetes mellitus in women. *Lancet.* 1991;338:774-778.
16. Field AE, Coakley EH, Must A, et al. Impact of overweight on the risk of developing common chronic diseases during a 10-year period. *Arch Intern Med.* 2001;161:1581-1586.
17. Hu FB, Manson JE, Stampfer MJ, et al. Diet, lifestyle, and the risk of type 2 diabetes mellitus in women. *N Engl J Med.* 2001;345:790-797.
18. Wacholder S, Benichou J, Heineman EF, et al. Attributable risk: advantages of a broad definition of exposure [published erratum appears in *Am J Epidemiol.* 1994;140:668]. *Am J Epidemiol.* 1994;140:303-309.
19. Tucker LA, Friedman GM. Television viewing and obesity in adult males. *Am J Public Health.* 1989;79:516-518.
20. Tucker LA, Bagwell M. Television viewing and obesity in adult females. *Am J Public Health.* 1991;81:908-911.
21. Ching PLYH, Willett WC, Rimm EB, et al. Activity level and risk of overweight in male health professionals. *Am J Public Health.* 1996;86:25-30.
22. Coakley EH, Rimm EB, Colditz G, Kawachi I, Willett W. Predictors of weight change in men. *Int J Obes Relat Metab Disord.* 1998;22:89-96.
23. Helmrigh SP, Ragland DR, Leung RW, Paffenbarger RS Jr. Physical activity and reduced occurrence of non-insulin-dependent diabetes mellitus. *N Engl J Med.* 1991;325:147-152.
24. Manson JE, Nathan DM, Krolewski AS, et al. A prospective study of exercise and incidence of diabetes among US male physicians. *JAMA.* 1992;268:63-67.
25. Gurwitz JH, Field TS, Glynn RJ, et al. Risk factors for non-insulin-dependent diabetes mellitus requiring treatment in the elderly. *J Am Geriatr Soc.* 1994;42:1235-1240.
26. Perry IJ, Wannamethee SG, Walker MK, et al. Prospective study of risk factors for development of non-insulin dependent diabetes in middle aged British men. *BMJ.* 1995;310:560-564.
27. Burchfiel CM, Sharp DS, Curb JD, et al. Physical activity and incidence of diabetes: the Honolulu Heart Program. *Am J Epidemiol.* 1995;141:360-368.
28. Lynch J, Helmrigh SP, Kakha TA, et al. Moderately intense physical activities and high levels of cardiorespiratory fitness reduce risk of non-insulin-dependent diabetes mellitus in middle-aged men. *Arch Intern Med.* 1996;156:1307-1314.
29. Hu FB, Sigal RJ, Rich-Edwards JW, et al. Walking compared with vigorous physical activity and risk of type 2 diabetes in women. *JAMA.* 1999;282:1433-1439.
30. Robinson TN. Television viewing and childhood obesity. *Pediatr Clin North Am.* 2001;48:1017-1024.
31. Falciglia GA, Gussow JD. Television commercials and eating behavior of obese and normal-weight women. *J Nutr Educ.* 1980;12:196-199.
32. van Dam RM, Rimm EB, Willett WC, Stampfer MJ, Hu FB. Dietary patterns and risk for type 2 diabetes mellitus in US men. *Ann Intern Med.* 2002;136:201-209.
33. Flegal KM, Carroll MD, Ogden CL, Johnson CL. Prevalence and trends in obesity among US adults, 1999-2000. *JAMA.* 2002;288:1723-1727.