TABLE 3. Hazard ratios for total cancer incidence according to daily total physical activity level and body mass index or frequency of leisure-time sports or physical exercise (n = 79,771), Japan Public Health Center-based Prospective Study, 1995–2004

Quartile of physical activity level (quartile of METs*/day score)	No. of subjects	Person-years of follow-up	Total			Excluding cases diagnosed within the first 3 years		
			No. of cases	HR*,†	95% CI*	No. of cases	HR†	95% CI
Men (n = 37,898)								
Age (years)								
<60								
Lowest	8,239	61,181	364	1.00	Reference	259	1.00	Reference
Second	5,063	38,860	239	1.00	0.85, 1.18	174	1.00	0.83, 1.22
Third	4,709	36,624	219	0.94	0.79, 1.12	161	0.94	0.77, 1.15
Highest	6,301	49,823	269	0.86	0.73, 1.01	202	0.87	0.72, 1.06
p for trend					0.049			0.135
≥60								
Lowest	4,727	31,240	557	1.00	Reference	345	1.00	Reference
Second	2,759	19,096	336	0.99	0.86, 1.14	207	0.96	0.80, 1.14
Third	2,870	19,887	355	0.97	0.85, 1.11	225	0.96	0.81, 1.14
Highest	3,230	23,018	365	0.87	0.76, 1.00	231	0.85	0.72, 1.01
p for trend					0.051			0.064
p for interaction					0.505			0.976
Body mass index‡								
<20								
Lowest	2,316	15,737	196	1.00	Reference	121	1.00	Reference
Second	1,409	10,180	118	0.93	0.73, 1.17	69	0.85	0.63, 1.16
Third	1,407	10,194	131	0.97	0.77, 1.22	89	1.02	0.77, 1.36
Highest	1,772	13,162	126	0.79	0.63, 1.00	71	0.69	0.51, 0.94
p for trend					0.063			0.031
20–<27								
Lowest	9,081	65,122	632	1.00	Reference	420	1.00	Reference
Second	5,493	40,888	386	0.97	0.86, 1.11	264	0.99	0.83, 1.14
Third	5,325	39,896	397	0.96	0.85, 1.09	263	0.92	0.79, 1.08
Highest	6,779	52,341	451	0.87	0.77, 0.98	324	0.89	0.77, 1.04
p for trend					0.026			0.118
≥27								
Lowest	1,569	11,562	93	1.00	Reference	63	1.00	Reference
Second	920	6,889	71	1.16	0.84, 1.62	48	1.23	0.83, 1.84
Third	847	6,422	46	0.84	0.58, 1.22	34	0.94	0.60, 1.46
Highest	980	7,339	57	0.93	0.66, 1.32	38	0.96	0.63, 1.47
p for trend					0.501			0.713
p for interaction					0.515			0.797
Frequency of leisure-time sports or physical exercise (days/week)								
<1								
Lowest	10,378	74,547	723	1.00	Reference	479	1.00	Reference
Second	6,077	45,423	453	1.02	0.91, 1.15	309	1.01	0.88, 1.17
Third	5,704	42,999	443	1.00	0.88, 1.12	303	0.98	0.85, 1.14
Highest	7,497	57,786	499	0.88	0.79, 0.99	343	0.87	0.75, 1.00
p for trend					0.032			0.044
≥1								
Lowest	2,588	17,875	198	1.00	Reference	125	1.00	Reference
Second	1,745	12,534	122	0.90	0.72, 1.14	72	0.84	0.63, 1.13
Third	1,875	13,513	131	0.84	0.67, 1.06	83	0.84	0.63, 1.12
Highest	2,034	15,055	135	0.78	0.62, 0.99	90	0.82	0.62, 1.09
p for trend					0.034			0.190
p for interaction					0.766			0.566

Table continues

TABLE 3. Continued

Quartile of physical activity level (quartile of METs/day score)	No. of subjects	Person-years of follow-up	Total			Excluding cases diagnosed within the first 3 years		
			No. of cases	HR†	95% CI	No. of cases	HR†	95% CI
Women (n = 41,873)								
Age (years)								
<60								
Lowest	7,946	61,385	279	1.00	Reference	184	1.00	Reference
Second	7,053	55,628	261	1.03	0.87, 1.22	184	1.09	0.88, 1.33
Third	6,271	48,932	202	0.90	0.75, 1.08	131	0.86	0.69, 1.08
Highest	5,501	43,242	188	0.95	0.79, 1.15	120	0.91	0.72, 1.14
p for trend					0.419			0.241
≥60								
Lowest	5,331	38,000	290	1.00	Reference	184	1.00	Reference
Second	3,785	28,016	167	0.81	0.67, 0.98	106	0.78	0.61, 0.996
Third	3,392	25,141	148	0.77	0.63, 0.95	91	0.72	0.56, 0.93
Highest	2,594	19,042	95	0.71	0.56, 0.90	56	0.63	0.47, 0.86
p for trend					0.001			0.001
p for interaction					0.667			0.396
Body mass index								
<20								
Lowest	2,896	20,823	116	1.00	Reference	72	1.00	Reference
Second	2,383	17,909	86	0.92	0.68, 1.22	64	1.08	0.76, 1.54
Third	2,096	15,459	69	0.87	0.64, 1.18	45	0.92	0.63, 1.36
Highest	1,598	12,009	47	0.76	0.54, 1.09	35	0.92	0.60, 1.40
p for trend					0.119			0.623
20–<27								
Lowest	8,467	63,889	370	1.00	Reference	238	1.00	Reference
Second	7,117	55,220	283	0.91	0.78, 1.06	190	0.92	0.76, 1.12
Third	6,453	49,990	239	0.82	0.70, 0.97	149	0.76	0.62, 0.93
Highest	5,515	42,597	192	0.81	0.68, 0.97	116	0.73	0.58, 0.92
p for trend					0.009			0.002
≥27								
Lowest	1,914	14,673	83	1.00	Reference	58	1.00	Reference
Second	1,338	10,516	59	1.05	0.74, 1.48	36	0.94	0.61, 1.44
Third	1,114	8,624	42	0.82	0.56, 1.20	28	0.79	0.49, 1.25
Highest	982	7,678	44	0.96	0.65, 1.41	25	0.76	0.46, 1.25
p for trend					0.643			0.223
p for interaction					0.839			0.137
Frequency of leisure-time sports or physical exercise (days/week)								
<1								
Lowest	10,837	81,716	464	1.00	Reference	297	1.00	Reference
Second	8,773	68,595	354	0.95	0.83, 1.10	236	0.96	0.81, 1.14
Third	7,521	58,563	274	0.84	0.72, 0.98	174	0.80	0.66, 0.97
Highest	5,811	45,696	223	0.92	0.78, 1.08	139	0.87	0.70, 1.06
p for trend					0.140			0.065
≥1								
Lowest	2,440	17,670	105	1.00	Reference	71	1.00	Reference
Second	2,065	15,049	74	0.80	0.59, 1.09	54	0.85	0.59, 1.22
Third	2,142	15,510	76	0.81	0.59, 1.09	48	0.74	0.51, 1.08
Highest	2,284	16,587	60	0.61	0.44, 0.84	37	0.55	0.37, 0.83
p for trend					0.003			0.003
p for interaction					0.158			0.105

* METs, metabolic equivalents; HR, hazard ratio; CI, confidence interval.

† Adjusted for age (stratified, 5-year categories), area (stratified, 10 public health center areas), total energy intake (stratified, quintiles), history of diabetes (no, yes), smoking status (never smoking, past smoking, or 1–19, 20–29, or ≥30 cigarettes/day), alcohol intake status (almost none, occasional, or regular), body mass index (weight (kg)/height (m)^2; <20, 20–<27, or ≥27), and leisure-time sports or physical exercise (<1, 1–2, or ≥3–4 days/week).

‡ Weight (kg)/height (m)^2.

earliest date of diagnosis was used in cases with multiple primary cancers diagnosed at different times. A total of 4,334 newly diagnosed cancer cases were identified.

Physical activity levels

The main exposure of interest in the present study was daily total physical activity level. In our questionnaire (see Appendix), subjects were asked about the average amount of time spent per day in three types of physical activity: heavy physical work or strenuous exercise (none, <1 hour, or ≥1 hour), sitting (<3, 3–<8, or ≥8 hours), and standing or walking (<1, 1–<3, or ≥3 hours). The following values were assigned as time scores for each activity: heavy physical work or strenuous exercise—0 for none, 0.5 for <1 hour, and 3 for ≥1 hour; sitting—1.5 for <3 hours, 5.5 for 3–<8 hours, and 7.5 for ≥8 hours; standing or walking—0.5 for <1 hour, 2 for 1–<3 hours, and 8.5 for ≥3 hours. The midpoint of the time range for each category was assigned when minimum and maximum values were presented on the questionnaire, and arbitrary values considered to have the highest validity from the validation study were assigned for the highest category. MET-hours/day were estimated by multiplying the daily time score for each activity by the MET intensity of that activity (16): for heavy physical work or strenuous exercise, 4.5; for standing or walking, 2.0; for being sedentary, 1.5; and for sleep or other passive activity, 0.9. After data were summed across all activities, subjects were grouped by sex into four exposure levels according to quartile of total METs/day score. Because the question on MET calculation incorporated all activities, including occupation, housework, leisure-time sports, etc., a separate question on the frequency of leisure-time sports and physical exercise was not included in the estimation of total physical activity level.

The validity of the total METs/day score was assessed among 108 eligible samples (53 men and 55 women) derived from 110 original volunteer subjects from the cohort using 4-day, 24-hour physical activity records (Sunday or another day off plus three weekdays) in two different seasons (namely, harvesting and one other season in a single year). The mean number of total METs/day for physical activity obtained from the self-report was 33.5 in men and 33.4 in women, while the mean from the 24-hour physical activity record was 39.5 in men and 40.8 in women. Energy expenditure estimated in METs showed little difference by area. Spearman's rank correlation coefficient for the correlation between the total METs/day score and the physical activity records was 0.46 when the average of two seasons was taken (men, 0.53; women, 0.35).

Analysis

The number of person-years in the follow-up period was counted from the starting point (i.e., the date of response to the 5-year follow-up questionnaire) to the date of occurrence of any cancer, emigration from the study area, death, or the end of the study period, whichever came first. For subjects who withdrew from the study or were lost to follow-up, the date of withdrawal or the last confirmed date of presence in the study was used as the date of censoring.

Hazard ratios and 95 percent confidence intervals were used to characterize the relative risk of cancer occurrence associated with daily total physical activity level. Daily total physical activity was assessed in quartiles of total METs/day score. The median METs/day value for each quartile was used when the linear association was assessed. To investigate whether the effect on the outcome differed by type of physical activity, we also assessed risk by the frequency of leisure-time sports or physical exercise (≤1–3 days/month, 1–2 days/week, 3–4 days/week, or almost every day), in addition to the amount of time spent per day in heavy physical work or strenuous exercise (none, <1 hour, or ≥1 hour) and in standing or walking (<1, 1–<3, or ≥3 hours). Ordinal values were used to assess linear trends for these variables.

The Cox proportional hazards model was employed to control for potentially confounding factors, namely age at the starting point (5-year categories), area (10 public health center areas), history of diabetes (no, yes), smoking status (never smoking, past smoking, or 1–19, 20–29, or ≥30 cigarettes/day), alcohol intake status (almost none, occasional, or regular), body mass index (weight (kg)/height $(m)^2$; 14–<20, 20–<27, or ≥27), and total energy intake (in quintiles, estimated by semiquantitative food frequency questionnaire). These variables, obtained from the questionnaire, are either known or suspected risk factors for cancer that have been identified in previous studies. We treated age, area, and total energy intake as strata to allow for a different baseline hazard for each stratum. In testing of the proportional hazards assumption by Schoenfeld residuals and scaled Schoenfeld residuals, we found no violation of proportionality. In addition, we evaluated whether the effect of total physical activity was influenced by age, body mass index, or frequency of leisure-time sports or physical exercise using a test of interaction, by entering into the model multiplicative terms for interaction between the respective factors. Since the effect of total physical activity was significantly influenced by sex (p for interaction ≤ 0.001), all analysis were conducted by sex. All statistical analyses were performed using Stata 10 (Stata Corporation, College Station, Texas) (17).

RESULTS

During 599,117 person-years of follow-up (average follow-up period, 7.5 years) for the 79,771 subjects (37,898 men and 41,873 women), 4,334 newly diagnosed cases of cancer (2,704 in men and 1,630 in women), including skin cancer (n = 53; 1.2 percent), were identified and included in the analyses. In men, gastric cancer was the most common cancer (n = 621; 23.0 percent), followed by cancers of the lung (n = 388; 14.3 percent), colon (n = 328; 12.1 percent), and prostate (n = 279; 10.3 percent). In women, breast cancer was the most common (n = 294; 18.0 percent), followed by cancers of the stomach (n = 232; 14.2 percent), colon (n = 228; 14.0 percent), and lung (n = 144; 8.8 percent).

Characteristics of the study subjects according to physical activity level are shown in table 1. The median values in the lowest, second, third, and highest quartiles of total METs/day

TABLE 4. Hazard ratios* for total cancer incidence according to type of physical activity ($n = 79,771$), Japan Public Health Center-based Prospective Study, 1995–2004

	No. of subjects	Person-years of follow-up	Total			Excluding cases diagnosed within the first 3 years		
			No. of cases	HR†	95% CI†	No. of cases	HR	95% CI
Men ($n = 37,898$)								
Heavy physical work or strenuous exercise (hours/day)								
None	22,235	161,694	1,670	1.00	Reference	1,093	1.00	Reference
<1	5,165	38,119	324	0.95	0.84, 1.07	229	1.02	0.88, 1.18
≥1	10,498	79,918	710	0.89	0.81, 0.98	482	0.89	0.80, 1.00
p for trend					0.014			0.071
Standing or walking (hours/day)								
<1	8,243	59,839	564	1.00	Reference	369	1.00	Reference
1–<3	9,143	65,023	649	1.04	0.92, 1.17	425	1.04	0.90, 1.21
≥3	20,512	154,869	1,491	0.99	0.89, 1.11	1,010	0.99	0.87, 1.13
p for trend					0.787			0.764
Sitting (hours/day)								
<3	17,251	128,076	1,230	1.00	Reference	821	1.00	Reference
3–<8	17,472	128,067	1,247	0.97	0.89, 1.06	835	0.97	0.88, 1.08
≥8	3,175	23,588	227	1.02	0.87, 1.18	148	0.97	0.80, 1.16
p for trend					0.839			0.599
Leisure-time sports or physical exercise (days/week)								
<1	29,656	220,754	2,118	1.00	Reference	1,434	1.00	Reference
1–2	4,095	30,011	240	0.92	0.80, 1.05	155	0.87	0.74, 1.03
≥3–4	4,147	28,965	346	1.12	0.998, 1.26	215	1.09	0.94, 1.26
p for trend					0.158			0.519
Women ($n = 41,873$)								
Heavy physical work or strenuous exercise (hours/day)								
None	31,286	238,962	1,266	1.00	Reference	832	1.00	Reference
<1	4,097	30,583	138	0.91	0.76, 1.09	89	0.90	0.72, 1.12
≥1	6,490	49,840	226	0.93	0.80, 1.07	135	0.84	0.70, 1.01
p for trend					0.200			0.043
Standing or walking (hours/day)								
<1	6,077	45,688	259	1.00	Reference	164	1.00	Reference
1–<3	9,828	73,552	410	1.00	0.85, 1.18	266	1.02	0.84, 1.25
≥3	25,968	200,146	961	0.89	0.77, 1.04	626	0.90	0.75, 1.09
p for trend					0.054			0.128
Sitting (hours/day)								
<3	18,981	144,501	724	1.00	Reference	463	1.00	Reference
3–<8	20,184	153,659	785	0.98	0.88, 1.09	509	0.97	0.85, 1.11
≥8	2,708	21,226	121	1.05	0.86, 1.29	84	1.10	0.86, 1.41
p for trend					0.896			0.748
Leisure-time sports or physical exercise (days/week)								
<1	32,942	254,570	1,315	1.00	Reference	846	1.00	Reference
1–2	4,338	31,712	136	0.91	0.76, 1.09	85	0.91	0.73, 1.15
≥3–4	4,593	33,104	179	1.05	0.89, 1.23	125	1.20	0.99, 1.45
p for trend					0.883			0.160

* The model included age (stratified, 5-year categories), area (stratified, 10 public health center areas), total energy intake (stratified, quintiles), history of diabetes (no, yes), smoking status (never smoking, past smoking, or 1–19, 20–29, or ≥30 cigarettes/day), alcohol intake status (almost none, occasional, regular), body mass index (weight (kg)/height (m)^2; <20, 20–<27, or ≥27), heavy physical work or strenuous exercise (none, <1 hour, or ≥1 hour/day), sitting (<3, 3–<8, or ≥8 hours/day), standing or walking (<1, 1–<3, or ≥3 hours/day), and leisure-time sports or physical exercise (<1, 1–2, or ≥3–4 days/week).

† HR, hazard ratio; CI, confidence interval.

TABLE 5. Hazard ratios for incidence of cancer at specific sites according to daily total physical activity level (n = 79,771), Japan Public Health Center-based Prospective Study, 1995–2004

Site (*International Classification of Diseases for Oncology*, Third Edition, code)	Quartile of physical activity level (quartile of METs*/day score)	No. of subjects	Person-years of follow-up	No. of cases	Hazard ratio†	95% confidence interval
Men (n = 37,898)						
Stomach (C16)	Lowest	12,966	92,421	194	1.00	Reference
	Second	7,822	57,957	134	1.10	0.88, 1.37
	Third	7,579	56,512	136	1.10	0.88, 1.37
	Highest	9,531	72,841	157	1.04	0.84, 1.29
	p for trend					0.785
Colon (C18)	Lowest	12,966	92,421	131	1.00	Reference
	Second	7,822	57,957	72	0.83	0.62, 1.11
	Third	7,579	56,512	59	0.65	0.48, 0.89
	Highest	9,531	72,841	66	0.58	0.43, 0.79
	p for trend					<0.001
Rectum (C19–20)	Lowest	12,966	92,421	51	1.00	Reference
	Second	7,822	57,957	41	1.30	0.85, 1.97
	Third	7,579	56,512	35	1.11	0.72, 1.72
	Highest	9,531	72,841	35	0.88	0.57, 1.36
	p for trend					0.464
Liver (C22)	Lowest	12,966	92,421	82	1.00	Reference
	Second	7,822	57,957	32	0.69	0.45, 1.06
	Third	7,579	56,512	44	1.01	0.69, 1.49
	Highest	9,531	72,841	31	0.62	0.40, 0.96
	p for trend					0.062
Pancreas (C25)	Lowest	12,966	92,421	36	1.00	Reference
	Second	7,822	57,957	20	0.90	0.52, 1.57
	Third	7,579	56,512	15	0.67	0.36, 1.24
	Highest	9,531	72,841	16	0.55	0.30, 1.00
	p for trend					0.038
Lung (C34)	Lowest	12,966	92,421	108	1.00	Reference
	Second	7,822	57,957	81	1.22	0.91, 1.63
	Third	7,579	56,512	103	1.44	1.09, 1.90
	Highest	9,531	72,841	96	1.10	0.83, 1.45
	p for trend					0.494
Prostate (C61)	Lowest	12,966	92,421	77	1.00	Reference
	Second	7,822	57,957	68	1.39	1.00, 1.94
	Third	7,579	56,512	63	1.21	0.86, 1.69
	Highest	9,531	72,841	71	1.13	0.82, 1.57
	p for trend					0.644

Table continues

score were 25.45, 31.85, 34.25, and 42.65, respectively, in men and 26.10, 31.85, 34.25, and 42.65, respectively, in women. Men who were more physically active were more likely to report regular drinking, a higher frequency of leisure-time sports or physical exercise, and higher daily mean energy consumption and were less likely to report a history of diabetes mellitus and liver disease. No difference in body mass index was observed between groups by physical activity level. In women, similar trends were observed, except that the differences in the proportion of regular drinkers were not significant.

Associations between daily total physical activity level by total METs/day score and total cancer incidence are shown

TABLE 5. Continued

Site (*International Classification of Diseases for Oncology*, Third Edition, code)	Quartile of physical activity level (quartile of METs/day score)	No. of subjects	Person-years of follow-up	No. of cases	Hazard ratio†	95% confidence interval
Women (n = 41,873)						
Stomach (C16)	Lowest	13,277	99,385	91	1.00	Reference
	Second	10,838	83,644	53	0.74	0.52, 1.04
	Third	9,663	74,073	54	0.78	0.55, 1.10
	Highest	8,095	62,284	34	0.63	0.42, 0.94
	p for trend					0.020
Colon (C18)	Lowest	13,277	99,385	83	1.00	Reference
	Second	10,838	83,644	58	0.87	0.62, 1.22
	Third	9,663	74,073	48	0.74	0.52, 1.07
	Highest	8,095	62,284	39	0.82	0.56, 1.21
	p for trend					0.198
Rectum (C19–20)	Lowest	13,277	99,385	24	1.00	Reference
	Second	10,838	83,644	24	1.26	0.71, 2.23
	Third	9,663	74,073	16	1.05	0.55, 2.00
	Highest	8,095	62,284	22	1.79	0.99, 3.23
	p for trend					0.077
Liver (C22)	Lowest	13,277	99,385	29	1.00	Reference
	Second	10,838	83,644	19	0.96	0.52, 1.78
	Third	9,663	74,073	19	0.99	0.53, 1.84
	Highest	8,095	62,284	7	0.54	0.23, 1.29
	p for trend					0.248
Pancreas (C25)	Lowest	13,277	99,385	19	1.00	Reference
	Second	10,838	83,644	15	0.98	0.50, 1.95
	Third	9,663	74,073	11	0.83	0.39, 1.76
	Highest	8,095	62,284	13	1.29	0.62, 2.67
	p for trend					0.601
Lung (C34)	Lowest	13,277	99,385	50	1.00	Reference
	Second	10,838	83,644	37	0.90	0.58, 1.38
	Third	9,663	74,073	31	0.90	0.57, 1.42
	Highest	8,095	62,284	26	0.92	0.56, 1.49
	p for trend					0.686
Breast (C50)	Lowest	13,277	99,385	85	1.00	Reference
	Second	10,838	83,644	91	1.24	0.92, 1.66
	Third	9,663	74,073	67	1.02	0.74, 1.40
	Highest	8,095	62,284	51	0.91	0.64, 1.29
	p for trend					0.529

* METs, metabolic equivalents.

† Adjusted for age (stratified, 5-year categories), area (stratified, 10 public health center areas), total energy intake (stratified, quintiles), history of diabetes (no, yes), smoking status (never smoker, past smoker, or 1–19, 20–29, or ≥30 cigarettes/day), alcohol intake status (almost none, occasional, or regular), body mass index (weight (kg)/height (m)^2; <20, 20–<27, or ≥27), and leisure-time sports or physical exercise (<1, 1–2, or ≥3–4 days/week).

in table 2. Upon multivariate adjustment, compared with subjects in the lowest quartile, increased daily total physical activity was significantly associated with a decreased risk of cancer incidence in both men and women. In men, hazard ratios in the second, third, and highest quartiles were 1.00 (95 percent confidence interval (CI): 0.90, 1.11), 0.96 (95 percent CI: 0.86, 1.07), and 0.87 (95 percent CI: 0.78, 0.96), respectively (p for trend = 0.005); in women, they were 0.93

(95 percent CI: 0.82, 1.05), 0.84 (95 percent CI: 0.73, 0.96), and 0.84 (95 percent CI: 0.73, 0.97), respectively (p for trend = 0.007). Our estimates also showed that the risk decreased by 7 percent in men and 10 percent in women with each 10-MET/day increase in physical activity level. The results did not differ substantially after exclusion of early cancer cases—those occurring within 3 years of the starting point—or after further exclusion of subjects with very low physical activity levels (<23 METs/day; 2 percent of subjects), considered to result from poor physical condition. On further estimation of the population attributable fraction (18) from our results, 4.5 percent of cases in men and 5.5 percent of cases in women were considered to have been preventable if the persons in the lowest physical activity category had increased their activity to a higher level.

In both sexes, the degree of risk decrease was attenuated among persons with increasing body mass index. In contrast, it was strengthened among the elderly and among persons who regularly engaged in leisure-time sports or physical exercise; this relation appeared more clearly in women. No significant interaction was observed for age, obesity status, or frequency of leisure-time sports and physical exercise (table 3). No particularly significant associations were identified in analysis by type of physical activity (table 4).

Results from analyses of specific cancer sites are shown in table 5. Significantly decreased risks were observed for colon, liver, and pancreatic cancer in men and for stomach cancer in women. In additional analyses for these cancers stratified by age, body mass index, and frequency of leisure-time sports or physical exercise, larger risk reductions were observed in persons with a lower body mass index, persons with frequent leisure-time sports or physical exercise, and the elderly for female stomach cancer and in persons with lower body mass index and persons with infrequent leisure-time sports or physical exercise for male colon cancer. For male liver and pancreatic cancers, we did not detect any significant difference or tendency in risk between stratified groups. In the analysis of breast cancer, the null association was not influenced by menopausal status.

DISCUSSION

The health benefits of physical activity are well established for certain cancer sites (1, 19), but the extent to which the grand sum of these effects influences total cancer incidence has not been clarified. Of course, any such association depends to some degree on the background population, namely the site distribution of cancers which are strongly or weakly associated with physical activity. According to recent statistics, in Japan the cancer sites with the highest incidence rates are the stomach, followed by the lung, colon, liver, and prostate, for men and the breast, followed by the stomach, colon, uterus, and lung, for women (20). In this large-scale, population-based cohort study of Japanese men and women, we found a significant inverse association between daily total physical activity level and total cancer incidence. To reduce the potential for spurious associations from reverse causation, we excluded all subjects with a history of cancer at the starting point. Moreover, exclusion of early cases (those occurring within 3 years of the starting point) had no substantial effect on the results.

To our knowledge, only two studies have assessed the association between physical activity and total risk of cancer (2, 3); both were carried out in relatively small populations. One, which targeted men only, observed a reduced risk with increased physical activity (2), while the second observed an increased risk with increased nonrecreational physical inactivity (3). Our findings, obtained with a substantially larger sample, accord with those of these previous studies.

Our results showed basically similar risk reductions in men and women. Shephard and Shek (21) suggested that differences between the sexes in benefits associated with regular physical activity are due to the difference in hormonal conditions, which may lead to the failure to adapt activity questionnaires to traditional patterns of physical activity in females. Methodologically, it is commonly noted that men are more likely to be physically active in their jobs and women are more likely to be involved in housework (22). In our questionnaire, rank correlation coefficients for correlation with the 24-hour physical activity record were higher in men than in women. This may have partly resulted from the failure of our questionnaire to suitably account for housework. This type of measurement error may have led to underestimation of the association. Nevertheless, in the present study, a stronger effect of total physical activity among persons who engaged in regular leisure-time sports or physical exercise than among those who did not appears to have been more clearly observed in women. The larger proportion of strenuous work as a fraction of total physical activity in men than in women may be one reason for this discrepancy between men and women.

Our findings also showed that the effect of physical activity was diminished among subjects with a high body mass index, which is accordant with a previous report (3). To a substantial degree, physical activity may affect the risk of cancer by reducing weight and body mass index. We therefore suggest that the effect of physical activity appears less clear in persons with a high body mass index.

By site, our results showed inverse associations for colon, liver, and pancreatic cancer in men and for stomach cancer in women. In our population, we observed a positive association with a high body mass index for colon cancer only (23) and little association for pancreatic cancer (24). A recent evaluation found no association for stomach or liver cancer (1). In addition, nonalcoholic fatty liver disease, an increasingly recognized cause of chronic liver disease across the world, appears to be most strongly associated with central obesity and insulin resistance, and hepatocellular carcinoma has been postulated to arise through the development and progression of nonalcoholic fatty liver disease (25, 26). In the Japanese population, however, most cases of hepatocellular carcinoma are associated with hepatitis virus infection, and attribution to other factors may be small. Therefore, the effect of physical activity on these cancers, if any, appears to be operating not only via any improvement in obesity and related factors but also via other mechanisms.

Discussions on the possible mechanisms by which physical activity protects against cancer remain inconclusive. Various mechanisms have been plausibly associated with various cancers, such as alterations in sex hormones or insulin and

insulin-like growth factors, immune modulation, alterations in free radical generation, changes in body fatness, and direct effects on cancer (1, 19, 27–32). Hyperinsulinemia produces an increase in circulating insulin-like growth factor 1, which is thought to play a major role in promoting carcinogenesis, and a decrease in insulin-like growth factor-binding proteins (33). Exercise increases insulin sensitivity and decreases fasting insulin and C-peptide levels (34), which may improve insulin resistance. Exercise-induced changes in the activity of macrophages, natural killer cells, lymphokine-activated killer cells, neutrophils, and regulating cytokines suggest that immunomodulation may contribute to the protective value of exercise (35). Strenuous physical exercise enhances oxygen free radical production, and the increased number of reactive oxygen species that are generated potentially results in damage to lipids, protein, and DNA. The antioxidant defense systems have co-evolved to counteract oxidative damage from oxygen free radicals (24, 36, 37). Moderate physical activity may be of benefit as a means of slowing or stopping the loss of antioxidants, whereas severe exercise might overwhelm the antioxidant system, potentially leading to damage and increased cell mutagenesis (37). Other mechanisms include a decrease in gut transit time, which has beneficial effects on bile content and secretion (1, 38), and have been proposed by site (1).

The major strength of the present study was its prospective design, which enabled us to avoid exposure recall bias. Study subjects were selected from the general population, the sample was large, the response rate to the questionnaire (81 percent) was acceptable for study settings such as this, and the loss to follow-up (0.3 percent) was negligible. Further, the number of exclusions due to missing data on physical activity (7 percent) was not particularly large. Although a difference in the characteristics of subjects with and without missing information had the potential to influence the results, no such difference was seen. In addition, the cancer registry in the study population was of sufficient quality to reduce the possibility of misclassification of the outcome.

In addition to those mentioned above, however, several methodological limitations can be identified. In particular, since assessment of physical activity was based on self-reports, misclassification may have been unavoidable. Nevertheless, because the data were collected before diagnosis, any imprecision is likely to have resulted in underestimation of the association. Changes in physical activity over time may also have caused misclassification, which might have led to underestimation of the association. In addition, some types of cancers or health conditions related to them may have caused low levels of physical activity from the starting point of the study; therefore, we cannot deny the possibility of spurious associations. Further, although adjustment was made for lifestyle factors possibly associated with cancer, unmeasured confounders may not have been controlled. Finally, our results may not be generalizable to populations with a different general lifestyle or a different degree of leanness from the Japanese.

Allowing for these methodological issues, our results suggest that increased daily total physical activity may be beneficial in preventing the development of cancer among Japanese men and women, who are characterized as relatively lean. Further research on the generalizability of our results to other relatively lean populations is warranted.

ACKNOWLEDGMENTS

This study was supported by a Grant-in-Aid for Cancer Research, a Health and Labour Sciences Research Grant for Research on Hepatitis, and a Health and Labour Sciences Research Grant for the Third Term Comprehensive Control Research for Cancer (Ministry of Health, Labour and Welfare of Japan).

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Conflict of interest: none declared.

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APPENDIX

Questions related to physical activity in the 5-year follow-up survey of the Japan Public Health Center-based Prospective Study:

How long on average do you engage in the following activities each day?

Heavy physical work or strenuous exercise	None	<1 hour	≥1 hour
Sitting	<3 hours	3–<8 hours	≥8 hours
Standing or walking	<1 hour	1–<3 hours	≥3 hours

How often do you participate in sports or physical exercise?

Almost never	≤1–3 days a month	1–2 days a week	3–4 days a week	Almost every day

論文名	Daily total physical activity level and total cancer risk in men and women: results from a large-scale population-based cohort study in Japan
著 者	Inoue M, Yamamoto S, Kurahashi N, Iwasaki M, Sasazuki S, Tsugane S
雑誌名	Am J Epidemiol
巻・号・頁	168 391-403
発行年	2008
PubMedリンク	http://www.ncbi.nlm.nih.gov/pubmed/18599492

対象の内訳	ヒト	動物	地 域	国内	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	45-74歳	[redacted]		( )		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	な し	ガン予防	な し	( )	( )
アウトカム 維持・改善	な し	な し	な し	な し	( )	( )

図 表

TABLE 2. Hazard ratios for total cancer incidence according to daily total physical activity level (n = 79,771), Japan Public Health Center-based Prospective Study, 1995–2004

Quartile of physical activity level (quartile of METs*/day score)	No. of subjects	Person-years of follow-up	Total					Excluding cases diagnosed within first 3 years				
			No. of cases	HR1*,†	95% CI*	HR2‡	95% CI	No. of cases	HR1	95% CI	HR2	95% CI
Men (n = 37,898)					(n = 2,704)					(n = 1,804)		
Lowest	12,966	92,421	921	1.00	Reference	1.00	Reference	604	1.00	Reference	1.00	Reference
Second	7,822	57,957	575	1.00	0.90, 1.10	1.00	0.90, 1.11	381	0.98	0.86, 1.11	0.98	0.86, 1.11
Third	7,579	56,512	574	0.96	0.86, 1.06	0.96	0.86, 1.07	386	0.95	0.83, 1.08	0.95	0.83, 1.08
Highest	9,531	72,841	634	0.87	0.79, 0.96	0.87	0.78, 0.96	433	0.86	0.76, 0.97	0.86	0.76, 0.98
p for trend					0.006		0.005			0.015		0.017
Per 1-MET increase				0.99	0.99, 0.998	0.99	0.99, 0.998		0.99	0.99, 0.999	0.99	0.99, 0.999
Per 10-MET increase				0.93	0.88, 0.99	0.93	0.88, 0.99		0.93	0.87, 0.996	0.93	0.87, 0.997
Women (n = 41,873)					(n = 1,630)					(n = 1,056)		
Lowest	13,277	99,385	569	1.00	Reference	1.00	Reference	368	1.00	Reference	1.00	Reference
Second	10,838	83,644	426	0.92	0.81, 1.04	0.93	0.82, 1.05	290	0.94	0.81, 1.10	0.94	0.81, 1.10
Third	9,663	74,073	350	0.84	0.73, 0.96	0.84	0.73, 0.96	222	0.80	0.68, 0.95	0.79	0.67, 0.94
Highest	8,095	62,284	283	0.83	0.72, 0.96	0.84	0.73, 0.97	176	0.78	0.65, 0.93	0.78	0.65, 0.94
p for trend					0.004		0.007			0.002		0.002
Per 1-MET increase				0.99	0.98, 0.997	0.99	0.98, 0.997		0.98	0.97, 0.995	0.98	0.97, 0.995
Per 10-MET increase				0.89	0.82, 0.97	0.90	0.82, 0.98		0.85	0.77, 0.95	0.85	0.77, 0.95

* MET(s), metabolic equivalent(s); HR, hazard ratio; CI, confidence interval.
† Adjusted for age (stratified, 5-year categories) and area (stratified, 10 public health center areas).
‡ Adjusted for age (stratified, 5-year categories), area (stratified, 10 public health center areas), total energy intake (stratified, quintiles), history of diabetes (no, yes), smoking status (never smoking, past smoking, or 1–19, 20–29, or ≥30 cigarettes/day), alcohol intake status (almost none, occasional, or regular), body mass index (weight (kg)/height (m)^2; <20, 20–<27, or ≥27), and leisure-time sports or physical exercise (<1, 1–2, or ≥3–4 days/week).

図表掲載箇所	P393, Table2
概 要 (800字まで)	本研究は、日本のThe Japan Public Health Center-based Prospective Studyに参加した男女79,771名を対象に平均7.5年間の追跡調査を行い、総身体活動量とがん発症リスクとの関連を検討したものである。質問紙によって、一日当たりの身体活動量を次の3つの項目について尋ねた。1)きつい肉体労働または激しい運動を行った時間、2)座位時間、3)立位または歩行時間。それぞれの活動をメッツ値に換算し、時間で乗じ、一日当たりの身体活動量をメッツ時/日で算出した後、少ない順に4分位に分類した。身体活動量の最も低い集団と比較すると、女性では、3番目に低い集団、最も高い集団で全がん発症リスクが0.79(95%信頼区間:0.67-0.94)、0.78(0.65-0.94)と有意に低下した。男性では、最も高い集団でのみ0.86(0.76-0.98)と有意に低下した。男女共にリスクの減少は量反応的に有意であった(Ptrend=0.017(男性)、0.002(女性))。また、60歳以上の女性においては、すべての分位において全がん発症リスクが有意に減少した(Ptrend=0.001)。座位時間の延長によるがん発症リスクには男女とも有意な差はみられなかった。部位別のがん発症リスクに関しては、男性で大腸がんと肝臓がんに
結 論 (200字まで)	日本人大規模コホートにおいて、身体活動量と全がん発症リスクには負の相関があり、特に高齢の女性においてその傾向が強いことが明らかとなった。部位別にみると、身体活動量が多いほど、男性で大腸がんと肝臓がん、女性で胃がんの発症リスクが有意に低下す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使用された研究である。我が国の多くの参加者を対象としたことと、ガン発症の部位別に身体活動の効果を検証した点が極めて意義深い。

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Sitting Time and Mortality from All Causes, Cardiovascular Disease, and Cancer

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ABSTRACT

KATZMARZYK, P. T., T. S. CHURCH, C. L. CRAIG, and C. BOUCHARD. Sitting Time and Mortality from All Causes, Cardiovascular Disease, and Cancer. *Med. Sci. Sports Exerc.*, Vol. 41, No. 5, pp. 998–1005, 2009. **Purpose:** Although moderate-to-vigorous physical activity is related to premature mortality, the relationship between sedentary behaviors and mortality has not been fully explored and may represent a different paradigm than that associated with lack of exercise. We prospectively examined sitting time and mortality in a representative sample of 17,013 Canadians 18–90 yr of age. **Methods:** Evaluation of daily sitting time (almost none of the time, one fourth of the time, half of the time, three fourths of the time, almost all of the time), leisure time physical activity, smoking status, and alcohol consumption was conducted at baseline. Participants were followed prospectively for an average of 12.0 yr for the ascertainment of mortality status. **Results:** There were 1832 deaths (759 of cardiovascular disease (CVD) and 547 of cancer) during 204,732 person-yr of follow-up. After adjustment for potential confounders, there was a progressively higher risk of mortality across higher levels of sitting time from all causes (hazard ratios (HR): 1.00, 1.00, 1.11, 1.36, 1.54; *P* for trend <0.0001) and CVD (HR: 1.00, 1.01, 1.22, 1.47, 1.54; *P* for trend <0.0001) but not cancer. Similar results were obtained when stratified by sex, age, smoking status, and body mass index. Age-adjusted all-cause mortality rates per 10,000 person-yr of follow-up were 87, 86, 105, 130, and 161 (*P* for trend <0.0001) in physically inactive participants and 75, 69, 76, 98, 105 (*P* for trend = 0.008) in active participants across sitting time categories. **Conclusions:** These data demonstrate a dose–response association between sitting time and mortality from all causes and CVD, independent of leisure time physical activity. In addition to the promotion of moderate-to-vigorous physical activity and a healthy weight, physicians should discourage sitting for extended periods. **Key Words:** PHYSICAL ACTIVITY, SEDENTARY BEHAVIOR, COHORT, DEATH, SURVIVAL

Current public health recommendations for physical activity focus on accumulating adequate levels of moderate and vigorous physical activity. For example, the most recent recommendations from the American Heart Association and the American College of Sports Medicine call for a minimum of 30 min of moderate-intensity physical activity 5 $d \cdot wk^{-1}$ or 20 min of vigorous-intensity physical activity 3 $d \cdot wk^{-1}$ (12). These recommendations are based on a large body of evidence linking a physically active lifestyle to lower rates of morbidity and mortality (18,22,27).

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Submitted for publication July 2008.
Accepted for publication October 2008.

0195-9131/09/4105-0998/0
MEDICINE & SCIENCE IN SPORTS & EXERCISE®

DOI: 10.1249/MSS.0b013e3181930355

Although there is good evidence that higher levels of moderate-to-vigorous physical activity lead to substantial health benefits, there is increasing interest in identifying the health risks associated with sedentary behaviors (9,10, 14,26). Sedentary pursuits represent a unique aspect of human behavior and should not be viewed as simply the extreme low end of the physical activity level continuum. For example, several studies have demonstrated excess television viewing time, independent from overall physical activity levels, to be adversely associated with metabolic risk factors (10). The effects of extended periods of sedentary behavior in otherwise physically active individuals have begun to be delineated, and they seem to be characterized by metabolic alterations commonly seen in diabetogenic and atherogenic profiles (2,10,13).

A recent study using data from the 2003–2004 National Health and Nutrition Examination Survey has reported that children and adults in the United States spend an average of 55% of their waking day in sedentary pursuits (21). Many common forms of sedentary behavior involve sitting. For example, riding in a car, working at a desk, eating a meal at

a table, playing video games, using a computer, and watching television are all activities that are generally performed in the seated position. Given the ubiquitous nature of sitting in modern society, it is important to determine whether it has any associated adverse health effects. Thus, the purpose of this study was to determine the relationship between sitting time in main activities (work, school, housework, etc.) and mortality rates from all causes, cardiovascular disease, and cancer. It is of particular importance to gain insight into the risk associated with excessive sitting in individuals who meet the physically active recommendations yet sit for most of the day. Should excessive sitting carry health risks that are independent of physical activity levels then future physical activity guidelines may need to include recommendations addressing daily sitting time.

METHODS

Study population. The sample included 7278 men and 9735 women 18–90 yr of age, who participated in the 1981 Canada Fitness Survey (CFS). The CFS was based on a representative sample of the Canadian population, including individuals from urban and rural areas of every province. Approximately 3% of the total population was excluded, including aboriginal people living on reserves, institutionalized persons, armed forces personnel living on bases, and residents of the Territories and remote areas. Participants were given an explanation of the study protocol, and informed consent was obtained before participation. All protocols were reviewed and approved by a panel of experts working in the field of exercise science at the time of the baseline survey.

Exposure assessment. Baseline data were collected in 1981 during household visits, which consisted of the administration of a detailed lifestyle questionnaire and an extensive battery of physical fitness and anthropometric measurements (6). The amount of time participants spent sitting during work, school, and housework was obtained from the lifestyle questionnaire. Participants were asked to indicate the amount of time they spent sitting during the course of most days of the week as either 1) almost none of the time, 2) approximately one fourth of the time, 3) approximately half of the time, 4) approximately three fourths of the time, or 5) almost all of the time.

Age was determined from birth and observation dates and coded as a continuous variable. The smoking status of participants was coded as nonsmokers, former smokers, or current smokers, whereas alcohol consumption was categorized on the basis of average intake and frequency of consumption (abstainer, <10 drinks per month, 10–50 drinks per month, >50 drinks per month). Leisure time physical activity levels were calculated in MET-hours per week by summing the products of the metabolic costs of each activity, its duration, and the average occasions per week across a 12-month recall period (4). The leisure time physical activity questionnaire collects information primarily on 20 leisure time physical activities, 19 of which have MET values of 3.0 or greater. The one activity was included on the list with a MET value below 3.0 was yoga, with an associated MET value of 2.5 (1). Because of the significant skewness of the original leisure time physical activity variable, the natural logarithm was used in all regression analyses. Participants were dichotomized into physically active and inactive groups using a threshold of 7.5 $MET \cdot h \cdot wk^{-1}$, which corresponds to the minimum current physical activity recommendations (moderate activity, 3 METs for 30 min on 5 $d \cdot wk^{-1}$ = 3.0 METs × 2.5 h = 7.5 $MET \cdot h \cdot wk^{-1}$) (12). Information on conditions such as cardiovascular disease, cancer, and diabetes was not available at baseline. However, to account for possible reverse causation, data from the Physical Activity Readiness Questionnaire (PAR-Q) was included as a covariate (pass/fail/missing). The PAR-Q asks several questions regarding heart trouble, chest pain, high blood pressure, dizzy spells, joint problems, and other problems that may prevent participants from participating in physical activities (3). A positive response to any question results in a failure of the PAR-Q. Finally, the body mass index (BMI) was calculated from measured height and weight ($kg \cdot m^{-2}$), and participants were grouped into three categories (<25, 25–29.9, and ≥30 $kg \cdot m^{-2}$). Direct measurements of BMI were taken on a subsample of 10,477 participants.

Ascertainment of mortality. The CFS database was linked to the Canadian Mortality Database (CMDB) at Statistics Canada. The CMDB contains all recorded deaths in Canada since 1950 and is regularly updated using death registrations supplied by every province and territory. Record linkage was performed using computerized probabilistic techniques, and the potential for death linkages to be missed using the method used by Statistics Canada is quite small (24,25). All deaths occurring from the end of CFS data collection (1981) through December 31, 1993, were included in the present analysis. A total of 1832 deaths occurred during an average of 12.0 (SD 2.1) yr of follow-up.

Statistical analyses. All data management and statistical analyses were conducted using SAS software version 9.1 (SAS, Inc., Cary, NC). Descriptive statistics were used to summarize the baseline characteristics of the sample of men and women by survival status and across sitting time categories. Continuous variables were compared using Student's *t*-tests and ANOVA, whereas categorical variables were compared using chi-square for comparison by survival status. Kaplan–Meier survival curves were plotted to examine differences in cumulative survival across categories of daily sitting time and differences were compared with log-rank statistics. Age-adjusted all-cause mortality rates per 10,000 person-yr of follow-up were computed across categories of daily sitting time.

Cox proportional hazard models were used to estimate the hazard ratios and 95% confidence intervals (CI) for all-cause, cardiovascular disease (*ICD-9* codes 390–449),

TABLE 1. Descriptive characteristics by vital status [mean (SD)] at baseline in 17,013 men and women from the Canada fitness survey.

Characteristic	Men		Women	
	Survivors	Decedents	Survivors	Decedents
N	6327	951	8854	881
Follow-up time (yr)	12.7 (0.1)	6.6 (3.6)*	12.7 (0.1)	7.1 (3.4)*
Age (yr)	38.6 (15.3)	64.3 (14.1)*	39.7 (15.9)	66.1(14.6)*
Age group (%)				
18–59 yr	87.8	29.3*	85.6	25.9*
>60 yr	12.2	70.7	14.4	74.1
Physical activity ($MET \cdot h \cdot wk^{-1}$)	13.1 (15.6)	11.0 (14.6)*	10.5 (13.3)	7.8 (11.6)*
Physical activity level (%)				
<7.5 $MET \cdot h \cdot wk^{-1}$	50.2	56.7*	56.5	65.7*
≥7.5 $MET \cdot h \cdot wk^{-1}$	49.8	43.3	43.5	34.3
Body mass index[a] ($kg \cdot m^{-2}$)	25.0 (3.6)	25.8 (3.9)*	23.6 (4.2)	26.0 (5.0)*
Body mass index category[a] (%)				
<25 $kg \cdot m^{-2}$	53.2	40.8*	71.1	45.6*
25–29.9 $kg \cdot m^{-2}$	38.5	48.6	20.9	34.2
≥30 $kg \cdot m^{-2}$	8.3	10.6	8.0	20.3
Smoking status (%)				
Nonsmoker	30.5	19.7*	47.4	60.1*
Former smoker	24.6	33.7	15.8	11.8
Current smoker	44.9	46.6	36.9	28.1
Alcohol consumption (%)				
Abstainer	14.1	28.7*	28.2	58.8*
<10 drinks per month	29.7	28.8	45.4	27.5
10–50 drinks per month	43.5	31.4	24.2	12.2
>50 drinks per month	12.6	11.1	2.2	1.5
Daily sitting (%)				
Almost none of the time	19.9	12.9*	17.6	9.4*
One fourth of the time	35.9	33.2	42.4	34.5
Half of the time	25.6	28.1	25.0	31.2
Three fourths of the time	14.0	17.0	10.7	16.2
Almost all of the time	4.5	8.7	4.3	8.6

[a] n = 10,477 (558 deaths).
* $P < 0.05$ compared with survivors within sex.

cancer (*ICD-9* codes 140–239) and other (all other *ICD-9* codes) mortality across categories of daily sitting time. All models included age as a covariate (as a continuous variable), and multivariate models were constructed that also included the effects of leisure time physical activity (as a continuous variable), smoking status, alcohol consumption, and PAR-Q. Differences in the results according to sex, activity level, BMI category, and age group were assessed using stratified analyses. Tests of linear trends in mortality rates were conducted using ordinal scaling across categories of daily sitting time. The proportional hazards assumption was examined by comparing plots of the cumulative hazard functions across exposure categories. No appreciable violations in the assumption were found. To minimize the potential confounding effects of occult disease at baseline, the analyses were repeated after eliminating all deaths that occurred during the first year of follow-up.

RESULTS

During the maximum follow-up interval of 12.9 yr, there were 951 deaths in men and 881 deaths in women. A total of 86,416 and 118,316 person-yr of follow-up were accumulated in men and women, respectively. There were 759 deaths from cardiovascular disease, 547 deaths from cancer, and 526 deaths from "other" causes (respiratory diseases, 26%; injuries and violence, 24%; mental and nervous system disorders, 13%; digestive system disorders, 13%; others, 14%). The mean age of the sample at baseline was 42.0 (SD, 17.5) yr. Table 1 provides the descriptive baseline characteristics of the sample according to their vital status at follow-up, and Table 2 provides the baseline characteristics across levels of daily sitting time. Compared with survivors, decedents were significantly older, had a higher BMI, and were less physically active. Survival curves

TABLE 2. Descriptive characteristics by daily sitting time [mean (SD)] at baseline in 17,013 men and women from the Canada fitness survey.

Characteristic	All	Daily Sitting Time				
		Almost None the Time	One Fourth of the Time	Half of the Time	Three Fourths of the Time	Almost All the Time
N	17,013	3022	6652	4379	2138	822
Follow-up time (yr)	12.0 (2.1)	12.3 (1.8)	12.2 (1.9)	12.0 (2.2)	11.8 (2.6)	11.3 (3.3)*
Age (yr)	42.0 (17.5)	39.5 (14.8)	42.4 (16.9)	43.0 (18.6)	41.6 (19.0)	44.1 (20.2)*
Age group (%)						
18–59 yr	80.2	88.5	80.3	76.3	78.6	73.8*
>60 yr	19.8	11.5	19.8	23.7	21.4	26.2
Physical activity ($MET \cdot h \cdot wk^{-1}$)	11.4 (14.3)	11.5 (14.1)	11.9 (14.5)	11.6 (14.7)	10.3 (13.8)	8.2 (12.1)*
Physical activity level (%)						
<7.5 $MET \cdot h \cdot wk^{-1}$	54.7	54.0	52.2	54.1	60.2	65.7*
≥7.5 $MET \cdot h \cdot wk^{-1}$	45.4	46.0	47.8	46.0	39.8	34.3
Body mass index[a] ($kg \cdot m^{-2}$)	24.3 (4.0)	24.3 (4.0)	24.4 (4.0)	24.4 (4.1)	24.1 (4.0)	24.4 (4.5)
Body mass index category[a] (%)						
<25 $kg \cdot m^{-2}$	76.5	76.5	75.6	76.7	77.3	81.4*
25–29.9 $kg \cdot m^{-2}$	18.2	18.3	18.6	18.2	18.7	13.8
≥30 $kg \cdot m^{-2}$	5.2	5.1	5.8	5.1	4.0	4.9
Smoking status (%)						
Nonsmoker	40.2	38.9	41.1	41.3	38.6	36.4*
Former smoker	19.8	19.8	19.6	19.9	20.1	18.9
Current smoker	40.0	41.3	39.4	38.8	40.4	44.7
Alcohol consumption (%)						
Abstainer	24.7	26.0	24.4	23.9	23.5	29.3*
<10 drinks per month	37.8	37.5	40.2	36.5	35.4	32.4
10–50 drinks per month	31.1	29.2	29.6	33.0	34.4	31.8
>50 drinks per month	6.5	7.4	5.9	6.6	6.7	6.6

[a] n = 10,477 (558 deaths).
* $P < 0.05$ across categories of daily sitting time.

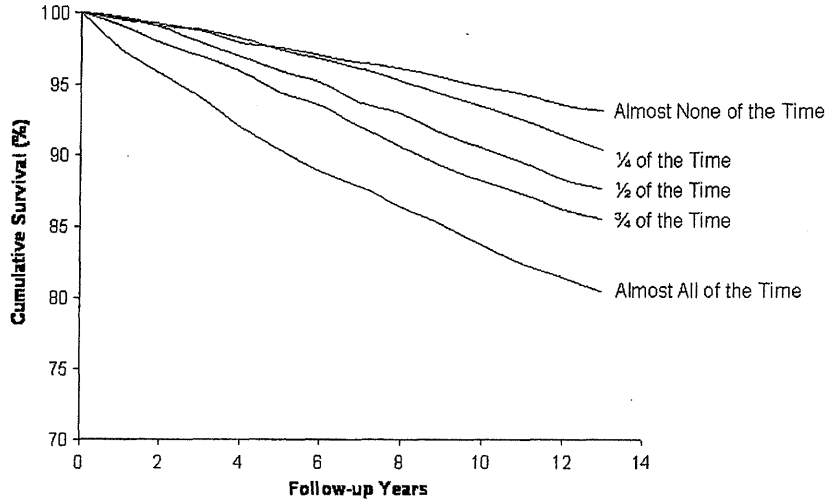

FIGURE 1—Kaplan–Meier survival curve for all-cause mortality across categories of daily sitting time in 17 ,013 men and women 18–90 yr of age, in the Canada Fitness Survey, 1981–1993. Log-rank $\chi^2 = 174.4$, $df = 4$, $P < 0.0001$. The sample sizes across the categories were 3022 (17.8%), 6652 (39.1%), 4379 (25.7%), 2138 (12.6%), and 822 (4.8%), for the categories of almost none of the time, one fourth of the time, half of the time, three fourths of the time, and almost all of the time, respectively.

for all-cause mortality across categories of daily sitting time are presented in Figure 1. There was a significant difference in survival probability across categories of daily sitting time (log-rank $\chi^2 = 174.4$, $df = 4$, $P < 0.0001$).

The amount of daily sitting time was positively associated with mortality rates from all causes, cardiovascular disease, and other causes but not from cancer in the combined sample of men and women (Table 3). Further, there was no relationship between sitting and cancer mortality when the analyses were stratified by sex. The multivariate-adjusted hazard ratios increased across successive sitting groups for all-cause (1.00, 1.00, 1.11, 1.36, 1.54; P for trend <0.0001), cardiovascular disease (1.00, 1.01, 1.22, 1.47, 1.54; P for trend <0.0001), and other (1.00, 1.06, 1.15, 1.65, 2.15; P for trend <0.0001) mortality. Similar trends were observed in the sex-specific analyses. The multivariate-adjusted hazard ratios for all-cause mortality were higher in the highest sitting groups in both men (1.00, 0.90, 0.93, 1.18, 1.32; P for trend = 0.005) and in women (1.00, 1.17, 1.37, 1.61, 1.85; P for trend <0.0001). Similarly, the multivariate-adjusted hazard ratios for cardiovascular disease mortality were increased across sitting groups in men (1.00, 0.91, 1.08, 1.25, 1.35; P for trend = 0.03) and in women (1.00, 1.23, 1.50, 1.77, 1.81; P for trend = 0.002). Effect modification between sex and daily sitting time on mortality risk was explored by including interaction terms in models for the all-cause, cardiovascular disease, and other mortalities. The interaction terms were not significant in either the age-adjusted ($P = 0.15$; $P = 0.11$; $P = 0.07$) or the multivariate-adjusted ($P = 0.07$; $P = 0.08$; $P = 0.05$) model for the all-cause, cardiovascular disease, and other mortalities, respectively.

Figure 2 presents age-adjusted all-cause death rates per 10,000 person-yr. There was a dose–response relationship observed between daily sitting time and mortality rates, which was similar among those who are physically inactive and active, among nonsmokers, former smokers and current smokers, and across BMI categories. Age-adjusted all-cause mortality rates per 10,000 person-yr of follow-up were 87, 86, 105, 130, and 161 (P for trend <0.0001) in physically inactive participants and 75, 69, 76, 98, 105 (P for trend = 0.008) in active participants across sitting categories. Effect modification between leisure time physical activity level and sitting time on all-cause mortality was explored by including an interaction term in the models; however, the interaction term was not significant in either the age-adjusted ($P = 0.18$) or the multivariate-adjusted model ($P = 0.45$).

Given that BMI was available on a subsample only ($n = 10,477$), it was not included as a covariate in the multivariate models. However, in the combined sample of men and women, when restricting the sample to those with a BMI measurement, the inclusion of BMI in the model did not appreciably affect the significance of the linear trend between sitting time and mortality ($P = 0.027$ vs $P = 0.029$). Age-adjusted mortality rates increased across sitting categories within the normal weight, overweight, and obese groups, and the highest mortality rates observed in this sample were among obese individuals who sat most of the time during their major activities of daily living (Fig. 2).

Age-adjusted all-cause death rates were also computed separately in younger (<59 yr) and older (>60 yr) adults. The death rates increased across daily sitting categories in a dose–response manner in both younger (29, 27, 28, 39, 43; $P = 0.01$) and older (329, 319, 391, 497, 625; $P < 0.0001$) adults.

The primary analyses were repeated after exclusion of all deaths that occurred in the first year of follow-up ($n = 96$) to

TABLE 3. Risk of all-cause, cardiovascular disease, cancer, and other mortality associated with daily sitting time in 17,013 men and women from the Canada fitness survey, 1981–1993.

	Almost None of the Time	One Fourth of the Time	Half of the Time	Three Fourths of the Time	Almost All of the Time	*P* for Trend
Men and women combined						
N	3022	6652	4379	2138	822	
Person-yr of follow-up	37,023	80,942	52,346	25,144	9277	
All-cause mortality						
Deaths	206	620	542	305	159	
Age-adjusted hazard ratio[a] (95% CI)	1.00	0.96 (0.82–1.13)	1.11 (0.94–1.30)	1.38 (1.15–1.65)	1.67 (1.36–2.06)	<0.0001
Multivariate hazard ratio (95% CI)	1.00	1.00 (0.86–1.18)	1.11 (0.94–1.30)	1.36 (1.14–1.63)	1.54 (1.25–1.91)	<0.0001
Cardiovascular disease mortality						
Deaths	72	240	244	136	67	
Age-adjusted hazard ratio[a] (95% CI)	1.00	0.96 (0.74–1.26)	1.22 (0.93–1.59)	1.46 (1.09–1.95)	1.60 (1.14–2.25)	<0.0001
Multivariate hazard ratio (95% CI)	1.00	1.01 (0.77–1.31)	1.22 (0.94–1.60)	1.47 (1.09–1.96)	1.54 (1.09–2.17)	<0.0001
Cancer mortality						
Deaths	77	206	155	73	36	
Age-adjusted hazard ratio[a] (95% CI)	1.00	0.91 (0.70–1.18)	0.93 (0.70–1.22)	0.98 (0.71–1.36)	1.15 (0.77–1.71)	NS
Multivariate hazard ratio (95% CI)	1.00	0.92 (0.71–1.20)	0.91 (0.69–1.20)	0.96 (0.69–1.33)	1.07 (0.72–1.61)	NS
Other mortality						
Deaths	57	174	143	96	56	
Age-adjusted hazard ratio[a] (95% CI)	1.00	1.04 (0.77–1.41)	1.17 (0.86–1.59)	1.75 (1.26–2.44)	2.44 (1.68–3.55)	<0.0001
Multivariate hazard ratio (95% CI)	1.00	1.06 (0.78–1.44)	1.15 (0.84–1.57)	1.65 (1.18–2.31)	2.15 (1.47–3.14)	<0.0001
Men						
N	1384	2590	1887	1047	370	
Person-yr of follow-up	16,794	31,109	22,277	12,181	4056	
All-cause mortality						
Deaths	123	316	267	162	83	
Age-adjusted hazard ratio (95% CI)	1.00	0.85 (0.69–1.05)	0.92 (0.74–1.14)	1.19 (0.94–1.51)	1.47 (1.11–1.96)	<0.0001
Multivariate hazard ratio (95% CI)	1.00	0.90 (0.73–1.11)	0.93 (0.75–1.16)	1.18 (0.93–1.50)	1.32 (0.99–1.76)	0.005
Cardiovascular disease mortality						
Deaths	46	134	129	70	34	
Age-adjusted hazard ratio (95% CI)	1.00	0.88 (0.63–1.24)	1.07 (0.76–1.50)	1.24 (0.85–1.81)	1.42 (0.91–2.23)	0.009
Multivariate hazard ratio (95% CI)	1.00	0.91 (0.65–1.29)	1.08 (0.76–1.52)	1.25 (0.86–1.83)	1.35 (0.85–2.13)	0.03
Cancer mortality						
Deaths	42	92	66	46	21	
Age-adjusted hazard ratio (95% CI)	1.00	0.72 (0.50–1.04)	0.66 (0.44–0.97)	0.98 (0.64–1.50)	1.08 (0.64–1.84)	NS
Multivariate hazard ratio (95% CI)	1.00	0.75 (0.52–1.09)	0.66 (0.45–0.98)	0.96 (0.62–1.47)	1.00 (0.58–1.71)	NS
Other mortality						
Deaths	35	90	72	46	28	
Age-adjusted hazard ratio[a] (95% CI)	1.00	0.96 (0.65–1.42)	1.00 (0.67–1.51)	1.35 (0.87–2.10)	2.06 (1.25–3.41)	0.002
Multivariate hazard ratio (95% CI)	1.00	1.06 (0.71–1.57)	1.06 (0.70–1.59)	1.36 (0.87–2.13)	1.73 (1.04–2.89)	0.02
Women						
N	1638	4062	2492	1091	452	
Person-yr of follow-up	20,229	49,834	30,069	12,964	5220	
All-cause mortality						
Deaths	83	304	275	143	76	
Age-adjusted hazard ratio (95% CI)	1.00	1.14 (0.89–1.45)	1.39 (1.09–1.78)	1.66 (1.26–2.19)	1.96 (1.42–2.68)	<0.0001
Multivariate hazard ratio (95% CI)	1.00	1.17 (0.92–1.50)	1.37 (1.07–1.76)	1.61 (1.22–2.12)	1.85 (1.35–2.55)	<0.0001
Cardiovascular disease mortality						
Deaths	26	106	115	66	33	
Age-adjusted hazard ratio (95% CI)	1.00	1.16 (0.75–1.78)	1.49 (0.97–2.28)	1.77 (1.11–2.82)	1.84 (1.09–3.11)	0.0007
Multivariate hazard ratio (95% CI)	1.00	1.23 (0.80–1.90)	1.50 (0.98–2.31)	1.77 (1.11–2.82)	1.81 (1.07–3.07)	0.002
Cancer mortality						
Deaths	35	114	89	27	15	
Age-adjusted hazard ratio (95% CI)	1.00	1.10 (0.75–1.60)	1.26 (0.85–1.88)	0.92 (0.56–1.53)	1.19 (0.64–2.19)	NS
Multivariate hazard ratio (95% CI)	1.00	1.10 (0.75–1.61)	1.23 (0.83–1.83)	0.90 (0.54–1.50)	1.14 (0.62–2.10)	NS
Other mortality						
Deaths	22	84	71	50	28	
Age-adjusted hazard ratio[a] (95% CI)	1.00	1.21 (0.76–1.94)	1.43 (0.88–2.32)	2.38 (1.43–3.95)	2.99 (1.69–5.27)	<0.0001
Multivariate hazard ratio (95% CI)	1.00	1.24 (0.77–1.98)	1.38 (0.85–2.24)	2.23 (1.34–3.72)	2.77 (1.56–4.90)	<0.0001

Multivariate models included age (as a continuous variable), smoking (former, current, nonsmoker), alcohol consumption (abstainer, <10 drinks per month, 10–50 drinks per month, >50 drink per month), leisure time physical activity (as a continuous variable, MET·h·wk^{-1}), and the Physical Activity Readiness Questionnaire (pass/fail/missing).
[a] Also adjusted for sex.

account for occult disease at baseline, and the results were unchanged.

DISCUSSION

Most sedentary behaviors involve sitting for extended periods. The results of this study suggest that greater daily time spent sitting in major activities is associated with elevated risks of mortality from all causes and from cardiovascular disease. These results remain significant after adjustment for potential confounders, including age, sex, smoking status, alcohol consumption, leisure time physical activity levels, and the PAR-Q. Even within physically active individuals, there was a strong association between sitting

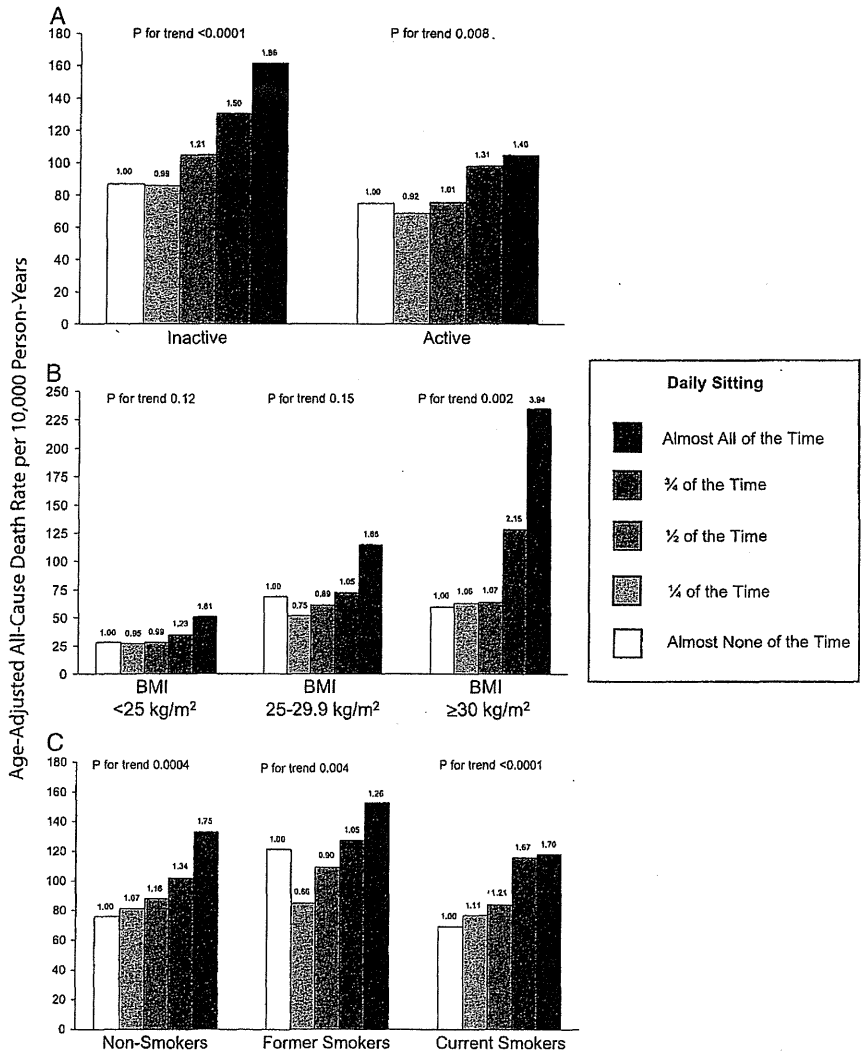

FIGURE 2—Age-adjusted all-cause death rates across categories of daily sitting time in subgroups defined by (A) leisure time physical activity (active defined as ≥7.5 MET·h·wk^{-1}), (B) body mass index, and (C) smoking status in 17,013 men and women from the Canada Fitness Survey, 1981–1993. The height of the *bars* indicates the mortality rates, and the *numbers atop the bars* are the hazard ratios from the proportional hazards regression. The sample size for body mass index was 10,477.

and risk of mortality. Thus, sitting seems to have an independent association with mortality rates beyond that explained by leisure time physical activity level *per se*. This is an important observation because it suggests that high amounts of sitting cannot be compensated for with occasional leisure time physical activity even if the amount exceeds the current minimum physical activity recommendations. The results also highlight the importance of limiting time spent sitting among obese individuals. The highest mortality rates observed were in obese individuals who spend most of their time sitting. Across most analyses, the group that was in the highest sitting time category had a significantly higher risk of mortality compared with the reference group. This highlights an important area for future research. Studies that characterize the biology of sitting may be best placed for discoveries if they focus on individuals at the extremes of sitting behavior.

There are likely many potential mechanistic pathways that contribute to the health risks associated with excessive sitting. Data from studies of extended bed rest in humans and from restriction of normal activity in animal models provide some insight into such mechanisms. For example, activity restriction studies have noted adverse changes to cardiac stroke volume and output (23), glucose tolerance (19), and clearance of triglycerides from triglyceride-rich lipoprotein particles as assessed by lipoprotein lipase activity (2). There is also preliminary evidence to suggest that the physiological mechanisms associated with excessive sitting are different than the physiological benefits of regular exercise. A recent review by Hamilton et al. (10)

suggests that sitting or sedentary behavior may have differential effects on lipoprotein lipase activity in different tissues (2,8). For example, restriction of physical activity has been reported to result in a 10-fold decrease in lipoprotein lipase activity in red oxidative muscle fibers (2). This preliminary work supports our observation that the risk of premature mortality associated with excess sitting is independent of leisure time physical activity level and may at least in part explain when even in active individuals excess sitting is associated with adverse health risks. Further exploring the pathophysiological disturbances associated with excess sitting time is clearly of great interest, and this represents an important area for future research.

There are few existing data available on the relationship between daily sitting time and indicators of morbidity and mortality. A prospective study of 73,732 women enrolled in the Women's Health Initiative Study reported that women who spent 16 or more hours per day sitting had an elevated risk for incident CVD (RR = 1.68; 95% CI: 1.07–2.64) during 6 yr of follow-up compared with women who spent less than 4 $h \cdot d^{-1}$ sitting; however, other durations of sitting were not associated with CVD risk (20). Further, sitting while watching television, sitting at work or away from home or driving, and other sitting at home were all positively associated with incident type 2 diabetes during 6 yr of follow-up among 68,497 women from the Nurses' Health Study (16). A previous analysis of women from the CFS cohort (7-yr follow-up) reported that those who spent less than half of their time sitting had a lower risk of all-cause (OR = 0.58; 95% CI: 0.44–0.75) and CVD (OR = 0.37; 95% CI: 0.24–0.56) mortalities compared with those who spent more than half of their day sitting (28). The present study extends and expands on this previous work by providing a detailed evaluation of the dose–response relationship between sitting time and mortality rates.

Several studies have examined specific aspects of sedentary behavior and their independent relationship with chronic disease risk factors, morbidity, and mortality. For example, independent of physical activity, television viewing has been reported to be associated with obesity (16,17), metabolic syndrome (5,7), and incident type 2 diabetes (15,16) among adults. A recent study has also reported an independent effect of television viewing on metabolic risk factors in a sample of adults who met the physical activity guidelines for physical activity (≥2.5 $h \cdot wk^{-1}$ of moderate-to-vigorous activity) (13). Recent technological advances have allowed for the objective measurement of sedentary behavior. On the basis of data from accelerometry, time in sedentary behavior was related to waist circumference and metabolic risk factor clustering, independent of moderate-to-vigorous physical activity, in a sample of Australian adults (14). These studies suggest that sedentary behavior is an important independent predictor of health status beyond leisure time physical activity levels.

There are several strengths and limitations of this study that warrant discussion. The strengths include the prospective design, the large representative national sample of men and women, and the detailed evaluation of participants at baseline, which was conducted during face-to-face home visits. The large sample size allowed for the stratification of analyses by sex, age, leisure time physical activity status, smoking status, and BMI category. A potential weakness in the design is the inability to screen for preexisting disease at baseline. However, in secondary analyses, we eliminated deaths that occurred during the first year of follow-up to account for the existence of occult disease, and the results were unchanged. Further, responses to the PAR-Q were included as a covariate in the multivariate models, and the results were unchanged. Unfortunately, data were only available at baseline, so changes in the exposure variables during the follow-up period could not be assessed. Daily time spent sitting, which was limited to major activities of daily living and did not include leisure time sitting, particularly among younger participants, was assessed by self-report and classified on an ordinal scale. Even with these limitations, the results demonstrated a strong and consistent dose–response association between reported sitting time and mortality rates.

In conclusion, in this nationally representative sample of adults, daily time spent sitting was associated with an elevated risk of all-cause and cardiovascular disease mortality. Of particular note, the association between sitting time and mortality was independent of leisure time physical activity levels and BMI. Current physical activity guidelines for adults are focused on increasing moderate-to-vigorous physical activity levels. The results of this study provide evidence to support the suggestion that recommendations to limit sedentary time may be important for public health (11). The findings of the study also support that physicians should counsel patients to not only increase their level of physical activity and maintain a normal body weight but to reduce the amount of time they spend being sedentary in general and sitting in particular.

Funding for the record linkage at Statistics Canada was provided by Health Canada. P. K. is supported, in part, by the Louisiana Public Facilities Authority Endowed Chair in Nutrition. T. C. is funded, in part, by the John S. McIlhenny Endowed Chair in Health Wisdom. C. B. is funded, in part, by the George A. Bray, Jr. Chair in Nutrition. P. K. had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. No potential conflicts of interest related to this article have been reported by the authors. The results of the present study do not constitute endorsement by ACSM.

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論文名	Sitting time and mortality from all causes, cardiovascular disease, and cancer
著 者	Katzmarzyk PT, Church TS, Craig CL, Bouchard C
雑誌名	Med Sci Sports Exerc
巻・号・頁	41(5)　998-1005
発行年	2009
PubMedリンク	http://www.ncbi.nlm.nih.gov/pubmed/19346988

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	42.0(±17.5)歳	[redacted]		( )		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

TABLE 3. Risk of all-cause, cardiovascular disease, cancer, and other mortality associated with daily sitting time in 17,013 men and women from the Canada fitness survey, 1981–1993.

	Almost None of the Time	One Fourth of the Time	Half of the Time	Three Fourths of the Time	Almost All of the Time	P for Trend
Men and women combined						
N	3022	6532	4379	2138	822	
Person-yr of follow-up	37,023	80,942	52,345	25,144	9277	
All-cause mortality						
Deaths	206	620	542	305	159	
Age-adjusted hazard ratio[a] (95% CI)	1.00	0.96 (0.82–1.13)	1.11 (0.94–1.30)	1.35 (1.15–1.65)	1.67 (1.36–2.06)	<0.0001
Multivariate hazard ratio (95% CI)	1.00	1.00 (0.86–1.18)	1.11 (0.94–1.30)	1.36 (1.14–1.63)	1.54 (1.25–1.91)	<0.0001
Cardiovascular disease mortality						
Deaths	72	240	244	136	67	
Age-adjusted hazard ratio[a] (95% CI)	1.00	0.99 (0.74–1.26)	1.22 (0.93–1.59)	1.46 (1.09–1.95)	1.80 (1.14–2.25)	<0.0001
Multivariate hazard ratio (95% CI)	1.00	1.01 (0.77–1.31)	1.22 (0.94–1.60)	1.47 (1.09–1.96)	1.54 (1.09–2.17)	<0.0001
Cancer mortality						
Deaths	77	205	155	73	36	
Age-adjusted hazard ratio[a] (95% CI)	1.00	0.91 (0.70–1.18)	0.93 (0.70–1.22)	0.98 (0.71–1.36)	1.15 (0.77–1.71)	NS
Multivariate hazard ratio (95% CI)	1.00	0.92 (0.71–1.20)	0.91 (0.69–1.20)	0.96 (0.69–1.33)	1.07 (0.72–1.61)	NS
Other mortality						
Deaths	57	174	143	96	58	
Age-adjusted hazard ratio[a] (95% CI)	1.00	1.04 (0.77–1.41)	1.17 (0.86–1.59)	1.75 (1.26–2.44)	2.44 (1.68–3.55)	<0.0001
Multivariate hazard ratio (95% CI)	1.00	1.06 (0.79–1.44)	1.15 (0.84–1.57)	1.65 (1.18–2.31)	2.15 (1.47–3.14)	<0.0001
Men						
N	1384	2590	1887	1047	370	
Person-yr of follow-up	16,794	31,109	22,277	12,151	4068	
All-cause mortality						
Deaths	123	316	267	162	83	
Age-adjusted hazard ratio (95% CI)	1.00	0.85 (0.69–1.05)	0.92 (0.74–1.14)	1.19 (0.94–1.51)	1.47 (1.11–1.96)	<0.0001
Multivariate hazard ratio (95% CI)	1.00	0.90 (0.73–1.11)	0.93 (0.75–1.16)	1.18 (0.93–1.50)	1.32 (0.99–1.76)	0.005
Cardiovascular disease mortality						
Deaths	48	134	129	78	34	
Age-adjusted hazard ratio (95% CI)	1.00	0.88 (0.63–1.24)	1.07 (0.76–1.50)	1.24 (0.85–1.81)	1.42 (0.91–2.23)	0.009
Multivariate hazard ratio (95% CI)	1.00	0.97 (0.69–1.39)	1.08 (0.76–1.52)	1.25 (0.86–1.82)	1.35 (0.85–2.13)	0.03
Cancer mortality						
Deaths	42	92	56	48	21	
Age-adjusted hazard ratio (95% CI)	1.00	0.72 (0.50–1.04)	0.46 (0.44–0.97)	0.58 (0.54–1.50)	1.06 (0.64–1.84)	NS
Multivariate hazard ratio (95% CI)	1.00	0.75 (0.52–1.09)	0.65 (0.45–0.98)	0.96 (0.62–1.47)	1.00 (0.58–1.71)	NS
Other mortality						
Deaths	35	90	72	46	28	
Age-adjusted hazard ratio[a] (95% CI)	1.00	0.89 (0.55–1.42)	1.00 (0.67–1.51)	1.35 (0.87–2.10)	2.06 (1.25–3.41)	0.002
Multivariate hazard ratio (95% CI)	1.00	1.08 (0.71–1.57)	1.08 (0.70–1.59)	1.36 (0.87–2.13)	1.73 (1.04–2.89)	0.02
Women						
N	1638	4062	2492	1091	452	
Person-yr of follow-up	20,229	49,834	30,069	12,994	5232	
All-cause mortality						
Deaths	83	304	275	143	76	
Age-adjusted hazard ratio (95% CI)	1.00	1.14 (0.89–1.45)	1.39 (1.09–1.78)	1.65 (1.26–2.19)	1.96 (1.42–2.68)	<0.0001
Multivariate hazard ratio (95% CI)	1.00	1.17 (0.92–1.50)	1.37 (1.07–1.76)	1.61 (1.22–2.12)	1.85 (1.35–2.55)	<0.0001
Cardiovascular disease mortality						
Deaths	26	105	115	56	33	
Age-adjusted hazard ratio (95% CI)	1.00	1.16 (0.75–1.78)	1.49 (0.97–2.28)	1.77 (1.11–2.82)	1.84 (1.09–3.11)	0.0037
Multivariate hazard ratio (95% CI)	1.00	1.23 (0.80–1.90)	1.58 (0.98–2.31)	1.77 (1.11–2.82)	1.81 (1.07–3.07)	0.002
Cancer mortality						
Deaths	35	114	89	27	15	
Age-adjusted hazard ratio (95% CI)	1.00	1.10 (0.75–1.60)	1.26 (0.85–1.86)	0.92 (0.56–1.53)	1.19 (0.64–2.19)	NS
Multivariate hazard ratio (95% CI)	1.00	1.10 (0.75–1.61)	1.23 (0.83–1.83)	0.99 (0.54–1.50)	1.14 (0.62–2.10)	NS
Other mortality						
Deaths	22	84	71	60	28	
Age-adjusted hazard ratio[a] (95% CI)	1.00	1.21 (0.76–1.94)	1.43 (0.89–2.32)	2.38 (1.43–3.95)	2.69 (1.59–4.57)	<0.0001
Multivariate hazard ratio (95% CI)	1.00	1.24 (0.77–1.98)	1.39 (0.85–2.24)	2.33 (1.34–3.72)	2.77 (1.56–4.90)	<0.0001

Multivariate models included age (as a continuous variable), smoking (former, current, ex-smoker), alcohol consumption (abstainer, <10 drinks per month, 10–50 drinks per month, >50 drink per month), leisure time physical activity (as a continuous variable, MET·h·wk^{-1}), and the Physical Activity Readiness Questionnaire (positive/missing).
[a] Also adjusted for sex.

図表掲載箇所	P1002, Table3
概 要 (800字まで)	本研究は、カナダのThe 1981 Canada Fitness Survey(CFS)に参加した男女17,103名を対象に平均12年間の追跡調査を行い、不活動時間(特に座位時間)と総死亡、心血管疾患死亡およびがん死亡の関連について検討したものである。質問紙によって、睡眠時間以外の時間で座って過ごす割合を尋ね、殆どなし、4分の1程度、半分程度、4分の3程度、殆ど全てに分類した。座位時間が殆どなしと答えた集団と比較すると、総死亡リスクがそれぞれ1.00(95%信頼区間:0.86-1.18)、1.11(0.94-1.30)、1.36(1.14-1.63)、1.54(1.25-1.91)、心血管疾患による死亡リスクがそれぞれ1.01(0.77-1.31)、1.22(0.94-1.60)、1.47(1.09-1.96)、1.54(1.09-2.17)、その他死因による死亡リスクがそれぞれ1.06(0.78-1.44)、1.15(0.84-1.57)、1.65(1.18-2.31)、2.15(1.47-3.14)と量反応的に上昇した(全てPtrend<0.0001)。座位時間とがんによる死亡リスクとの関連はなかった。男女共に、座位時間の最も長い集団で総死亡リスクが最も高かった。さらに、座位時間の延長は余暇時間の身体活動量とは独立して死亡リスク
結 論 (200字まで)	座位時間の延長は、総死亡リスク増加、心血管疾患による死亡リスク増加と関連していることが明らかとなった。さらにそれらは、余暇時間中の身体活動量や肥満度(BMI)とは独立して関連してい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。座位時間や不活動が死亡や様々な疾患発症と関連していることが近年報告されており、本研究でも総死亡や心血管系疾患による死亡との関連が示唆されており、座位時間を短くすることの重要性が支持された。一方、がんによるについては本研究では座位時間との関連が認められていないが、認められるとする報告もあり、今後、がんの種類等についても詳細に検討することが求められる。

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