Original Contribution

Physical Activity and Television Watching in Relation to Risk of Type 2 Diabetes

The Black Women's Health Study

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Few modifiable risk factors for type 2 diabetes have been documented in the high-risk population of US black women. The authors used data from 45,668 black women aged 21–69 years, followed biennially from 1995 to 2005 in the Black Women's Health Study, to estimate incidence rate ratios for type 2 diabetes comparing various levels of physical activity and television watching. Cox proportional hazards models were used to control confounding factors. During 10 years of follow-up, 2,928 incident cases of type 2 diabetes were identified. Vigorous activity was inversely associated with type 2 diabetes risk ($P_{trend} < 0.0001$); the incidence rate ratio for ≥ 7 hours per week was 0.43 (95% confidence interval (CI): 0.31, 0.59) relative to no activity. Brisk walking for ≥ 5 hours per week was associated with reduced type 2 diabetes risk (incidence rate ratio = 0.67, 95% CI: 0.49, 0.92) relative to no walking. Television watching was associated with an increased type 2 diabetes risk: The incidence rate ratio was 1.86 (95% CI: 1.54, 2.24) for ≥ 5 hours relative to <1 hour of television per day, independent of physical activity. These observational data suggest that black women might reduce their risk of developing type 2 diabetes by increasing their time spent walking or engaged in vigorous physical activity and by limiting television watching.

African continental ancestry group; diabetes mellitus, type 2; exercise; incidence; motor activity; television; walking; women's health

Abbreviations: BWHS, Black Women's Health Study; CI, confidence interval; MET, metabolic equivalent.

Type 2 diabetes has reached epidemic proportions in the United States and affects an estimated 20.6 million people (1, 2). The burden of this disease is particularly large among African-American women, among whom the prevalence is almost twice that of non-Hispanic whites (2). Although epidemiologic studies support a role for physical activity in preventing type 2 diabetes (3–15), there has been little attention focused on the impact of this factor in the high-risk population of African-American women. A recent randomized clinical trial (Diabetes Prevention Program) showed that an intensive lifestyle modification (healthy diet and moderate physical activity of 30 minutes a day for 5 days a week) reduced the incidence of type 2 diabetes by 50% as compared with placebo (10). We undertook to examine how the actual levels of physical activity in a large population of African-American women were related to type 2 diabetes

incidence. With detailed questionnaire data collected every 2 years from over 40,000 women in the Black Women's Health Study (BWHS), we were able to assess the influence of vigorous activity, walking, and television watching on the incidence of type 2 diabetes in black women.

MATERIALS AND METHODS

The BWHS, a collaborative project of Boston University and Howard University, is an ongoing prospective follow-up study of African-American women from across the United States (16). The study began in 1995 when women aged 21–69 years were enrolled through postal questionnaires mailed to subscribers of *Essence* magazine, members of several professional organizations, and friends and relatives of early respondents. The baseline questionnaire collected

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information on demographics, medical and reproductive history, height, weight, physical activity, and cigarette and alcohol use, among other factors. Dietary intake was assessed by using a modified version of the NCI [National Cancer Institute]-Block food frequency questionnaire (17, 18).

After exclusion of 5,500 women who had completed the questionnaire but were outside the age range 21–69 years, who had not completed the questionnaire satisfactorily, or whose addresses were judged to be invalid, 59,052 women comprised the cohort that has been followed. Biennial follow-up questionnaires collect updated information on incident disease, weight, smoking, physical activity, and other factors. Follow-up has averaged over 80% of the baseline cohort over 5 completed questionnaire cycles.

Analyses are based on follow-up from 1995 through 2005, with follow-up beginning at age 30 years. We excluded women who did not reach the age of 30 years by the end of follow-up ($n = 1,330$); who reported a history of diabetes ($n = 2,930$) or gestational diabetes ($n = 636$) at baseline; who reported stroke ($n = 359$), myocardial infarction ($n = 447$), or cancer ($n = 1,144$) at baseline (whose questionnaire assessment of physical activity and diet may not reflect long-term patterns because these conditions may have caused modifications of physical activity level and diet); who were pregnant at baseline ($n = 957$); or who had missing data on weight, height, or physical activity at baseline ($n = 5,581$). The final analysis cohort consisted of 45,668 women.

Case definition

Each follow-up questionnaire asked about new diagnoses of diabetes during the previous 2-year period. Incident diabetes was reported by 2,928 women during follow-up.

We assessed the accuracy of self-reported diabetes among a random sample of 227 women whose physicians provided data from their medical records. The diagnosis of type 2 diabetes was confirmed for 218 (96%) of the women. Of the remaining 9 women, 3 did not have diabetes, 2 had type 1 diabetes, 2 had gestational diabetes, 1 had steroid-induced diabetes, and 1 was classified as having metabolic syndrome.

Exposure measurement

Physical activity data were obtained on each follow-up questionnaire. Subjects were asked separate questions on the number of hours per week spent on vigorous physical activity (e.g., running, swimming), walking for exercise, and walking to and from work. Response options were 0, <1, 1–2, 3–4, 5–6, 7–9, and ≥10 hours per week. Participants were asked on the 2003 questionnaire to classify their usual walking pace as casual/strolling (<2 mph), average/normal (2–<3 mph), fairly brisk (3–<4 mph), and brisk/striding (≥4 mph) (1 mile = 1.6 km). In our analysis of walking and diabetes risk, we used data on walking pace from the 2003 questionnaire to reflect their usual walking pace at all time periods. We created a variable that grouped participants into categories based on both walking pace (casual, average, or brisk (fairly brisk and brisk)) and amount of walking, taking into account both walking for exercise and walking to and from work. We created cumulative

average variables for each individual based on activity data from each questionnaire that preceded the occurrence of diabetes or end of follow-up; when data are available for a number of different time periods, cumulative averages give a better representation of long-term exposure, as compared with the standard follow-up approach of updating the exposure variable for each time period (19). The number of hours per day spent watching television was also assessed in each questionnaire with possible response categories of 0, <1, 1–2, 3–4, and ≥5 hours per day.

Physical activity assessment in the BWHS was validated in a study conducted at the Howard University Cancer Center (20). Actigraphs (activity monitors) were worn by 101 BWHS participants during their waking hours for 7 days. They also completed 7-day physical activity diaries and completed the BWHS questions on physical activity. Significant positive correlations were observed between BWHS questionnaire data and actigraph measurements for total activity (metabolic equivalent (MET)-hours/week), $r = 0.28$, $P < 0.01$; walking, $r = 0.26$, $P < 0.01$; and vigorous activity, $r = 0.40$, $P < 0.01$. Correlations between the diary data and the BWHS questionnaire data were significant for total activity (MET-hours/week), $r = 0.32$, $P < 0.01$, as well as vigorous activity, $r = 0.41$, $P < 0.01$.

Data analysis

Age- and time-stratified Cox proportional hazards models were used to calculate incidence rate ratios, also known as hazard ratios, and 95% confidence intervals (21). Person-years were calculated from baseline to the year of diagnosis of type 2 diabetes, loss to follow-up, death, or the end of follow-up in 2005, whichever came first. Incidence rate ratios for diabetes were calculated for the levels of each physical activity measure relative to the lowest level. Time-varying covariates were reassigned every 2 years by using the Anderson-Gill data structure (22). The Anderson-Gill data structure creates a new record for every follow-up cycle at which the participant is at risk and assigns covariate values reported for that specific questionnaire cycle. The covariates included in the multivariable models were age (continuous), questionnaire cycle, family history of diabetes (biologic parents, siblings, or children), years of education (≤12, 13–15, 16, ≥17), household income in dollars (≤15,000, 15,001–25,000, 25,001–35,000, 35,001–50,000, 50,001–100,000, and >100,000), marital status (single, married, divorced/separated/widowed), cigarettes smoked per day (0, <15, 15–24, and ≥25), alcoholic drinks per week (0, 1–6, 7–13, ≥14), energy intake in kilocalories (quintiles), and coffee consumption in cups/week (<1, 1, 2–3, ≥4) (1 cup = 236.6 ml). We carried out analyses with and without terms for body mass index (weight (kg)/height (m)^2) that we hypothesized to be in the causal pathway between physical activity and type 2 diabetes risk. Tests for linear trend across categories of physical activity variables were carried out by including in the regression model an ordinal term for increasing levels of exposure. Departure from the proportional hazards assumption was tested by using a likelihood ratio test comparing models with and without cross-product terms between exposure and age.

Table 1. Baseline Characteristics by Hours of Vigorous Physical Activity and Television Watching, the Black Women's Health Study, 1995–2005[a]

	Vigorous Physical Activity						Television Watching					
	0 hours/week			≥7 hours/week			0 or <1 hour/day			≥5 hours/day		
	No.	%	Mean (SD)	No.	%	Mean (SD)	No.	%	Mean (SD)	No.	%	Mean (SD)
Study participants	14,449	31.6		3,310	7.2		5,285	11.6		6,674	14.6	
Age, years			41.4 (10.5)			36.2 (9.1)			38.4 (9.5)			37.9 (10.6)
Body mass index, kg/m²			29.2 (7.3)			25.9 (5.1)			26.5 (5.8)			29.1 (7.5)
Energy intake, kcal/day			1,729 (1,038)			1,645 (952)			1,536 (845)			1,970 (1,227)
Carbohydrates, % of energy			49.7 (9.5)			53.2 (9.7)			52.3 (9.6)			49.5 (9.7)
Fat, % of energy			34.5 (7.9)			30.3 (8.4)			31.5 (8.2)			34.6 (8.1)
Family history of diabetes		27.6			24.9			26.3			26.4	
Education, ≥17 years		18.9			22.0			33.5			13.4	
Income, >$100,000		9.3			13.7			19.5			6.2	
Married/living as married		41.3			33.6			41.5			34.3	
Cigarette use, ≥15/day		14.8			9.6			10.0			14.6	
Alcohol use, ≥7 drinks/day		6.6			7.1			3.5			10.8	
No coffee consumption		48.4			52.2			49.6			52.7	
No vigorous activity								25.2			41.7	
No walking for exercise		32.5			9.8			16.9			22.5	
Watching television, ≥5 hours/day		19.3			18.2								

Abbreviation: SD, standard deviation.

[a] The data shown are for extreme categories of vigorous activity and television watching.

RESULTS

Table 1 shows the baseline characteristics of the study population by vigorous physical activity and television watching. At baseline, 31.6% of the cohort reported no vigorous physical activity. Compared with women who exercised ≥7 hours per week, women who reported no vigorous activity were older, had a higher mean body mass index, smoked more, had a higher percentage of energy from fat, and were less likely to walk for exercise. At baseline, 14.6% of the population watched ≥5 hours of television per day. Compared with women who watched <1 hour per day of television, those who watched ≥5 hours per day were less educated; had a higher mean body mass index, higher energy intake, higher percentage of energy from fat, and greater use of cigarettes and alcohol; and were less likely to participate in vigorous physical activity or to walk for exercise. The correlation coefficient for the relation between vigorous activity and television watching was −0.035 ($P < 0.0001$).

There were 2,928 incident cases of type 2 diabetes ascertained during 182,994 person-years of follow-up. In the multivariable model, vigorous physical activity was inversely associated with the risk of type 2 diabetes (Table 2). The incidence rate ratio for ≥7 hours per week of vigorous activity relative to 0 hours was 0.43 (95% confidence interval (CI): 0.31, 0.59) ($P_{trend} < 0.0001$). When body mass index was added to the model, the incidence rate ratio was 0.57 (95% CI: 0.41, 0.79) (data not shown). Brisk walking was also associated with a reduced risk: The incidence rate ratio for walking at a brisk pace for ≥5 hours per week

relative to no walking was 0.67 (95% CI: 0.49, 0.92). With inclusion of terms for body mass index in the regression model, the incidence rate ratio was 0.87 (95% CI: 0.64, 1.19) (data not shown).

Television watching was positively associated with the risk of type 2 diabetes (Table 2). The incidence rate ratio was 1.86 (95% CI: 1.54, 2.24) for watching ≥5 hours per day relative to <1 hour per day ($P_{trend} < 0.0001$). In a multivariable model that included body mass index, the incidence rate ratio was 1.56 (95% CI: 1.29, 1.89) (data not shown).

The inverse association between vigorous physical activity and type 2 diabetes risk was present at all levels of body mass index (Table 3), even among those with a body mass index of ≥30, the World Health Organization definition of obesity (23). The positive association of television watching and risk of type 2 diabetes was also present at all levels of body mass index. The association was strongest in those with a body mass index of <25, among whom the incidence rate ratio for watching ≥5 hours per day of television was 2.49 (95% CI: 1.24, 5.02) relative to <1 hour per day ($P_{trend} = 0.01$). The associations for vigorous activity and television watching were similar among premenopausal and postmenopausal women (data not shown).

Figure 1 shows the combined effect of vigorous physical activity and television watching. The reference group was those women who reported ≥3 hours per week of vigorous activity and <1 hour per day of television watching. Type 2 diabetes risk increased with decreasing physical activity in each category of television watching and increased with increased television watching in each category of physical

Table 2. Incidence Rate Ratios for the Association of Physical Activity, Television Watching, and Risk of Type 2 Diabetes, the Black Women's Health Study, 1995–2005

	Cases, no.	Person-Years, no.	Age-adjusted Incidence Rate Ratio	Multivariable[a]	
				Incidence Rate Ratio	95% Confidence Interval
Vigorous physical activity, hours/week					
0	994	42,665	1.0	1.0	
<1	994	51,646	0.79	0.90	0.82, 0.99
1–2	668	51,057	0.62	0.77	0.69, 0.85
3–4	170	21,368	0.41	0.53	0.45, 0.63
5–6	63	9,101	0.38	0.49	0.38, 0.64
≥7	39	7,157	0.33	0.43	0.31, 0.59
			$P_{trend} < 0.0001$	$P_{trend} < 0.0001$	
Walking for exercise or transport, pace[b]					
No walking	69	5,375	1.0	1.0	
Casual, hours/week					
<1	182	8,598	1.06	1.04	0.78, 1.37
1–2	310	14,097	1.06	1.09	0.84, 1.42
3–4	113	4,726	1.15	1.21	0.89, 1.65
≥5	106	4,459	1.17	1.21	0.89, 1.65
Average, hours/week					
<1	176	10,386	0.92	1.02	0.77, 1.35
1–2	404	25,439	0.81	0.96	0.74, 1.24
3–4	198	11,242	0.84	1.04	0.78, 1.37
≥5	178	11,347	0.78	0.95	0.71, 1.26
Brisk, hours/week					
<1	67	5,432	0.73	0.91	0.64, 1.27
1–2	192	17,582	0.59	0.78	0.59, 1.03
3–4	107	10,735	0.49	0.69	0.51, 0.95
≥5	115	12,417	0.46	0.67	0.49, 0.92
Television watching, hours/day					
0–<1	135	16,390	1.0	1.0	
1–2	935	68,284	1.51	1.43	1.19, 1.71
3–4	1,146	67,901	1.77	1.53	1.28, 1.83
≥5	712	30,419	2.38	1.86	1.54, 2.24
			$P_{trend} < 0.0001$	$P_{trend} < 0.0001$	

[a] The multivariable incidence rate ratio included terms for age, time period, family history of diabetes, years of education, family income, marital status, cigarette use, alcohol use, energy intake, coffee consumption, vigorous activity, television watching, and walking.

[b] The pace of walking was reported on only 1 follow-up questionnaire, and values are missing for those who did not fill out that questionnaire.

activity. The incidence rate ratio for no vigorous physical activity and watching ≥5 hours per day of television was 3.64 (95% CI: 2.23, 5.92).

DISCUSSION

In this large prospective study of black women, vigorous physical activity was associated with a reduced risk of type

2 diabetes. Walking at a brisk pace, but not slow walking, was also associated with a reduction in risk. The risk of type 2 diabetes was increased among women who spent an appreciable amount of time watching television, and this increase was apparent at every level of physical activity.

The present findings on vigorous physical activity in black women are consistent with those reported for white women in previous studies (4, 5, 7, 9, 12–14). Results from

Table 3. Incidence Rate Ratios for the Association of Vigorous Physical Activity and Television Watching With Risk of Type 2 Diabetes, Stratified by Body Mass Index, the Black Women's Health Study, 1995–2005

Body Mass Index, kg/m²	Vigorous Physical Activity				Television Watching			
	Hours/ Week	No. of Cases (N = 2,928)	Incidence Rate Ratio[a]	95% Confidence Interval	Hours/ Day	No. of Cases (N = 2,928)	Incidence Rate Ratio[a]	95% Confidence Interval
<25	0	57	1.0		0–<1	10	1.0	
	<1	58	0.97	0.65, 1.43	1–2	67	1.64	0.84, 3.19
	1–2	50	0.89	0.59, 1.36	3–4	69	1.71	0.87, 3.34
	≥3	32	0.74	0.46, 1.19	≥5	51	2.49	1.24, 5.02
			$P_{trend} = 0.08$				$P_{trend} = 0.01$	
25–29	0	236	1.0		0–<1	38	1.0	
	<1	236	0.92	0.76, 1.12	1–2	270	1.42	1.01, 2.00
	1–2	186	0.84	0.68, 1.04	3–4	297	1.41	1.00, 1.98
	≥3	90	0.65	0.50, 0.85	≥5	143	1.57	1.09, 2.25
			$P_{trend} = 0.001$				$P_{trend} = 0.07$	
30–34	0	250	1.0		0–<1	44	1.0	
	<1	268	0.95	0.79, 1.14	1–2	249	1.08	0.78, 1.49
	1–2	173	0.81	0.65, 0.99	3–4	300	1.10	0.80, 1.52
	≥3	83	0.75	0.57, 0.98	≥5	181	1.29	0.92, 1.81
			$P_{trend} = 0.01$				$P_{trend} = 0.07$	
≥35	0	451	1.0		0–<1	43	1.0	
	<1	432	0.93	0.81, 1.07	1–2	349	1.37	1.00, 1.89
	1–2	259	0.93	0.79, 1.11	3–4	480	1.35	0.99, 1.86
	≥3	67	0.57	0.43, 0.74	≥5	337	1.59	1.15, 2.19
			$P_{trend} = 0.002$				$P_{trend} = 0.01$	

[a] Adjusted for age, time period, family history of diabetes, years of education, family income, marital status, cigarette use, alcohol use, energy intake, coffee consumption, vigorous activity, television watching, and walking.

the Diabetes Prevention Program trial showed that a lifestyle intervention consisting of diet and physical activity was effective in reducing the incidence of diabetes among all racial subgroups, including African Americans (10). In the Women's Health Initiative observational cohort, there was no significant association among African-American women, but statistical power was limited because there were only 395 diabetic cases among the black women (13). The Women's Health Initiative cohort included only postmenopausal women, but this does not explain the difference between their results and ours. We found an inverse association of physical activity with diabetes in both pre- and postmenopausal women. The other epidemiologic studies that have included an appreciable number of black women have been cross-sectional in design (5, 6).

We had enough statistical power to assess the association of physical activity and type 2 diabetes within strata of body mass index, and we found that physical activity is beneficial regardless of body mass index. Previous studies of physical activity and diabetes that have assessed physical activity within strata of body mass index have provided inconsistent results (3, 4, 9, 12).

Our results showing that walking at a brisk pace is associated with a reduction in risk of type 2 diabetes are consistent with findings on white women from the Nurses' Health Study (7). The Women's Health Initiative did not find a sig-

nificant association of walking with diabetes risk in black women, but statistical power was limited (13).

The positive association between television watching and type 2 diabetes risk in our study of black women is similar to that found in 2 previous studies of white women (24) and men (25). Importantly, this association was independent of physical activity and other known risk factors for type 2 diabetes.
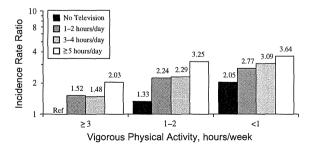

Figure 1. Incidence rate ratios for type 2 diabetes by levels of vigorous physical activity and television watching, the Black Women's Health Study, 1995–2005. The reference category for all other strata is no television watching and ≥3 hours/week of physical activity (Ref).

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Body mass index, which is influenced in part by levels of physical activity and is a strong independent risk factor for type 2 diabetes, may be an intermediate in the association of physical activity and diabetes or a confounder of the association. When we controlled for body mass index in multivariable analyses, the association between physical activity and type 2 diabetes was reduced slightly, but a strong inverse association still remained. In addition, the inverse association of physical activity with diabetes risk was present at all levels of body mass index, including the <25 category of body mass index where confounding from body mass index would be smallest. The latter 2 observations suggest that confounding, if present, played a minor role in the present study and that mechanisms other than body mass index may also play a role in the reduction in risk.

The relation between type 2 diabetes and physical activity may be mediated through increased insulin sensitivity due to increases in levels of the glucose transporter protein GLUT-4 and muscle glycogen synthase activity, a decrease in serum triglyceride concentration, and an increase in muscle capillary network (15, 26). Physical activity can also lead to weight loss or maintenance of a healthy weight (27), which in turn can lead to a lower risk of type 2 diabetes.

The positive association between television watching and type 2 diabetes might be explained by 2 mechanisms (28). First, television watching is related to a lower expenditure of energy, which in turn can lead to obesity, weight gain, and increased risk of diabetes. Adjustment for body mass index attenuated the incidence rate ratios in our study; this is compatible with the association of television watching with type 2 diabetes being at least partially mediated through obesity. Another possible mechanism is that television watching leads to a higher caloric intake and a relatively unhealthy dietary pattern. Participants in our study who watched more television had a higher energy intake and a higher fat and carbohydrate intake as compared with those who watched no television.

One of the main strengths of our study is the prospective study design, which reduces the potential of recall bias. In addition, the BWHS has high follow-up rates that reduce the possibility of bias resulting from selective losses. The sample size was large, providing excellent statistical power to assess effects overall and in subgroups. We were able to adjust for a large number of possible confounding variables.

Physical activity was self-reported. Because we had repeated measures of physical activity, we were able to get a better representation of long-term physical activity. Our validation study showed significant correlations of questionnaire responses with diary and actigraph measurement of physical activity. Nonetheless, measurement errors are likely but should be nondifferential, which would move estimates for the highest exposure categories toward the null. To the extent that there was misclassification of exposure, the true association of activity with diabetes risk may be even stronger than shown here.

Identification of type 2 diabetes cases was based on self-report. A validation study indicated that type 2 diabetes was reported with a high degree of accuracy. Some women with undiagnosed type 2 diabetes were undoubtedly misclassified as noncases, but the prevalence of undiagnosed disease was

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likely to be low (29). Physicians are well aware of the high risk of diabetes among African-American women, and it seems likely that BWHS participants were screened for the disease during the course of regular check-ups. Access to health care is quite good among BWHS participants: 93% reported that they had health insurance in 1997, and 98% reported that they had visited a physician/hospital in the past 2 years.

The BWHS participants were from 17 states across the United States with approximately equal numbers living in the Northeast, South, West, and Midwest. In addition, 97% of the participants have completed high school or a higher level of education. Among the US black female population of the same ages, 83% have at least a high school education (30). In this respect, our results should be applicable to most US black women, except possibly the approximately 17% who have not completed high school.

The present observational findings suggest that physical activity may reduce the risk of type 2 diabetes in African-American women, a population at high risk of the disease. Recent recommendations for physical activity for adults include "moderate-intensity physical activities for at least 30 minutes on 5 or more days of the week" (Centers for Disease Control and Prevention) and "vigorous-intensity physical activity 3 or more days per week for 20 or more minutes per occasion" (Healthy People 2010) (31). Like the majority of adults in the United States, most African-American women do not meet recommended levels of physical activity. Our results for vigorous activity and brisk walking suggest that levels approximating those recommended might indeed be protective against type 2 diabetes. Regular brisk walking may be easier to implement than vigorous physical activity. Reducing sedentary behaviors, such as television watching, or at least reducing the excess eating that often accompanies it, might also be effective. A necessary first step for the translation of scientific findings into behavioral change is dissemination of the health information to those affected, and the current results provide the basis for educating African-American women about the benefits of physical activity in preventing type 2 diabetes.

ACKNOWLEDGMENTS

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論文名	Physical activity and television watching in relation to risk of type 2 diabetes: the Black Women's Health Study
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対象の内訳		ヒト	動物	地 域		欧米	研究の種類	縦断研究
	対象	一般健常者	空白			（　　　）		コホート研究
	性別	女性	（　　　　）			（　　　）		（　　　）
	年齢	21-69歳				（　　　）		前向き研究
	対象数	10000以上				（　　　）		（　　　）

調査の方法	質問紙	（　　　　）		

アウトカム	予 防	な し	糖尿病予防	な し	な し	（　　　）	（　　　）
	維持・改善	な し	な し	な し	な し	（　　　）	（　　　）

図 表

Table 2. Incidence Rate Ratios for the Association of Physical Activity, Television Watching, and Risk of Type 2 Diabetes, the Black Women's Health Study, 1995-2005

	Cases, no.	Person-Years, no.	Age-adjusted Incidence Rate Ratio	Multivariable[a] Incidence Rate Ratio	95% Confidence Interval
Vigorous physical activity, hours/week					
0	994	42,665	1.0	1.0	
<1	994	51,646	0.79	0.90	0.82, 0.99
1-2	668	51,057	0.62	0.77	0.69, 0.85
3-4	170	21,368	0.41	0.53	0.45, 0.63
5-6	63	9,101	0.38	0.49	0.38, 0.64
≥7	39	7,157	0.33	0.43	0.31, 0.59
			$P_{trend} < 0.0001$	$P_{trend} < 0.0001$	
Walking for exercise or transport, pace[b]					
No walking	69	5,375	1.0	1.0	
Casual, hours/week					
<1	182	8,598	1.06	1.04	0.78, 1.37
1-2	310	14,097	1.06	1.09	0.84, 1.42
3-4	113	4,726	1.15	1.21	0.89, 1.65
≥5	106	4,459	1.17	1.21	0.89, 1.65
Average, hours/week					
<1	176	10,386	0.92	1.02	0.77, 1.35
1-2	404	25,439	0.81	0.96	0.74, 1.24
3-4	198	11,242	0.84	1.04	0.78, 1.37
≥5	178	11,347	0.78	0.95	0.71, 1.26
Brisk, hours/week					
<1	67	5,432	0.73	0.91	0.64, 1.27
1-2	192	17,582	0.59	0.78	0.59, 1.03
3-4	107	10,735	0.49	0.69	0.51, 0.95
≥5	115	12,417	0.46	0.67	0.49, 0.92
Television watching, hours/day					
0-<1	135	16,390	1.0	1.0	
1-2	935	68,284	1.51	1.43	1.19, 1.71
3-4	1,146	67,901	1.77	1.53	1.28, 1.83
≥5	712	30,419	2.38	1.86	1.54, 2.24
			$P_{trend} < 0.0001$	$P_{trend} < 0.0001$	

[a] The multivariable incidence rate ratio included terms for age, time period, family history of diabetes, years of education, family income, marital status, cigarette use, alcohol use, energy intake, coffee consumption, vigorous activity, television watching, and walking.
[b] The pace of walking was reported on only 1 follow-up questionnaire, and values are missing for those who did not fill out that questionnaire.

図表掲載箇所	P431, Table2

概 要 (800字まで)	本研究は、アメリカのThe Black Women's Health Studyに参加した黒人女性45,668名を対象に10年間の追跡調査を行い、身体活動やテレビ視聴時間が2型糖尿病発症に及ぼす影響について検討したものである。質問紙によって、週当たりの高強度身体活動を実施した時間、歩行による運動または移動手段としての歩行を実施した時間および速度、1日当たりのテレビ視聴時間を尋ねた。高強度身体活動の実施時間を0時間/週、1時間/週未満、1-2、3-4、5-6、7時間/週以上の6群に、歩行時間を、のんびり(2mph未満)、普通(2-3mph)、やや速い(3-4mph)、早歩き(4mph以上)のペースでそれぞれ、1時間/週未満、1-2、3-4、5時間/週の4群に、テレビ視聴時間を、1時間/日未満、1-2、3-4、5時間/日以上の4群に分類した。高強度身体活動の実施が0時間/週の集団と比較すると、時間の延長につれて全ての群で糖尿病発症リスクがそれぞれ0.90(95%信頼区間:0.82-0.99)、0.77(0.69-0.85)、0.53(0.45-0.63)、0.49(0.38-0.64)、0.43(0.31-0.59)と量反応的に減少した(Ptrend<0.0001)。歩行時間0時間の集団と比較すると、のんびり歩行、普通歩行では糖尿病発症リスクの減少はみられなかったが、早歩きを週当たり3-4時間、または5時間以上実施している集団では、糖尿病発症リスクが0.69(0.51-0.95)、0.67(0.49-0.92)と有意に減少した。また、テレビ視聴時間1時間/日未満の集団と比較すると、1-2、3-4、5時間/日以上の全ての集団で、糖尿病発症リスクが1.43(1.19-1.71)、1.53(1.28-1.83)、1.86(1.54-2.24)と量反応的に上昇した(Ptrend<0.0001)。また、高強度身体活動とテレビ視聴時間の延長の複合効果として、高強度活動3時間/週以上かつ視聴1時間/日未満の集団と比較すると高強度活動1時間/未満かつ視聴5時間/日以上の集団で糖尿病発症リスクは3.64(2.23-5.92)と跳ね上がった。
結 論 (200字まで)	黒人女性コホートにおいて、高強度身体活動や歩行時間の延長は2型糖尿病発症の抑制に効果を示すことが明らかとなった。また、不活動時間(テレビ視聴)の延長が糖尿病発症リスクを高めることが明らかとなった。
エキスパートによるコメント (200字まで)	身体活動基準の策定に用いられた研究の1つである。糖尿病の発症は我が国においても年々増加しており、糖尿病発症を予防することは非常に重要な課題である。本研究では、高強度身体活動とテレビ視聴時間の相互作用が認められており、高強度身体活動を実施しておらず、テレビの視聴時間が多い人においては、特に重点的な支援を行うことが必要であることが示されている。

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Original Contribution

Leisure Time Spent Sitting in Relation to Total Mortality in a Prospective Cohort of US Adults

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The obesity epidemic is attributed in part to reduced physical activity. Evidence supports that reducing time spent sitting, regardless of activity, may improve the metabolic consequences of obesity. Analyses were conducted in a large prospective study of US adults enrolled by the American Cancer Society to examine leisure time spent sitting and physical activity in relation to mortality. Time spent sitting and physical activity were queried by questionnaire on 53,440 men and 69,776 women who were disease free at enrollment. The authors identified 11,307 deaths in men and 7,923 deaths in women during the 14-year follow-up. After adjustment for smoking, body mass index, and other factors, time spent sitting ($\geq$6 vs. <3 hours/day) was associated with mortality in both women (relative risk = 1.34, 95% confidence interval (CI): 1.25, 1.44) and men (relative risk = 1.17, 95% CI: 1.11, 1.24). Relative risks for sitting ($\geq$6 hours/day) and physical activity (<24.5 metabolic equivalent (MET)-hours/week) combined were 1.94 (95% CI: 1.70, 2.20) for women and 1.48 (95% CI: 1.33, 1.65) for men, compared with those with the least time sitting and most activity. Associations were strongest for cardiovascular disease mortality. The time spent sitting was independently associated with total mortality, regardless of physical activity level. Public health messages should include both being physically active and reducing time spent sitting.

mortality; motor activity; prospective studies; sedentary lifestyle

Abbreviations: CI, confidence interval; CPS-II, Cancer Prevention Study II; ICD, International Classification of Diseases; MET, metabolic equivalent.

It is now well established that the US obesity epidemic will have major public health consequences. This epidemic is attributed, at least in part, to reduced overall physical activity expenditure. It has long been recognized that physical activity has a beneficial impact on the incidence and mortality of many chronic diseases, including cardiovascular disease, diabetes, stroke, and various types of cancer including colon and postmenopausal breast cancer (1–5). Dose-response relations between physical activity and improved health outcomes have been reported, and substantial evidence supports health benefits even with physical activity below recommended levels (1, 3, 6, 7).

There is a growing body of evidence showing that reducing the amount of time spent sitting, regardless of the amount of physical activity, may improve the metabolic consequences of obesity (8–11). However, current public health guidelines focus largely on increasing physical activity with little or no reference to reducing time spent sitting (12–15). Numerous studies support an association with sitting time and endpoints such as obesity, type 2 diabetes, cardiovascular disease (11, 16, 17), and unhealthy dietary patterns in children and adults (18–20). However, to our knowledge, few studies have examined time spent sitting in relation to total mortality (21–23), but they were limited by sample size (21, 22) or qualitatively assessed time spent sitting (21).

To better assess the relation between time spent sitting and total mortality, both independent of and in combination with physical activity, we conducted a detailed analysis in the American Cancer Society's Cancer Prevention Study II

(CPS-II) Nutrition Cohort. This cohort has the advantage of being very large with approximately 184,000 US adults and over 19,000 deaths for whom detailed information on time spent sitting and physical activity was collected at baseline.

MATERIALS AND METHODS

Study population

Men and women in this analysis were drawn from the 184,190 participants in the CPS-II Nutrition Cohort (hereafter referred to as the "Nutrition Cohort"), a prospective study of cancer incidence and mortality begun by the American Cancer Society in 1992 (24). The Nutrition Cohort is a subgroup of approximately 1.2 million participants in the baseline CPS-II cohort, a prospective mortality study established by the American Cancer Society in 1982 (25). Members of the CPS-II cohort who resided in 21 states with population-based state cancer registries and were 50–74 years of age in 1992 were invited to participate by completing a mailed questionnaire. The 10-page mailed questionnaire included questions on demographic, reproductive, medical, behavioral, and lifestyle factors. The recruitment and characteristics of the Nutrition Cohort are described in detail elsewhere (24).

We excluded sequentially from this analysis men and women who reported a personal history of cancer ($n = 21,785$), heart attack ($n = 11,560$), stroke ($n = 2,513$), or emphysema/other lung disease ($n = 9,321$) at the time of enrollment. We also excluded individuals with missing data on physical activity ($n = 4,240$), missing sitting time ($n = 2,954$), missing or extreme (top and bottom 0.1%) values of body mass index ($n = 2,121$), or missing smoking status ($n = 1,347$) at baseline. Finally, to reduce the possibility of undiagnosed serious illness at baseline that would preclude or interfere with physical activity, we excluded individuals who reported both no daily life activities and no light housekeeping ($n = 4,730$), as well as those who died from any cause within the first year of follow-up ($n = 403$). After exclusions, the analytical cohort consisted of 123,216 individuals (53,440 men and 69,776 women) with a mean age of 63.6 (standard deviation, 6.0) years in men and 61.9 (standard deviation, 6.5) years in women when enrolled in the study in 1992.

Mortality endpoints

The primary endpoint was death from any cause occurring between 1 year after the time of enrollment and December 31, 2006. Deaths were identified through biennial automated linkage of the entire cohort with the National Death Index (26). Death certificates or codes for cause of death have been obtained for 98.7% of all known deaths. Causes of death were classified by using the *International Classification of Diseases* (ICD), Ninth Revision (27), for deaths occurring from 1992 to 1998 and the Tenth Revision (28) for deaths from 1999 to 2006. Specific causes of death were grouped into 3 broad categories: cardiovascular disease (ICD, Ninth Revision, codes 390–459 and ICD, Tenth Revision, codes I00–I99); cancer (ICD, Ninth Revision, codes 140–195 and 199–208 and ICD, Tenth Revision, codes C00–C76 and C80–C97); and all other causes.

Measures of time spent sitting and physical activity

Time spent sitting was assessed by using the question, "During the past year, on an average day (not counting time spent at your job), how many hours per day did you spend sitting (watching television, reading, etc.)?" Responses included "none, <3, 3–5, 6–8, >8 hours per day." Time spent sitting was categorized as 0–<3, 3–5, or ≥6 hours/day.

Information on recreational physical activity was collected by using the question, "During the past year, what was the average time per week you spent at the following kinds of activities: walking, jogging/running, lap swimming, tennis or racquetball, bicycling or stationary biking, aerobics/calisthenics, and dancing?" Responses to each individual activity included "none," "1–3 hours/week," "4–6 hours/week," or "≥7 hours/week." The summary metabolic equivalent of energy expenditure (MET)-hours/week was calculated for each participant. A MET is estimated by dividing the energy cost of a given activity by resting energy expenditure (29). The summary MET score for each participant was calculated by multiplying the lowest number of hours within each category by the general MET level of each activity according to the Compendium of Physical Activities (29) to provide conservatively estimated summary measures because of the likelihood of overreporting physical activity and the older age of study participants. MET scores assigned for various activities include the following: 3.5 for walking, 7.0 for jogging/running, 7.0 for lap swimming, 6.0 for tennis or racquetball, 4.0 for bicycling/stationary biking, 4.5 for aerobics/calisthenics, and 3.5 for dancing.

We also assessed daily life physical activities with the question, "During the past year, what was the average time per week you spent at the following kinds of activities: gardening/mowing/planting, heavy housework/vacuuming, heavy home repair/painting, and shopping?" We calculated MET-hours/week from these activities using the following values (29): 3.0 for gardening/mowing/planting, 2.5 for heavy housework/vacuuming, 3.0 for heavy home repair/painting, and 2.5 for shopping.

The primary purpose in this analysis was to examine the relation of leisure-time sitting to all-cause death rates. Therefore, we combined recreational and daily life activity into total leisure-time physical activity at baseline, because the relation between regular physical activity and all-cause mortality has been well documented. Total leisure-time activity was categorized in MET-hours/week as <17.5, 17.5–<24.5, 24.5–<31.5, 31.5–<42.0, 42.0–<52.5, 52.5–<63.0, or ≥63.0. The lowest cutpoint corresponds with approximately the 10th percentile of activity level in our population, and each subsequent category increases by the metabolic equivalent of approximately 3 hours of light-intensity daily life activities per week.

Statistical analysis

Cox proportional hazards modeling (30) was used to compute relative risk, with follow-up time in days as the time axis. All Cox models were stratified on exact year of age. For each exposure variable, we assessed risk in 3 models: 1) adjusted only for age, 2) adjusted for age and

other potential confounding factors, and 3) mutually adjusting for both physical activity and time spent sitting in addition to all potential confounders. The potential confounders included were race (white, black, other), smoking status (never, current, former), duration ($\leq$35, >35 years) and frequency (<20, $\geq$20 cigarettes/day) of smoking among current smokers, years since quitting among former smokers ($\leq$5, 6–10, 11–15, 16–20, 21–25, >25 years), body mass index (weight (kg)/height (m)^2) (<18.5, 18.5–22.4, 22.5–24.9, 25.0–27.4, 27.5–29.9, $\geq$30.0), marital status (married, widowed, divorced, separated, never married), education (less than high school, high school graduate, some college, college graduate, graduate school or higher), alcohol consumption (0, <1, 1, >1 drink/day), total caloric intake (quartiles), and comorbidity score (0, 1, $\geq$2). Dietary intake was assessed by using a 68-item modified brief food frequency questionnaire by Block et al. (31) and validated in a subset of cohort members (32). The comorbidities score included high blood pressure, diabetes, and high cholesterol. Other potential confounders assessed were fruit and vegetable intake, fat intake, red meat intake, and occupational status (employed, retired, homemaker), but these factors were not included in the model as they had no impact on any risk estimates for physical activity or time spent sitting.

Tests of linear trend for sitting time and physical activity measures were calculated by assigning the median value within each category to that category. We also examined the combined effects of physical activity and time spent sitting. For these models, the number of categories of total daily physical activity was reduced from 7 to 5 (<24.5, 24.5–<31.5, 31.5–<42.0, 42.0–<52.5, $\geq$52.5 MET-hours/week). Men and women who were most physically active and spent the least time sitting ($\geq$52.5 MET-hours/week and <3 hours/day sitting) served as the referent group.

Secondary analyses also examined the associations between body mass index and mortality from all cardiovascular diseases, all cancers, and all other causes of death among men and women separately. We also tested for effect modification by gender, body mass index, smoking status, attained age, and follow-up time. Because there was no statistically significant effect modification by gender, all other factors were tested for effect modification in both sexes combined to maximize statistical power.

We also conducted a sensitivity analysis to further examine whether the amount of time spent sitting at baseline was a result of undiagnosed illness that was not accounted for through exclusions for prevalent disease or excluding the first year of follow-up. Using data on physical activity and time spent sitting in 1992, as well as our first follow-up survey in 1997, we examined long-term (5-year) sitting time and physical activity in relation to subsequent mortality rates. Finally, we conducted a sensitivity analysis among men and women who were either retired or homemakers to eliminate the potential impact of occupational time spent sitting or in physical activity.

RESULTS

We observed 11,307 deaths in men and 7,923 in women over the 1,610,728 person-years of follow-up. Men and

women who spent the least leisure time sitting were leaner, more likely to have never smoked cigarettes, more likely to be employed, and had lower total energy intake (Table 1). Leisure time spent sitting was not associated with physical activity ($r = -0.03$). Study participants generally engaged in light- to moderate-intensity activities, such as walking for exercise, gardening, shopping, and housework. Moderate- to vigorous-intensity activities were relatively uncommon in this older population; 83% of men and 87% of women reported walking for exercise, and 37% of men and 36% of women listed walking as their only form of recreational physical activity.

Associations of leisure time spent sitting, physical activity, and their combined effects with mortality are shown in Table 2. After multivariate adjustment, leisure time spent sitting was positively associated with all-cause mortality rates in both women and men; however, associations appeared stronger in women (for $\geq$6 vs. <3 hours/day, relative risk = 1.37, 95% confidence interval (CI): 1.27, 1.47) than men (relative risk = 1.18, 95% CI: 1.12, 1.25) ($P_{\text{heterogeneity}} = 0.003$). After further adjustment for physical activity, these associations remained virtually unchanged. There was a dose-related, inverse relation between physical activity and mortality rates in women and in men beginning at relatively low levels of activity (Table 2). Risk estimates for physical activity similarly were virtually unchanged after further adjustment for time spent sitting.

When examining the combined effects of time spent sitting and physical activity on all-cause death rates, time spent sitting was associated with increased risk regardless of level of physical activity (Figures 1 and 2). The relative risks for the joint effects of sitting and physical activity ($\geq$6 hours/day sitting and <24.5 MET-hours/week activity) were 1.94 (95% CI: 1.70, 2.20) and 1.48 (95% CI: 1.33, 1.65), for women and men respectively, compared with women and men who reported both sitting the least (<3 hours/day) and being the most physically active ($\geq$52.5 MET-hours/week).

We examined the association between time spent sitting and total mortality in men and women combined, stratified by body mass index (Table 3). Although time spent sitting and physical activity were more strongly associated with mortality among lean persons (for time spent sitting, $P_{\text{interaction}} = 0.06$; for physical activity, $P_{\text{interaction}} = 0.002$), both measures were significantly associated with risk of total mortality regardless of body mass index. No other factors examined, including smoking status or attained age, appeared to modify the associations between time spent sitting and physical activity in relation to total mortality (data not shown). Results from the sensitivity analysis among participants who are retired or homemakers also did not differ from those in the overall cohort (data not shown).

Although we excluded the first year of follow-up and prevalent disease, we further examined whether observed associations were a result of unidentified prevalent illness in 2 ways. First, we examined the associations between baseline exposures stratified by follow-up time. Although associations were slightly attenuated, they persisted and remained statistically significant over the 14-year follow-up (data not shown). Second, we conducted a sensitivity analysis combining questions about sitting time and physical

Table 1. Age-adjusted Percentages and Means of Selected Baseline Characteristics in 1992, by Hours of Leisure Time Spent Sitting for Women and Men, Cancer Prevention Study II Nutrition Cohort

	Sitting in 1992											
	Women						Men					
	<3 hours/day (n = 34,075)		3–5 hours/day (n = 29,335)		≥6 hours/day (n = 6,366)		<3 hours/day (n = 22,876)		3–5 hours/day (n = 23,723)		≥6 hours/day (n = 6,841)	
	Mean (SE)	%	Mean (SE)	%	Mean (SE)	%	Mean (SE)	%	Mean (SE)	%	Mean (SE)	%
Age at baseline, years	60.7 (0.04)		62.8 (0.04)		63.4 (0.08)		62.6 (0.04)		64.1 (0.04)		64.8 (0.07)	
Body mass index in 1992, kg/m^2	24.9 (0.02)		25.9 (0.03)		26.8 (0.06)		26.1 (0.02)		26.6 (0.02)		27.0 (0.04)	
Total MET-hours/week	42.8 (0.12)		40.7 (0.13)		39.9 (0.29)		46.1 (0.16)		44.4 (0.16)		44.5 (0.29)	
Retired/homemaker		61.6		69.9		73.1		50.0		61.0		64.7
Race												
White		97.4		97.4		96.9		97.3		97.4		97.5
Black		1.4		1.5		1.6		1.2		1.3		1.2
Other		1.2		1.1		1.5		1.4		1.4		1.3
Educational level												
Less than high school		4.7		4.7		5.5		7.8		7.2		7.2
High school graduate		30.5		33.9		33.0		18.8		19.5		16.9
Some college		31.1		31.3		31.1		24.3		27.3		25.1
College graduate		19.9		18.2		17.3		22.2		21.7		22.5
Graduate school		13.2		11.2		12.3		26.3		23.7		27.8
Smoking status												
Never		60.1		53.8		48.7		39.5		31.7		30.8
Current		6.7		9.9		13.4		7.1		9.7		12.7
Former		32.4		35.7		37.0		52.1		57.4		55.1
Alcohol use												
Never		45.3		44.5		47.7		32.5		31.3		31.8
<1 drink/day		38.8		39.2		35.2		39.2		39.5		38.1
1 drink/day		7.7		7.9		7.4		12.9		13.1		12.1
>1 drink/day		4.3		5.0		5.7		11.3		12.9		14.4
Caloric intake, kcal/day	1,326.69 (2.7)		1,383.78 (2.9)		1,455.24 (6.2)		1,770.64 (4.3)		1,839.98 (4.1)		1,923.58 (7.8)	

Abbreviations: MET, metabolic equivalent; SE, standard error.

Table 2.   Relative Risk of Death From All Causes According to Leisure Time Sitting and Physical Activity Among Women and Men, Cancer Prevention Study II Nutrition Cohort, 1993–2006

	Women						Men					
	No. of Deaths	Person-Years	Relative Risk[a]	95% CI	Relative Risk[b]	95% CI	No. of Deaths	Person-Years	Relative Risk[a]	95% CI	Relative Risk[b]	95% CI
Sitting in 1992, hours/day												
0–<3	3,038	456,987	1.00	Referent	1.00	Referent	4,030	298,227	1.00	Referent	1.00	Referent
3–5	3,781	386,736	1.14	1.08, 1.19	1.13	1.07, 1.18	5,413	301,973	1.08	1.03, 1.12	1.07	1.03, 1.12
≥6	1,104	81,963	1.37	1.27, 1.47	1.34	1.25, 1.44	1,864	84,842	1.18	1.12, 1.25	1.17	1.11, 1.24
P_{trend}			<0.0001		<0.0001				<0.0001		<0.0001	
Total physical activity in 1992, MET-hours/week												
<17.5	1,157	107,418	1.00	Referent	1.00	Referent	1,186	63,336	1.00	Referent	1.00	Referent
17.5–<24.5	699	63,751	0.98	0.89, 1.07	0.98	0.89, 1.07	991	59,365	0.89	0.82, 0.97	0.90	0.82, 0.97
24.5–<31.5	1,382	159,718	0.81	0.75, 0.88	0.82	0.75, 0.88	1,397	86,898	0.84	0.78, 0.91	0.85	0.78, 0.92
31.5–<42	1,588	195,423	0.78	0.72, 0.84	0.78	0.73, 0.85	2,284	133,341	0.88	0.82, 0.94	0.88	0.82, 0.95
42–<52.5	1,255	157,978	0.76	0.70, 0.82	0.76	0.70, 0.83	1,857	115,894	0.81	0.75, 0.87	0.81	0.75, 0.87
52.5–<63	772	99,477	0.75	0.68, 0.82	0.76	0.69, 0.83	1,453	88,468	0.79	0.73, 0.85	0.79	0.74, 0.86
≥63	1,070	141,921	0.73	0.67, 0.80	0.74	0.68, 0.81	2,139	137,740	0.79	0.74, 0.85	0.80	0.74, 0.86
P_{trend}			<0.0001		<0.0001				<0.0001		<0.0001	
Physical activity, MET-hours/week, and sitting, sitting-hours/day, in 1992												
≥52.5, <3	788	126,961	1.00	Referent			1,401	100,780	1.00	Referent		
≥52.5, 3–5	831	94,582	1.12	1.02, 1.24			1,640	96,805	1.02	0.95, 1.09		
≥52.5, ≥6	223	19,854	1.25	1.07, 1.45			551	26,623	1.07	0.97, 1.18		
42–<52.5, <3	490	77,704	1.01	0.90, 1.13			656	50,122	0.98	0.89, 1.07		
42–<52.5, 3–5	596	66,885	1.14	1.03, 1.27			903	52,499	1.04	0.95, 1.13		
42–<52.5, ≥6	169	13,389	1.31	1.10, 1.54			298	13,274	1.20	1.06, 1.36		
31.5–<42, <3	603	96,191	1.00	0.90, 1.11			806	57,814	1.08	0.99, 1.18		
31.5–<42, 3–5	797	83,531	1.20	1.09, 1.33			1,131	59,678	1.13	1.05, 1.23		
31.5–<42, ≥6	188	15,701	1.35	1.15, 1.58			347	15,849	1.23	1.09, 1.38		
24.5–<31.5, <3	525	76,992	1.10	0.98, 1.23			467	38,048	0.96	0.86, 1.06		
24.5–<31.5, 3–5	682	68,555	1.20	1.09, 1.34			699	37,945	1.18	1.07, 1.29		
24.5–<31.5, ≥6	175	14,171	1.39	1.18, 1.64			231	10,905	1.13	0.99, 1.31		
<24.5, <3	632	79,138	1.30	1.17, 1.44			700	51,464	1.09	0.99, 1.19		
<24.5, 3–5	875	73,184	1.42	1.29, 1.57			1,040	55,045	1.23	1.13, 1.33		
<24.5, ≥6	349	18,847	1.94	1.70, 2.20			437	16,192	1.48	1.33, 1.65		

Abbreviations: CI, confidence interval; MET, metabolic equivalent.
[a] Adjusted for age at interview, race, marital status, education, smoking status, body mass index in 1992, alcohol use, total caloric intake, and comorbidities score.
[b] Adjusted for all of the above plus total physical activity (for sitting) and hours sitting (for total physical activity).
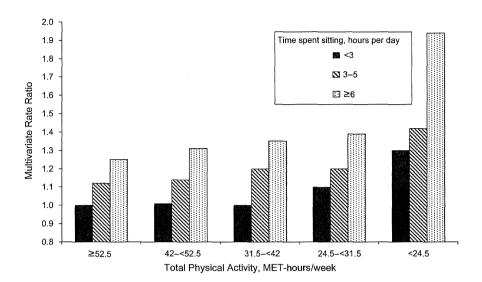
Figure 1. Combined multivariate-adjusted rate ratios ($P < 0.05$) for leisure time spent sitting and physical activity in relation to all-cause mortality, women only, in the Cancer Prevention Study II Nutrition Cohort, 1993–2006. MET, metabolic equivalent.

activity at baseline with those from our first follow-up survey in 1997 to examine sustained (5-year) measures. Results from these analyses did not differ from those presented for baseline alone (data not shown).

Associations between time spent sitting and physical activity were stronger for cardiovascular disease mortality than for cancer (Table 4). Time spent sitting was associated with an increased risk of cardiovascular disease mortality in both men and women, whereas it was associated with increased cancer mortality only among women. There was a statistically significant inverse relation between physical

activity and cardiovascular disease mortality beginning at relatively low levels of activity in both men ($P_{trend} = 0.0001$) and women ($P_{trend} < 0.0001$). In contrast, total physical activity was not significantly associated with lower cancer mortality among men and only modestly associated with lower cancer mortality in women. Longer time spent sitting was associated with higher death rates from all other causes, and physical activity was inversely associated with death rates from other causes. The most common conditions in this category were respiratory diseases (22.7% in men, 20.4% in women), central nervous system diseases (20.3%
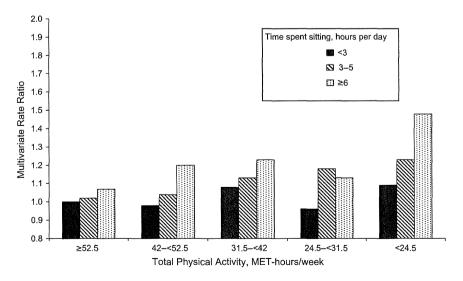

Figure 2. Combined multivariate-adjusted rate ratios ($P < 0.05$) for leisure time spent sitting and physical activity in relation to all-cause mortality, men only, in the Cancer Prevention Study II Nutrition Cohort, 1993–2006. MET, metabolic equivalent.

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Table 3. Relative Risk of Death From All Causes According to Leisure Time Spent Sitting and Physical Activity, Stratified by Body Mass Index, Among Women and Men, Cancer Prevention Study II Nutrition Cohort, 1993–2006

| | Body Mass Index, kg/m^2 | | | | | | | | |
| | <25.0 | | | 25.0–<30.0 | | | ≥30.0 | | |
	No. of Deaths	Relative Risk[a]	95% CI	No. of Deaths	Relative Risk[a]	95% CI	No. of Deaths	Relative Risk[a]	95% CI
Sitting in 1992, hours/day									
0–<3	3,278	1.00	Referent	2,768	1.00	Referent	1,022	1.00	Referent
3–5	3,768	1.10	1.05, 1.15	3,852	1.11	1.05, 1.16	1,574	1.05	0.97, 1.14
≥6	1,119	1.28	1.20, 1.37	1,220	1.21	1.12, 1.29	629	1.19	1.08, 1.32
P_{trend}	<0.0001			<0.0001			0.001		
			$P_{interaction} = 0.06$						
Total physical activity in 1992, MET-hours/week									
<17.5	866	1.00	Referent	935	1.00	Referent	542	1.00	Referent
17.5–<24.5	669	0.94	0.85, 1.04	668	0.90	0.81, 0.99	353	0.94	0.82, 1.08
24.5–<31.5	1,202	0.86	0.79, 0.94	1,054	0.79	0.72, 0.86	523	0.86	0.76, 0.97
31.5–<42	1,605	0.80	0.73, 0.87	1,622	0.86	0.80, 0.94	645	0.86	0.76, 0.96
42–<52.5	1,380	0.77	0.70, 0.83	1,250	0.78	0.72, 0.85	482	0.86	0.76, 0.98
52.5–<63	996	0.76	0.69, 0.83	937	0.79	0.72, 0.87	292	0.79	0.69, 0.92
≥63	1,447	0.72	0.66, 0.79	1,374	0.82	0.76, 0.89	388	0.78	0.69, 0.89
P_{trend}	<0.0001			0.0003			0.0001		
			$P_{interaction} = 0.002$						

Abbreviations: CI, confidence interval; MET, metabolic equivalent.

[a] Adjusted for age at interview, race, marital status, education, smoking status, body mass index in 1992, alcohol use, total caloric intake, comorbidities score, and total physical activity (for sitting) and hours sitting (for total physical activity).

in men, 19.8% in women), digestive diseases (9.6% in men, 10.4% in women), and diabetes (7.8% in men, 6.3% in women).

DISCUSSION

In this large prospective cohort, women who reported sitting for more than 6 hours during their leisure time versus less than 3 hours a day had an approximately 40% higher all-cause death rate, and men had an approximately 20% higher death rate. This association was independent of the amount of physical activity. The combination of both sitting more and being less physically active (>6 hours/day sitting and <24.5 MET-hours/week physical activity) was associated with a 94% and a 48% increase in all-cause death rates in women and men, respectively, compared with those who reported sitting the least and being most active (<3 hours/day sitting and ≥52 MET-hours/week physical activity).

Our findings for time spent sitting are consistent with those from the 3 other studies that have previously examined the association between time spent sitting and mortality (21–23). One study included approximately 17,000 Canadian adults with 1,832 deaths, and the authors reported a significant dose-response relation between a qualitative measure of time spent sitting (almost none of the time, one fourth of the time, half of the time, three fourths of the time, almost all of the time) and total mortality (21). The second study, which included 8,800 Australian adults and 284 deaths, found an almost 50% increase in total mortality with 4 or more hours of television viewing compared with less than 2 hours per day (22). In both of these studies, associations were strongest for cardiovascular disease mortality (21, 22). The third study included approximately 83,000 Japanese adults and reported a positive association with sedentary behavior and total mortality among men, but not women (23).

Our physical activity findings were similar to those reported from the majority of other studies (1, 2, 33). Mortality rates were approximately 25% lower among men and women who reported the most versus the least daily physical activity. Although optimal health benefits are achieved at a much higher level of physical activity, death rates were substantially lower even in the second lowest category compared with the lowest category, suggesting a benefit from even relatively light levels of physical activity. As mentioned, the participants in our study were older and engaged in primarily light-intensity activities, such as walking for exercise and gardening. It should be noted that no previous study has examined the combined effects of sitting time and physical activity.

Several factors could explain the positive association between time spent sitting and higher all-cause death rates.

Table 4. Relative Risk of Death From Cardiovascular Disease, Cancer, and All Other Causes According to Leisure Time Spent Sitting and Physical Activity Among Women and Men, Cancer Prevention Study II Nutrition Cohort, 1993–2006

	Cardiovascular Disease			Cancer			Other Causes		
	No. of Deaths	Relative Risk[a]	95% CI	No. of Deaths	Relative Risk[a]	95% CI	No. of Deaths	Relative Risk[a]	95% CI
Women									
Sitting in 1992, hours/day									
0–<3	833	1.00	Referent	1,284	1.00	Referent	921	1.00	Referent
3–5	1,196	1.20	1.10, 1.32	1,413	1.07	0.99, 1.16	1,172	1.13	1.04, 1.24
≥6	331	1.33	1.17, 1.52	411	1.30	1.16, 1.46	362	1.41	1.25, 1.60
P_{trend}	<0.0001			<0.0001			<0.0001		
Total physical activity in 1992, MET-hours/week									
<17.5	370	1.00	Referent	413	1.00	Referent	374	1.00	Referent
17.5–<24.5	224	0.98	0.83, 1.15	260	1.02	0.88, 1.20	215	0.93	0.78, 1.10
24.5–<31.5	400	0.74	0.64, 0.86	536	0.88	0.78, 1.00	446	0.82	0.71, 0.94
31.5–<42	484	0.76	0.67, 0.87	608	0.82	0.73, 0.94	496	0.76	0.67, 0.87
42–<52.5	369	0.72	0.62, 0.84	499	0.83	0.73, 0.95	387	0.74	0.64, 0.85
52.5–<63	224	0.71	0.60, 0.84	328	0.87	0.75, 1.01	220	0.68	0.57, 0.80
≥63	289	0.66	0.56, 0.77	464	0.86	0.75, 0.99	317	0.69	0.59, 0.80
P_{trend}	<0.0001			0.03			<0.0001		
Men									
Sitting in 1992, hours/day									
0–<3	1,413	1.00	Referent	1,457	1.00	Referent	1,160	1.00	Referent
3–5	1,911	1.06	0.99, 1.14	1,853	1.05	0.98, 1.12	1,649	1.13	1.04, 1.22
≥6	685	1.18	1.08, 1.30	571	1.04	0.94, 1.15	608	1.33	1.20, 1.47
P_{trend}	0.0007			0.29			<0.0001		
Total physical activity in 1992, MET-hours/week									
<17.5	435	1.00	Referent	379	1.00	Referent	372	1.00	Referent
17.5–<24.5	353	0.87	0.75, 1.00	314	0.91	0.78, 1.06	324	0.92	0.79, 1.07
24.5–<31.5	496	0.81	0.71, 0.92	488	0.96	0.84, 1.10	413	0.77	0.67, 0.89
31.5–<42	818	0.86	0.77, 0.97	781	0.98	0.87, 1.11	685	0.81	0.71, 0.92
42–<52.5	638	0.76	0.68, 0.86	636	0.91	0.80, 1.03	583	0.77	0.67, 0.87
52.5–<63	516	0.78	0.68, 0.88	511	0.92	0.81, 1.05	426	0.70	0.61, 0.80
≥63	753	0.77	0.68, 0.87	772	0.95	0.84, 1.07	614	0.68	0.60, 0.78
P_{trend}	0.0001			0.52			<0.0001		

Abbreviations: CI, confidence interval; MET, metabolic equivalent.

[a] Adjusted for age at interview, race, marital status, education, smoking status, body mass index in 1992, alcohol use, total caloric intake, comorbidities score, and total physical activity (for sitting) and hours sitting (for total physical activity).

First, time spent sitting might be more easily measured than physical activity and/or may reflect a different aspect of inactivity than other indices usually used in epidemiologic studies. However, this potential misclassification of exposure is unlikely to fully explain our findings, because time spent sitting was significantly associated with mortality even among men and women with the highest levels of physical activity.

Second, time spent sitting might be associated with other unhealthy behaviors that are either not captured or incompletely captured through questionnaires. Total energy expenditure is reduced among individuals who are sedentary.

However, consistent with previous studies, the present study found no correlation between physical activity and time spent sitting ($r = -0.03$). Time spent sitting is also associated with greater food consumption and subsequent weight gain, especially when watching television (16, 34, 35). Time spent sitting was previously shown to be associated with increased weight gain in this cohort (18). While residual confounding by obesity could contribute to the association between sitting time and mortality, this association was attenuated but not eliminated by controlling for or stratifying on body mass index.

Third, prolonged time spent sitting, independent of physical activity, has important metabolic consequences that may influence specific biomarkers (such as triglycerides, high density lipoprotein cholesterol, fasting plasma glucose, resting blood pressure, and leptin) of obesity and cardiovascular and other chronic diseases (8–11). Animal studies have also shown that sedentary time substantially suppresses enzymes centrally involved in lipid metabolism within skeletal muscle, and low levels of daily life activity are sufficient to improve enzyme activity (36–38). Furthermore, substantial evidence in both adults and children from observational studies and randomized clinical trials shows that reducing time spent sitting lowers the risk of obesity and type II diabetes (19, 39–42).

Over the past century, a number of technologic changes have contributed to a decrease in total daily energy expenditure. For example, during the 2006–2007 broadcast year, the average US household reported 8 hours of television watching per day, which is an increase of 1 hour per day of television watching from only a decade ago (43). Although leisure-time physical activity levels have remained relatively constant over the past few decades (44, 45), it is well recognized that technologic advances in the workplace have also greatly reduced occupational physical activity. This reduction in overall physical activity, in conjunction with increased time spent sitting and higher caloric intake, has contributed in large part to the rise in obesity and likely influenced temporal trends in cardiovascular disease, type 2 diabetes, and some cancers.

The strengths of our study include the large sample size, prospective design, and ability to control for many potential confounding factors. The lack of occupational physical activity data is a potential limitation; however, we believe this to have minimal impact on daily physical activity levels because the majority of study participants were retired/ homemakers (57% of men and 80% of women) and, among those that were not retired, few worked in jobs that involved any activity (21% of men and 7% of women). Because we measured only leisure time spent sitting, the lack of occupational sitting time may have underestimated sitting time among working individuals, since much of their sitting time may have occurred at work. However, adjusting for employment status (employed, retired, or homemaker) did not change risk estimates for time spent sitting or physical activity. Furthermore, we conducted a sensitivity analysis among only men and women who were retired or homemakers, and results were virtually identical to those in the overall cohort. Another limitation is the use of self-reported measures of time spent sitting, physical activity, and all

other covariates including height and weight. Although the physical activity and sitting time questions we used are subject to misreporting, they are very similar to those used and validated in the Nurses' Health Study II, a prospective study with similar participant characteristics, which found a correlation of 0.79 between activity reported on recalls and questionnaire (46). These measures have also been associated with various cancers in this cohort (47–50). Finally, we were not able to differentiate between types of sitting (i.e., while watching television, reading, driving), and the energy expenditure and other behaviors may vary with different types of sitting.

In conclusion, we found that both leisure time spent sitting and physical activity are independently associated with total mortality. Associations were stronger for cardiovascular disease mortality than for cancer mortality. Public health messages and guidelines should be refined to include reducing time spent sitting in addition to promoting physical activity. Because a sizeable fraction of the population spends much of their time sitting, it is beneficial to encourage sedentary individuals to stand up and walk around as well as to reach optimal levels of physical activity.

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対象の内訳

		ヒト	動物	地 域		欧米	研究の種類	縦断研究
	対象	一般健常者	空白			(　　)		コホート研究
	性別	男女混合	(　　)			(　　)		(　　)
	年齢	男63.6歳(±6.0)	▓▓▓▓.5)			(　　)		前向き研究
	対象数	10000以上				(　　)		(　　)

調査の方法	質問紙	(　　)		

アウトカム

予防	心疾患予防	なし	ガン予防	なし	死亡	(　　)
維持・改善	なし	なし	なし	なし	)	(　　)

図 表

図表掲載箇所	P423, Table2, P426, Table4

概 要 (800字まで)

本研究は、Americal Cancer SocietyによるNutrition Studyに参加している123,216名(男性53,440名、女性69,776名)を対象に、14年間の追跡調査を行い、余暇時間の不活動または身体活動量と総死亡における関連を検討したものである。余暇時間活動を評価するために、「過去一年間、仕事以外で、テレビや読書などの座位時間に一日何時間費やしたか。」「過去一年間、次のような活動を週あたり何時間行ったか(ウォーキング、ジョギング、水泳、テニス、自転車、エアロビクス、健康体操など)。」「過去一年間、次のような家事活動を週あたり何時間行ったか(ガーデニング、掃除、修繕、買い物など)。」といった質問を用いた。総死亡に関して、座位時間(不活動)3時間未満/日のグループと比較すると、座位時間6時間以上/日のグループは、女性でリスクが1.37(95%信頼区間:1.27-1.47)、男性で1.17(1.12-1.25)に上昇した。さらに、座位時間と身体活動量の複合効果として、座位時間3時間未満/日かつ身体活動量52.5MET時以上/週のグループと比較すると、座位時間6時間以上/日かつ身体活動量24.5MET時未満/週のグループは、女性で1.94(1.70-2.20)、男性で1.48(1.33-1.65)に上昇した。また、座位時間の長さは、男女共に心血管疾患による死亡リスクを有意に引き上げることがわかった。さらに、身体活動量の増加と心血管疾患による死亡リスクは逆相関を示すことがわかった。

結 論 (200字まで)

余暇時間における不活動(座位時間)は、身体活動量に関わらず総死亡のリスクを有意に引き上げることが明らかとなった。特に、心血管疾患による死亡との関連が最も有意であった。

エキスパートによるコメント (200字まで)

身体活動基準の策定に用いられた研究の1つである。身体不活動と死亡や疾患発症との関係については、近年非常に注目されている課題である。この身体不活動と死亡のリスクとの関係を12万以上の集団で追跡調査を行った非常に価値ある研究である。日本でも、このような不活動と死亡や様々な疾患発症との関係を明らかにすることが必要である。

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