# Physical Activity and Television Watching in Relation to Risk for Type 2 Diabetes Mellitus in Men

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**Background:** Television (TV) watching, a major sedentary behavior in the United States, has been associated with obesity. We hypothesized that prolonged TV watching may increase risk for type 2 diabetes.

**Methods:** In 1986, 37 918 men aged 40 to 75 years and free of diabetes, cardiovascular disease, and cancer completed a detailed physical activity questionnaire. Starting from 1988, participants reported their average weekly time spent watching TV on biennial questionnaires.

**Results:** A total of 1058 cases of type 2 diabetes were diagnosed during 10 years (347 040 person-years) of follow-up. After adjustment for age, smoking, alcohol use, and other covariates, the relative risks (RRs) for type 2 diabetes across increasing quintiles of metabolic equivalent hours (MET-hours) per week were 1.00, 0.78, 0.65, 0.58, and 0.51 (*P* for trend, <.001). Time spent watching TV was significantly associated with higher risk for diabetes. After adjustment for age, smoking, physical activity levels, and other covariates, the RRs of diabetes across categories of average hours spent watching TV per week (0-1, 2-10, 11-20, 21-40, and >40) were 1.00, 1.66, 1.64, 2.16, and 2.87, respectively (*P* for trend, <.001). This association was somewhat attenuated after adjustment for body mass index, but a significant positive gradient persisted (RR comparing extreme categories, 2.31; *P* for trend, .01).

**Conclusions:** Increasing physical activity is associated with a significant reduction in risk for diabetes, whereas a sedentary lifestyle indicated by prolonged TV watching is directly related to risk. Our findings suggest the importance of reducing sedentary behavior in the prevention of type 2 diabetes.

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EPIDEMIOLOGICAL evidence strongly supports a role of exercise in the prevention of type 2 diabetes mellitus.[1-8] However, less attention has focused on sedentary behaviors in relation to risk for diabetes. Television (TV) watching represents a major sedentary behavior in the United States; on average, a male adult spends approximately 29 hours per week watching TV, and a female adult, 34 hours per week.[9] Television watching results in lower metabolic rate compared with other sedentary activities such as sewing, playing board games, reading, writing, and driving a car.[10] In several studies, time spent watching TV has been strongly associated with weight gain and obesity in children[11,12] and adults.[13-15] The purpose of this study is to examine whether prolonged TV watching predicts subsequent diabetes risk independent of physical activity in a prospective cohort of men. We also examined total physical activity, vigorous exercise, and moderate-intensity activity in relation to risk for type 2 diabetes in this cohort.

## RESULTS

During 10 years (347 040 person-years) of follow-up, we documented 1058 newly diagnosed cases of type 2 diabetes. As described elsewhere,[15] physically more active men tended to be leaner and were less likely to be current smokers. Increasing total physical activity score was strongly associated with progressively reduced risk for type 2 diabetes (**Table 1**). The age-adjusted RRs across quintiles of MET score from total physical activity were 1.00, 0.76, 0.61, 0.55, and 0.47 (*P* for trend, <.001). Further adjustment for smoking, parental history of diabetes, and other covariates did not appreciably change these RRs. This inverse gradient remained strong even after adjusting for BMI (RRs across quintiles of MET score were 1.00, 0.82, 0.72, 0.66, and 0.62; *P* for trend, <.001). Adjustment for dietary intakes of

## SUBJECTS AND METHODS

### SUBJECTS

The Health Professional's Follow-up Study (HPFS) began in 1986 when 51 529 US health professionals (dentists, optometrists, pharmacists, podiatrists, osteopaths, and veterinarians), aged 40 to 75 years, answered a detailed questionnaire that included a comprehensive diet survey and items on lifestyle practice and medical history.[16] Follow-up questionnaires were sent in 1988, 1990, 1992, 1994, and 1996 to update information on potential risk factors and to identify newly diagnosed cases of diabetes and other diseases. We excluded from the present analysis men with a previous diagnosis of cardiovascular disease (n=4639), cancer (n=1638), or diabetes (n=1796) at baseline. Participants with diagnosed cardiovascular disease or cancer at baseline were excluded because these diagnoses may lead to change in physical activity levels. Participants who had missing information on activity questions or reported implausible total energy intake on the food frequency questionnaire[17] (<3347 or >17 572 kJ/d) were also excluded (n=5538). We followed up the remaining 37 918 men for incidence of type 2 diabetes during the subsequent 10 years of the study.

### ASSESSMENT OF PHYSICAL ACTIVITY

Physical activity was assessed using mailed questionnaires at baseline and every 2 years thereafter. Subjects were asked to report the average amount of time they spent per week on each of the following activities: walking, jogging, running, bicycling, calisthenics or use of a rowing machine, lap swimming, squash or racquetball, and tennis. They were also asked about their usual walking pace, specified as easy or casual (<2 miles/h), normal (2-2.9 miles/h), brisk (3-3.9 miles/h), or striding (≥4 miles/h). From this information, weekly energy expenditure in metabolic equivalent hours (MET-hours) was calculated.[10] We defined any physical activity requiring 6 MET-hours or greater (a 6-fold or greater increase above resting metabolic rate) as *vigorous*. These activities included jogging, running, bicycling, calisthenics or use of a rowing machine, lap swimming, squash or racquetball, and tennis. In contrast, walking requires an energy expenditure of only 2 to 4.5 MET-hours, depending on pace, and was therefore considered to be a moderate-intensity activity.

The reproducibility and validity of the physical activity questionnaire was evaluated in a subsample (n=238) of participants in the HPFS cohort.[18] The Pearson correlation between moderate plus vigorous physical activity, assessed by means of diaries for 4 weeks across different seasons, and that reported on the questionnaire was 0.58. The correlation between vigorous activity score, assessed by means of the questionnaire, and resting pulse was −0.45; for pulse after stopping, the correlation was −0.41. 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 similar questionnaire and maximum oxygen consumption was 0.54.[19] In a subsample of participants in the HPFS cohort (n=466), high-density lipoprotein (HDL) cholesterol level increased by 0.06 mmol/L (2.4 mg/dL) for each increment of 20 MET-hours per week (*P*<.01).[20]

Starting from 1988, participants reported their average weekly time spent watching TV (including videotapes) on the biennial questionnaires. The 1988 questionnaire included 6 response categories (ranging from 0-1 to >40 h/wk). Subsequent questionnaires included 13 response categories (ranging from 0 to >40 h/wk). In the present analyses, 5 categories were coded consistently across all questionnaires (0-1, 2-10, 11-20, 21-40, and >40 h/wk). In a subsample of participants in the HPFS (n=466), average hours of TV watching were significantly associated with higher levels of leptin and low-density lipoprotein (LDL) cholesterol and with lower levels of HDL cholesterol and apolipoprotein A-I.[20]

### DIAGNOSIS OF TYPE 2 DIABETES

A supplementary questionnaire regarding symptoms, diagnostic tests, and hypoglycemic therapy was mailed to men

Continued on next page

fats and cereal fiber did not appreciably change the results.

To minimize potential bias from subclinical disease, we conducted additional analyses in which we excluded cases of type 2 diabetes that occurred during the first 2 years of follow-up. The multivariate RRs (without BMI) across quintiles of physical activity score were 1.00, 0.88, 0.75, 0.69, and 0.57 (*P* for trend, <.001). The inverse association between total physical activity score and diabetes risk was persistent in subgroup analyses according to age (<65 or ≥65 years), family history of diabetes, smoking (never or ever), and BMI (<25.0, 25.0-29.9, or ≥30.0 kg/m$^2$) (**Table 2**). In particular, the increased risks associated with family history of diabetes and obesity were substantially mitigated by increasing physical activity levels. To address the possibility that medical surveillance may have varied according to physical activity level, we conducted an analysis restricted to subjects reporting at least 1 symptom of diabetes at diagnosis (n=595). Results from this subgroup were similar to those for the entire cohort (multivariate RRs without BMI in the model across quintiles of MET score were 1.00, 0.66, 0.65, 0.57, and 0.49; *P* for trend, <.001).

After adjustment for age and other covariates, we observed a significant inverse association between MET score for walking and risk for type 2 diabetes. The multivariate RRs across quintiles of walking score were 1.00, 1.02, 0.80, 0.76, and 0.72 (*P* for trend, <.001). This inverse association remained significant after adjustment for vigorous exercise (RRs were 1.00, 1.06, 0.86, 0.82, and 0.80; *P* for trend, .006). Independent of the number of hours spent walking, walking pace was strongly associated with risk for diabetes. Compared with men whose usual walking pace was easy or casual, multivariate RRs were 0.68 for normal pace, 0.46 for brisk pace, and 0.39 for very brisk pace (*P* for trend, <.001).

Walking and vigorous exercise were associated with comparable risk reductions for equivalent energy expenditure. When the walking and vigorous activity scores were entered into the model as continuous variables siwho 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) 1 or more classic symptoms (excessive thirst, polyuria, weight loss, hunger) plus 1 fasting plasma glucose level of at least 7.8 mmol/L (140 mg/dL) or random plasma glucose of at least 11.1 mmol/L (200 mg/dL); (2) at least 2 elevated plasma glucose concentrations on different occasions (fasting, ≥7.8 mmol/L [≥140 mg/dL]; random, ≥11.1 mmol/L [≥200 mg/dL]; and/or ≥11.1 mmol/L [≥200 mg/dL] after ≥2 hours of oral glucose tolerance testing) in the absence of symptoms; or (3) treatment with hypoglycemic medication (insulin or oral hypoglycemic agent). Because of potential associations between weight and physical activity, no body weight criteria were used in the classification of type of diabetes for these analyses. Our criteria for diabetes classification are consistent with those proposed by the National Diabetes Data Group[21] for 1986-1996. The validity of self-report of diabetes has been verified in a subsample of 71 men from the HPFS cohort. A physician blinded to the information reported on the supplementary questionnaire and reviewed the medical records according to the diagnostic criteria. Of the 71 patients, 12 had incomplete records, eg, absent laboratory data (n=2), or 1 set only of laboratory data (n=9). Among the remaining 59 cases, the diagnosis of type 2 diabetes was confirmed in 57 (97%). One patient denied the diagnosis and another lacked evidence of diabetes in his submitted records. Similarly, 98% of diabetic cases reported by the supplementary questionnaire were confirmed by medical record review in a subsample of participants (n=62) in the Nurses' Health Study.[22]

### STATISTICAL ANALYSIS

Person-time for each participant was calculated from the date of return of the 1986 (physical activity) or 1988 (TV watching) questionnaires to the date of confirmed type 2 diabetes, death due to any cause, or January 1, 1996, whichever came first. Incidence rates of type 2 diabetes were obtained by dividing the number of cases by person-years in each category of physical activity or average time spent on watching TV. Relative risks (RRs) were computed as the incidence rate in a specific category of MET score (ie, MET-hours per week) or TV watching divided by that in the reference category, with adjustment for 5-year age categories. Tests for linear trend across increasing categories of MET score or average time spent watching TV were conducted by treating the categories as a continuous variable and assigning the median score for the category as its value. Both MET score or time spent watching TV were updated every 2 years.

We used pooled logistic regression to adjust estimated incidence rate ratios simultaneously for potential confounding variables. In this approach, independent 2-year blocks of person-time of follow-up are pooled for regression analysis, and the dependence of the incidence rates on time is modeled nonparametrically with indicator variables. D'Agostino et al[23] have shown that the pooled logistic model is asymptotically equivalent to the Cox regression when the time intervals are short and the probability of outcome in the intervals is low. Our covariates included age (40-44, 45-49, 50-54, 55-59, 60-64, 65-69, and ≥70 years), smoking (never, past, or current [1-14, 15-24, and ≥25 cigarettes per day]), alcohol consumption (0-4, 5-9, 10-14, 15-29, and ≥30 g/d), parental history of diabetes, and history of hypercholesterolemia or hypertension at baseline. In additional analyses, we included body mass index (BMI [calculated as weight in kilograms divided by the square of height in meters], in quintiles) in the model to examine the degree to which the relation with physical activity was mediated through BMI.

To examine whether the effects of physical activity on diabetes were modified by important covariates, we conducted multivariate analyses according to categories of age (<65 or ≥65 years), family history of diabetes (no or yes), smoking (never or ever), and BMI (<25.0, 25.0-29.9, or ≥30.0 kg/m$^2$). To examine independent effects of physical activity and TV watching, we estimated RRs of diabetes according to joint classifications of these 2 variables. In this analysis, both variables were classified into quartiles rather than 5 categories to have sufficient power.

multaneously, RRs associated with an increase in energy expenditures of 10 MET-hours per week were 0.89 (95% confidence interval [CI], 0.82-0.96) for walking and 0.88 (95% CI, 0.85-0.92) for vigorous exercise.

Men who spent more time watching TV were more likely to smoke and drink alcohol and less likely to exercise (**Table 3**). They were substantially heavier and more likely to have hypertension and hypercholesterolemia. These men also had higher intake of total energy, total and saturated fats, red meat, processed meat, French fries, refined grain products, snacks, and sweets or desserts and lower intakes of fish, vegetables, fruits, and whole grains.

After adjustment for age, average time spent watching TV was strongly associated with increased risk for diabetes (**Table 4**). The RRs across categories of average hours spent watching TV per week (0-1, 2-10, 11-20, 21-40, and >40) were 1.00, 1.62, 1.61, 2.22, and 3.35 (95% CI, 1.71-6.55, respectively; *P* for trend, <.001). After further adjustment for smoking, alcohol use, physical activity, and other covariates, the positive association persisted (RR comparing extreme categories, 2.87; 95% CI, 1.46-5.65; *P* for trend, <.001). The significant positive association persisted even after adjustment for BMI (RR comparing extreme categories, 2.31; 95% CI, 1.17-4.56; *P* for trend, .01). Further simultaneous adjustment for intakes of saturated fat, monounsaturated fat, polyunsaturated fat, *trans*-fatty acids, and cereal fiber did not appreciably change the results (Table 4).

In multivariate analyses, we observed independent effects of TV watching and physical activity levels (**Figure**). Compared with men who were in the most active (>46 MET-hours per week) and the lowest TV watching category (<3.5 h/wk), those who were in the least active (<10 MET-hours per week) and most sedentary category (>15 h/wk watching TV) had a significantly increased risk for type 2 diabetes (RR, 2.92; 95% CI, 1.87-4.55; *P* for interaction, .90). When total physical activity score and time spent watching TV were simultaneously included in a multivariate model (without BMI), an in-

**Table 1. Relative Risks for Type 2 Diabetes According to Quintiles of Total Physical Activity Score Among US Male Health Professionals, 1986-1996***

| Variable | Quintile 1 | 2 | 3 | 4 | 5 | *P* for Trend |
|---|---|---|---|---|---|---|
| MET-hours per week† | 0-5.9 | 6.0-13.7 | 13.8-24.2 | 24.3-40.8 | ≥40.9 | . . . |
| Median values | 2.7 | 9.6 | 18.6 | 31.6 | 57.8 | . . . |
| Cases of diabetes | 311 | 243 | 196 | 169 | 139 | . . . |
| Person-years of follow-up | 73 198 | 70 994 | 69 649 | 67 324 | 65 875 | . . . |
| RR (95% CI) | | | | | | |
| Age-adjusted RR | 1.00 | 0.76 (0.64-0.90) | 0.61 (0.51-0.74) | 0.55 (0.45-0.66) | 0.47 (0.38-0.57) | <.001 |
| Multivariate RR‡ | 1.00 | 0.78 (0.66-0.93) | 0.65 (0.54-0.78) | 0.58 (0.48-0.70) | 0.51 (0.41-0.63) | <.001 |
| Multivariate RR‡ with additional adjustment for BMI | 1.00 | 0.82 (0.69-0.98) | 0.72 (0.60-0.86) | 0.66 (0.54-0.80) | 0.62 (0.50-0.76) | <.001 |
| Multivariate RR‡ with additional adjustment for dietary variables§ | 1.00 | 0.80 (0.68-0.95) | 0.67 (0.56-0.81) | 0.61 (0.50-0.74) | 0.55 (0.45-0.68) | <.001 |
| Multivariate RR‡ excluding first 2 years of follow-up‖ | 1.00 | 0.88 (0.71-1.10) | 0.75 (0.60-0.94) | 0.69 (0.54-0.87) | 0.57 (0.44-0.74) | <.001 |

*RR indicates relative risk; CI, confidence interval; ellipses, not applicable; MET-hours, metabolic equivalent hours; and BMI, body mass index.

†MET-hours per week = sum of the average time per week spent in each activity × MET value of each activity.

$$\text{MET-value} = \frac{(\text{Energy Need/Kilograms of Body Weight})/\text{Hours of Activity}}{(\text{Energy Need/Kilograms of Body Weight})/\text{Hours at Rest}}.$$

For MET-value, energy need is given in joules. To convert joules to calories, divide by 4.184.

‡The multivariate model included the following: age (5-year categories), pack-years of smoking (7 categories), parental family history of diabetes (yes or no), alcohol intake (6 categories), and vitamin E supplement use (3 categories).

§Adjusted for intakes of saturated fat, monounsaturated fat, polyunsaturated fat, trans-fatty acids, and cereal fiber.

‖Excluding first 2 years of follow-up to minimize potential bias from subclinical disease.

**Table 2. Relative Risks of Type 2 Diabetes According to Quintiles of MET-Hours from Total Physical Activity Among Various Subpopulations of US Male Health Professionals, 1986-1996***

| Variable | Quintile of MET-Hours From Total Physical Activity, RR (95% CI): 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Age <65 y | 1.00 | 0.71 (0.58-0.87) | 0.54 (0.43-0.67) | 0.48 (0.38-0.60) | 0.44 (0.34-0.56) |
| Age ≥65 y | 0.89 (0.68-1.17) | 0.92 (0.71-1.20) | 0.89 (0.68-1.17) | 0.79 (0.60-1.04) | 0.62 (0.45-0.85) |
| Family history of diabetes | | | | | |
| No | 1.00 | 0.76 (0.63-0.93) | 0.60 (0.48-0.74) | 0.55 (0.44-0.68) | 0.45 (0.36-0.58) |
| Yes | 1.95 (1.49-2.55) | 1.55 (1.17-2.06) | 1.43 (1.06-1.93) | 1.18 (0.85-1.62) | 1.22 (0.87-1.70) |
| Smoking | | | | | |
| Never | 1.00 | 0.76 (0.57-1.01) | 0.55 (0.40-0.75) | 0.63 (0.46-0.85) | 0.46 (0.33-0.64) |
| Ever | 1.38 (1.08-1.77) | 1.07 (0.82-1.39) | 0.99 (0.75-1.29) | 0.70 (0.52-0.94) | 0.69 (0.51-0.94) |
| BMI, kg/m$^2$ | | | | | |
| <25.0 | 1.00 | 0.82 (0.49-1.35) | 0.88 (0.54-1.43) | 0.89 (0.55-1.45) | 0.70 (0.42-1.16) |
| 25.0-29.9 | 2.59 (1.75-3.85) | 2.39 (1.60-3.56) | 2.05 (1.36-3.08) | 1.85 (1.22-2.81) | 1.72 (1.12-2.66) |
| ≥30.0 | 8.78 (5.88-13.10) | 7.12 (4.66-10.90) | 5.71 (3.61-9.04) | 5.00 (3.05-8.18) | 6.49 (3.91-10.80) |

*Abbreviations are explained in the first footnote to Table 1. The multivariate models included the same variables as in Table 1 except the stratifying variables.

crement of 2 h/d spent watching TV was associated with a 20% (95% CI, 8%-32%) increase in risk for diabetes, whereas an increment of 18 MET-hours per week (equivalent to very brisk walking for 40 minutes per day) was associated with a 19% (95% CI, 13%-24%) reduction in risk.

## COMMENT

In this large prospective cohort of men, greater leisure time physical activity was associated with reduced risk for type 2 diabetes. In contrast, a sedentary lifestyle, as indicated by time spent watching TV, was significantly associated with an increased risk for diabetes, independent of the effects of physical activity and body weight.

Our findings extend the literature showing that regular physical activity is associated with a substantial reduction in risk for type 2 diabetes.[1-5,7,22] Our results also suggest that the apparent beneficial effect of exercise is not confined to high-risk groups (eg, subjects with ≥1 risk factors such as obesity and family history of diabetes). Contrary to the belief that fitness and physical activity might offset the adverse effects of obesity,[24] we found that men who were obese and physically active had a substantially increased risk for diabetes compared with those who were lean and inactive (Table 2), although obese and inactive men were at

**Table 3. Age-Standardized Characteristics According to Average Number of Hours Watching Television per Week in the HPFS at Baseline in 1988***

| | Average No. of Hours Watching Television per Week | | | | |
|---|---|---|---|---|---|
| | 0-1 | 2-10 | 11-20 | 21-40 | >40 |
| No. of men | 1315 | 17 434 | 9271 | 3173 | 186 |
| % of group | | | | | |
| Current smoking | 5.6 | 7.3 | 9.5 | 12.4 | 20.4 |
| Parental history of diabetes | 18.7 | 19.8 | 20.9 | 20.6 | 19.2 |
| Vitamin E supplement use | 21.1 | 19.6 | 18.7 | 17.8 | 18.2 |
| Hypertension | 17.5 | 20.2 | 22.8 | 26.1 | 22.7 |
| Hypercholesterolemia | 15.8 | 17.9 | 19.7 | 22.3 | 21.5 |
| Means | | | | | |
| Age, y | 53.1 | 54.5 | 55.9 | 58.1 | 60.8 |
| BMI, kg/m$^2$ | 24.6 | 25.3 | 25.7 | 26.0 | 26.7 |
| Alcohol use, g/d | 9.8 | 11.0 | 12.3 | 13.0 | 15.2 |
| Physical activity, MET-hours/wk | 29.8 | 29.1 | 27.4 | 24.7 | 19.8 |
| Nutrient intakes (energy-adjusted) | | | | | |
| Total energy, kJ/d | 8192.3 | 8322.0 | 8501.9 | 8585.6 | 8669.2 |
| Total fat, g/d | 69.9 | 71.0 | 72.5 | 73.7 | 73.9 |
| Saturated fat, g/d | 24.0 | 24.4 | 25.0 | 25.6 | 26.1 |
| Monounsaturated fat, g/d | 26.5 | 27.1 | 27.8 | 28.3 | 28.2 |
| Polyunsaturated fat, g/d | 13.1 | 13.1 | 13.2 | 13.3 | 13.0 |
| *Trans*-fatty acids, g/d | 2.6 | 2.8 | 3.0 | 3.1 | 3.1 |
| Fiber, g/d | 23.6 | 22.5 | 21.4 | 20.6 | 18.7 |
| Food intake, servings per day† | | | | | |
| Red meat | 0.57 | 0.60 | 0.66 | 0.69 | 0.74 |
| Fish | 0.37 | 0.39 | 0.37 | 0.34 | 0.32 |
| Vegetables | 3.01 | 2.98 | 2.84 | 2.67 | 2.39 |
| Fruits | 2.14 | 1.94 | 1.76 | 1.61 | 1.48 |
| French fries | 0.08 | 0.10 | 0.12 | 0.13 | 0.13 |
| Whole grain products | 1.39 | 1.14 | 1.03 | 0.98 | 0.73 |
| Refined grain products | 1.03 | 1.12 | 1.19 | 1.27 | 1.40 |
| Snacks | 0.47 | 0.54 | 0.61 | 0.66 | 0.50 |
| Sweets/desserts | 0.95 | 1.06 | 1.16 | 1.20 | 1.17 |

**HPHS indicates Health Professionals' Follow-up Study. Other abbreviations are given in the first footnote to Table 1.*

*†Red meat is a composite score of beef, pork, lamb as a main dish or mixed dish, and hamburger. Vegetables are a composite score of 22 vegetable foods. Fruits are a composite score of 12 fruits. Whole grain products included cooked oatmeal, other cooked breakfast cereal, dark bread, brown rice, other grains, bran added to food, and wheat germ. Refined grain products included white bread, English muffins, bagels or rolls, muffins or biscuits, white rice, pasta, and pancakes or waffles. Snacks included potato chips or corn chips, crackers, and popcorn. Sweets/desserts included chocolate bars or pieces, candy bars, cookies, brownies, doughnuts, cake, pie, and sweet roll or coffee cake or pastry.*

highest risk. In addition, we found that equivalent energy expenditure from brisk walking or vigorous exercise may confer comparable benefits. These findings are consistent with emerging evidence to support the benefits of moderate-intensity activities in the prevention of diabetes and cardiovascular disease.[8,25-27] Since walking is an activity that is highly accessible, readily adopted, and rarely associated with exercise-related injury, these findings may have important public health implications.

The beneficial effects of vigorous exercise and walking on risk for type 2 diabetes are partly mediated by body weight and body fat distribution. Leaner individuals have a reduced risk for diabetes,[28-30] and physical activity facilitates weight loss and weight maintenance.[31] Furthermore, exercise may lead to loss in visceral fat,[32] which is strongly associated with insulin resistance and the related metabolic syndrome. To the extent that exercise causes individuals to have lower BMI than they would otherwise, adjustment for BMI in regression models constitutes statistical overcorrection and results in underestimation of the true beneficial effect of physical activity.

In our study, prolonged TV watching was strongly associated with risk for diabetes. These findings do not necessarily imply that TV watching per se causes type 2 diabetes; rather, they suggest that a sedentary lifestyle substantially affects future risk for diabetes. There are at least 2 explanations for the observed positive association between TV watching and diabetes risk. First, TV watching is directly related to obesity and weight gain,[11-15,33] probably due to lower energy expenditure (ie, less physical activity) and higher caloric intake. Second, participants who spent more time watching TV tended to eat more red meat, processed meat, snacks, refined grains, and sweets and fewer vegetables, fruits, and whole grains. Such an eating pattern, which is directly related to commercial advertisements and food cues appearing on TV,[34,35] may adversely affect diabetes risk. In our previous study of 466 men in the HPFS, average hours of TV watching was significantly associated with increased levels of leptin and LDL cholesterol and lower levels of HDL cholesterol and apolipoprotein A-I, independent of physical activity levels.[20]

Because our cohort did not undergo uniform screening for glucose intolerance, some diabetes cases may have

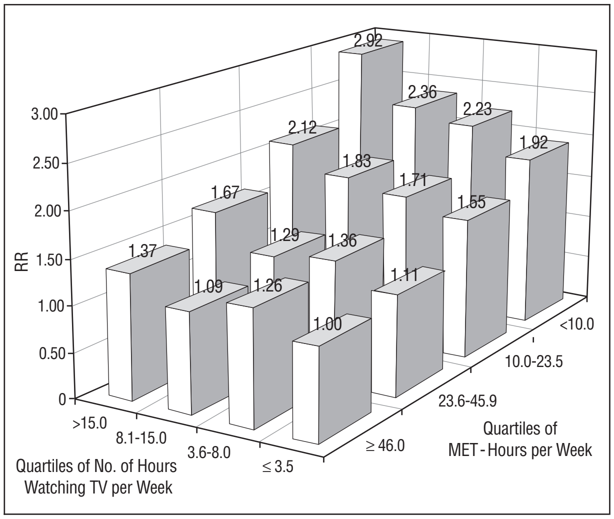
**Table 4. Relative Risks for Type 2 Diabetes According to Categories of Television Watching, HPFS 1988-1996**

| | Average Hours Watching Television per Week | | | | | |
|---|---|---|---|---|---|---|
| | 0-1 | 2-10 | 11-20 | 21-40 | >40 | *P* for Trend |
| No. of cases | 31 | 421 | 187 | 116 | 12 | . . . |
| No. of person-years | 16 646 | 142 635 | 62 553 | 26 133 | 1650 | . . . |
| RR (95% CI) | | | | | | |
| Age-adjusted | 1.00 | 1.62 (1.12-2.34) | 1.61 (1.10-2.36) | 2.22 (1.49-3.31) | 3.35 (1.71-6.55) | <.001 |
| Multivariate† | 1.00 | 1.63 (1.13-2.35) | 1.61 (1.10-2.36) | 2.16 (1.45-3.22) | 3.02 (1.53-5.93) | <.001 |
| Multivariate with physical activity levels (quintiles) | 1.00 | 1.66 (1.15-2.39) | 1.64 (1.12-2.41) | 2.16 (1.45-3.22) | 2.87 (1.46-5.65) | <.001 |
| Further adjustment for BMI | 1.00 | 1.51 (1.05-2.19) | 1.44 (0.98-2.11) | 1.83 (1.23-2.74) | 2.31 (1.17-4.56) | .01 |
| Further adjustment for BMI and dietary variables‡ | 1.00 | 1.49 (1.03-2.15) | 1.39 (0.95-2.05) | 1.77 (1.18-2.64) | 2.23 (1.13-4.39) | .02 |

*HPHS indicates Health Professionals' Follow-up Study. Other abbreviations are given in the first footnote to Table 1.

†Adjusted for age (40-44, 45-49, 50-54, 55-59, 60-64, 65-69, and ≥70 years); time (four 2-year periods); cigarette smoking (never, past, and current smoking of 1-14, 15-24, and ≥25 cigarettes per day); parental history of diabetes; and alcohol consumption (0-4, 5-9, 10-15, 15-29, and ≥30 g/d).

‡Adjusted for intakes of saturated fat, monounsaturated fat, polyunsaturated fat, trans-fatty acids, and cereal fiber.




*Multivariate relative risks (RRs) for type 2 diabetes mellitus according to categories of metabolic equivalent hours (MET-hours) per week and average weekly time spent watching television (TV). Adjusted for the same covariates as in Table 1 (body mass index not included in the model).*

been undiagnosed. However, misclassification would be expected to be small compared with that in the general population because of health professionals' ready access to medical care. For example, more than 85% of men in our study visited a physician for a physical examination, sigmoidoscopy, or colonoscopy at least once between 1988 and 1990. In addition, when the analyses were restricted to symptomatic cases of type 2 diabetes, the findings were similar, suggesting that surveillance bias according to activity level is unlikely. The diagnostic criteria for type 2 diabetes have recently changed[36] such that lower fasting glucose levels (>7.0 mmol/L [>126 mg/dL]) would now be considered diabetic. We used the criteria proposed by the National Diabetes Data Group[21] because all of our cases were diagnosed before January 1996. If new criteria were used, some nondiabetic subjects would have been classified as diabetic. However, this is unlikely to explain our results, because inclusion of diabetics in the nondiabetic group would have attenuated the associations we observed.

## CONCLUSIONS

Our data provide further evidence that higher levels of physical activity, including moderate-intensity exercise such as walking, are associated with a substantial reduction in risk for diabetes. In contrast, sedentary lifestyle indicated by prolonged TV watching is directly related to diabetes risk. Although these findings lend further support to current guidelines[37,38] that promote physical activity, they also suggest the importance of reducing sedentary behavior in the prevention of diabetes.

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