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Physical Activity, Sedentary Time, and Risk of Colorectal Cancer: The Singapore Chinese Health Study

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Abstract

Objective—Singapore has experienced a dramatic increase in colorectal cancer incidence over the past 40 years. Evidence from prospective studies in Western Europe and the U.S. suggest that low physical activity and high amounts of sedentary time are associated with increased colorectal cancer risk. The purpose of this study is to evaluate these relationships among an Asian population.

Methods—The Singapore Chinese Health Study enrolled 63,257 adults between 1993 and 1998. At enrollment, participants reported past year physical activity and time spent sitting. Incident colorectal cancers (n=1,994) were identified through December 31, 2014. Cox proportional hazards models were used to calculate hazard ratios (HRs) and 95% confidence intervals (CIs) adjusted for potential confounders.

Results—Any strenuous-vigorous or moderate physical activity was reported by 13.7% and 22.1% of the cohort, respectively. Strenuous-vigorous physical activity was associated with statistically significant reduced colorectal cancer risk (HR=0.85; 95% CI: 0.74, 0.99 for ½ hr/week versus none) but moderate was not. In analysis stratified by time spent watching television, an inverse relationship between moderate physical activity and colorectal cancer risk (HR=0.86; 95% CI: 0.72 1.01 for ½ hr/week versus none) was observed for those who reported 3 hrs/day sitting watching television (P interaction = 0.042).

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Conflicts of Interest

The authors have no conflicts of interest to declare.

Conclusions—Participation in strenuous-vigorous physical activity, such as jogging, swimming, or heavy manual labor was associated with reduced colorectal cancer risk among Singapore Chinese. Further research on physical activity and sedentary behaviors, independently and in combination, and colorectal cancer risk in Asian populations is needed.

Keywords

physical activity; sedentary lifestyle; colorectal cancer; Asian

Introduction

Colorectal cancer is the third most commonly diagnosed cancer in the world, accounting for close to 1.4 million new cancers each year (Ferlay et al., 2013). Although the highest incidence rates are observed in more developed countries; such as those in Western Europe, Australia, and the U.S., the rates of colorectal cancer are rising in more recently industrialized parts of the world such as Asia. As an example, Singapore experienced a rapid period of economic growth and development that was followed by an approximate 40% rise in the incidence rate of colorectal cancer in both men and women from 1975–79 to 1995–99 (National Registry of Diseases Office, 2016). Colorectal cancer incidence rates in Singapore have since stabilized, and appear to be showing a slight decline in recent years in both sexes (Forman et al., 2014; National Registry of Diseases Office, 2016). The 2010–2014 age-standardized incidence rates of colorectal cancer in Singapore are 38.2/100,000 men and 26.7/100,000 women (National Registry of Diseases Office, 2016). Among ethnic subgroups in Singapore, the highest incidence rates are observed among Chinese (age-standardized rates; 41.2/100,000 men and 27.9/100,000 women). These rates are comparable to that observed in Japan, while higher than that observed in the United States, China, the Philippines, and Thailand (Ferlay et al., 2013). While some of the initial rise in colorectal cancer incidence in Singapore was due to improved screening and detection, the current high incidence rate is likely due to shifts in traditional behaviors to those common to Western lifestyles that have coincided with dramatic increases in obesity (Epidemiology & Disease Control Division, 2011; Finucane et al., 2011). These behaviors include diets high in saturated fat and low levels of physical activity and high prevalence of sedentary behaviors (World Cancer Research Fund and American Institute for Cancer Research, 2007).

The role of leisure-time physical activity in preventing chronic disease has gained attention as occupation-related physical activities decline in industrialized countries (Hallal et al., 2012). There have been several systematic reviews and meta-analyses of the relationship between physical activity and cancer (Friedenreich et al., 2010; Boyle et al., 2012; Moore et al., 2016), supporting that higher levels of physical activity are associated with lower colorectal cancer risk. Based on results from epidemiologic studies, respected international agencies have designated the evidence level for the physical activity-colorectal cancer risk association to be “convincing” (World Cancer Research Fund and American Institute for Cancer Research, 2007; Kushi et al., 2012; Leitzmann et al., 2015). However, this designation is primarily driven by studies from populations in Western Europe and the U.S. Thus, these findings may not be generalizable to countries with different lifestyles and

historically lower colorectal cancer incidence that have recently experienced rapid economic growth and colorectal cancer rate increases, such as Singapore.

Economic prosperity and advances in technology have also led to increased sedentary behavior, such as time spent sitting watching television (Hallal et al., 2012). There is a growing body of literature supporting the potential adverse health effects of sedentary behavior on colorectal cancer risk (Simons et al., 2013; Cong et al., 2014; Patel et al., 2015). To date, there have been no prospective studies conducted among Asian populations that have evaluated sedentary behavior as a risk factor for colorectal cancer, or as a modifier of the relationship between physical activity and colorectal cancer risk. Investigating the independent and potential interactive roles of physical activity and sedentary behavior in the development of colorectal cancer are necessary to guide prevention efforts in populations more recently adopting aspects of Western diet and lifestyle.

The Singapore Chinese Health Study offers a unique opportunity to prospectively evaluate relationships between time spent in physical activities and sedentary behaviors and colorectal cancer risk among a recently transitioned population with relatively high incidence rate of colorectal cancer. The study includes a comprehensive in-person interview about participants' dietary habits, lifestyle, and medical history on over 60,000 Chinese living in Singapore. We have previously reported that a lifestyle factor index score that included physical activity was associated with a statistically significant decrease in colon cancer risk in the Singapore cohort (Odegaard et al., 2013). The purpose of the present investigation is to examine the relationship between physical activity and sedentary time on the risk of developing colorectal cancer in detail among the cohort participants.

Methods

Population

The Singapore Chinese Health Study, described elsewhere (Hankin et al., 2001; Yuan et al., 2003), is a population-based cohort that enrolled 63,257 Chinese adults living in Singapore. The study enrolled men and women between age 45 and 74 years who belonged to either the Hokkien or the Cantonese dialect groups. In-person interviews were conducted between April 1993 and December 1998. The study was approved by the Institutional Review Boards of the National University of Singapore and the University of Pittsburgh.

Assessment of Lifestyle Factors and Physical Activity

The baseline interview included questions on demographics, medical history (including diabetes and cancer), usual diet, tobacco and alcohol use, height, weight, physical activity, and family history of cancer. The interview and lifestyle factors have been described previously (Tsong et al., 2007; Odegaard et al., 2011a) (see Text, Supplemental Digital Content 1, description of lifestyle factors). Physical activity was reported for the past year in categories of moderate activities (brisk walking, bowling, bicycling on level ground, tai chi, or chi kung), strenuous sports (jogging, bicycling on hills, squash, swimming laps, or aerobics), and vigorous work (moving heavy furniture, loading or unloading trucks, shoveling, or equivalent manual labor). For each category of activity, participants reported

average time spent each week in intervals of never, ½–1 hr., 2–3 hrs., 4–6 hrs., 7–10 hrs., 11–20 hrs., 21–30 hrs., and 31 hrs. or more. Based on the frequency of physical activity in the study population, the intensity variables were dichotomized into ½ hr/week physical activity and no reported physical activity within each respective intensity. Participants were also asked to report the average time spent sitting per day for watching television and other sitting activities (i.e., reading, playing cards, and sewing) in intervals of never, less than 1 hr., 1–2 hrs., 3–4 hrs., 5–6 hrs., 7–10 hrs., and 11 hrs. or more. Time spent sitting watching television was dichotomized into 3 hrs/day and 2 hours/per day based on the distribution of television watching time in this sample. Other sitting was examined in categories of none, <1hr/day, 1–2 hrs/day, and 3 hrs/day.

Ascertainment of Colorectal Cancer Cases

Record linkage with the Singapore Cancer Registry and the Singapore Registry of Births and Deaths through December 31, 2014 identified incident colorectal cancer cases and deaths among the study cohort. The national cancer registry has been in place since 1968 and has been shown to be comprehensive in recording cancer cases among the entire population in Singapore (Forman et al., 2014). To date, <1% of cohort participants have been lost to follow-up due to out migration. Among those under follow-up who were free of cancer at baseline, 1,994 developed colorectal cancers. The Duke staging system (A, B, C, D) was used to classify tumors into early stage (A/B) and advanced stage (C/D).

Analysis

Cox proportional hazards regression analysis was conducted using person-years of follow-up time from date of baseline interview to colorectal cancer diagnosis, death from any cause, loss to follow-up, or December 31, 2014, whichever event occurred first. Participants with prevalent cancer at baseline (n=1,936) were excluded, leaving 61,321 subjects in the analytic sample. Participants with histologically confirmed *in situ* tumors (n=5) or tumors with uncertain histology (n=8) were excluded from the regression analysis. In total, 1,981 incident colorectal cancer cases (n=1,249 colon; n=732 rectum) were represented. Complete Duke staging information was available for 1,329 cases (67%).

The associations of physical activity and time spent sitting were evaluated in relation to colorectal cancer risk. Physical activity was considered separately by intensity (moderate or strenuous-vigorous) and combined as overall physical activity. The overall physical activity categories were none, low (moderate intensity only), medium (strenuous-vigorous intensity only), and high (both moderate and strenuous-vigorous intensity). Associations between physical activity and colorectal cancer risk were evaluated separately by tumor subsite (colon or rectum), sex, body mass index (BMI), diabetes status, and time spent sitting watching television to determine if associations vary by subgroups. If the risk estimates were dissimilar between subgroups, an interaction term was introduced and tested in regression models to determine if effect modification was present ($p<0.05$ for interaction term). Sensitivity analyses were conducted excluding the first two years of follow-up, and excluding those with self-reported diabetes at baseline (n=5,469) in order to rule out presence of underlying disease or disability and its impact on the potential physical activity-colorectal cancer risk association.

Regression models were adjusted for demographic, medical, and lifestyle factors that have been shown to be associated with colorectal cancer risk in the general population or in previous investigations within this cohort (Seow et al., 2006; Tsong et al., 2007; Odegaard et al., 2011b; Odegaard et al., 2013). Factors include age at interview, education (no formal schooling, primary school, or secondary school or higher), sex, year of interview (1993–1995 or 1996–1998), dialect group (Hokkien or Cantonese), cigarette smoking (never, light, or heavy), BMI (<18.5 or 18.5–27.4 kg/m²), alcohol consumption (0, <7, or ≥7 drinks/week), sleep duration (<6 or 6–8 hrs/day), fiber intake (g/1000kcal/day in quartiles), family history of colorectal cancer (yes or no), and history of physician diagnosed diabetes (yes or no).

Results

The mean age of participants at enrollment was 56.4 (SD 8.0) years. The average follow-up time for the entire cohort was 16.8 (SD 5.1) years. The mean age at colorectal cancer diagnosis was 70.9 (SD 8.6) years and the mean time and range from baseline interview to colorectal cancer diagnosis was 10.7 (SD 5.5) years and 0.16 months to 21.45 years, respectively.

The distribution of participant characteristics across overall physical activity level categories are presented in Table 1. In summary, 33.0% of participants reported any physical activity, with 19.3% reporting only moderate intensity activities, 10.9% reporting only strenuous-vigorous intensity activities, and 2.8% reporting both moderate and strenuous-vigorous intensity activities. Women were less likely to report strenuous-vigorous intensity activities than men. A higher education level and greater alcohol consumption appeared to increase across categories of physical activity. Prevalent diabetes, age at interview, and time spent sitting watching television showed decreasing trends as physical activity level increased. There were no clear trends in family history of colorectal cancer, BMI, sleep, or cigarette smoking across categories of physical activity. These lifestyle factors were evaluated in association with colorectal cancer risk (see Table 1S, Supplemental Digital Content 2, associations of lifestyle factors with colorectal cancer risk).

The associations of physical activity and sitting with colorectal cancer risk are summarized in Table 2. Participants who reported at least ½ hr/week of strenuous-vigorous intensity physical activity had a significant 15% reduced risk of colorectal cancer (HR=0.85; 95% CI= 0.74, 0.99). Overall physical activity level was associated with a reduced risk of colorectal cancer (*p*-trend = 0.045). High overall physical activity level (i.e., moderate and strenuous-vigorous intensity physical activity) versus none had the strongest inverse association, although the hazards ratio did not reach statistical significance. Moderate intensity physical activity, time spent sitting watching television, and time spent in other sitting activities (i.e. reading, playing cards, or sewing) were not associated with risk for colorectal cancer in the total sample. Results for three categories of increasing physical activity and sitting time showed similar results (see Table 2S, Supplemental Digital Content 3, associations of physical activity and sitting with colorectal cancer risk).

In analyses stratified by time spent sitting watching television, inverse associations between physical activity and colorectal cancer risk were clearest among those with longer sitting time (Table 3). There was a statistically significant interaction between moderate intensity physical activity and time spent watching television on colorectal cancer risk, such that a suggestive inverse association between moderate intensity physical activity and colorectal cancer risk was observed in those who sat ≥ 3 hrs/day watching television, but not in those who sat < 2 hrs/day watching television. Stronger inverse relationships were also seen between physical activity (i.e., strenuous-vigorous intensity and overall physical activity level) and colorectal cancer risk among those with longer time spent sitting watching television.

Among men, any strenuous-vigorous intensity physical activity compared with none was associated with a statistically significant reduction in risk of colorectal cancer (HR=0.84, 95% CI=0.71, 0.99). A weaker, statistically non-significant reduction in risk was observed for women (HR=0.94, 95% CI=0.69, 1.29). Any moderate intensity physical activity was inversely, albeit non-significantly, associated with colorectal cancer risk for women (HR=0.87, 95% CI=0.73, 1.02), but not for men (HR=1.07, 95% CI=0.93, 1.23) (p -interaction=0.028).

In analyses stratified by tumor subsite, BMI, and diabetes status, the associations between physical activity and cancer risk were similar (see Tables 3S.1–3, Supplemental Content 4, results by clinical factors). The associations between strenuous-vigorous physical activity and colorectal cancer risk were similar when excluding the first two years of follow-up (HR=0.86 for any vs. none, 95% CI= 0.74, 1.00; $p=0.04$) or those with prevalent diabetes (HR=0.86 for any vs. none, 95% CI=0.74, 1.00; $p=0.05$).

Discussion

In this prospective evaluation of physical activity and colorectal cancer risk in a population of Singapore Chinese, participation in strenuous-vigorous intensity physical activity was associated with a statistically significant 15% reduction in colorectal cancer risk. This inverse association was similar by tumor subsite, and consistent with that reported in studies of Western populations (Moore et al., 2016). This inverse association was also more pronounced in those reporting greater amounts of time spent sitting watching television. To our knowledge, this is the first population-based study to prospectively evaluate physical activity and sedentary time in relation to colorectal cancer risk in an Asian population.

We observed a statistically significant 16% reduced risk for colorectal cancer associated with strenuous-vigorous intensity physical activity among men and a weaker, statistically non-significant 6% reduction in risk among women. Additionally, we observed an apparent interaction between sex and moderate intensity activity in relation to colorectal cancer risk. Differences in the physical activity-colorectal cancer association by sex have also been observed in previous epidemiologic studies (Thune and Lund, 1996; Howard et al., 2008; Simons et al., 2013). In a prospective study of 292,000 men and 196,600 women enrolled in the NIH-AARP Diet and Health Study, Howard and colleagues reported a significant 18% reduced risk for colorectal cancer from frequent exercise and sports participation (≈ 5 times/

week vs. never/rarely) for men and a non-significant 13% reduced risk for women (Howard et al., 2008), adjusted for similar factors considered in this study. While our findings should be interpreted cautiously and considered in the context of the frequency of physical activity intensities undertaken by men and women in this population, there is a need for further research on host differences between men and women that may contribute to the disparities reported in the associations between physical activity and colorectal cancer risk.

We did not observe direct associations between sitting time and colorectal cancer risk. This null relationship is similar to that reported by Patel and colleagues in the American Cancer Society's Cancer Prevention Study-II Nutrition Cohort (Patel et al., 2015). Authors found that among men and women, sitting 6 hrs/day compared to <3 hrs/day during leisure time was not associated with colorectal cancer risk. This in contrast to two recent meta-analyses of 23 and 18 studies, respectively, primarily conducted in the U.S. and Western Europe, in which the authors reported an approximate 30% increased risk for colon cancer and no association with risk for rectal cancer for those with the highest amount of sedentary time compared to those with the least (Cong et al., 2014; Schmid and Leitzmann, 2014). There was considerable overlap in the studies included in these two meta-analyses and a majority of the studies reported associations for occupational sitting time. With that in mind, an earlier population study in Shanghai, China reported no association between occupational sitting and colorectal cancer risk (Chow et al., 1993). More information is needed on time spent sitting in different domains (e.g. occupation, leisure-time, transport) and colorectal cancer risk in Asian populations, given that they may not demonstrate the same relationship with colorectal cancer as observed in Western European and U.S. populations.

We report a clearer relationship between physical activity and colorectal cancer risk among those who were more sedentary, i.e. reported sitting 3 hrs/day watching television. To our knowledge, this is the first report of a potential interactive effect of physical activity and sedentary time on colorectal cancer risk. There is some evidence of an interactive effect from a study of total cancers, in which the adverse effect of sitting time on overall cancer risk varied by background level of physical activity (Patel et al., 2015). The notion that the protective effects of physical activity on cancer risk may be stronger among subgroups defined by sedentary activity is not without cause. In population-based assessments of physical activity, it has been documented that those who engage in less sedentary time spend more time in light intensity activities (e.g. cooking, standing) (Schuna et al., 2013). Assuming that participation in light intensity activity provides some benefit against colorectal cancer, then this may suggest that the benefits of moderate to strenuous-vigorous physical activity on colorectal cancer risk are seen most clearly among those with more sedentary time because these individuals have lower total activity (i.e., minimal light activity). Future evaluations of physical activity and colorectal cancer risk would benefit from including more precise measures of time spent in sedentary and light activities in order to add to our understanding of the physical activity-colorectal cancer relationship.

Strengths of this study include the large number of colorectal cancer cases to prospectively evaluate the association between categories of physical activity and risk for colorectal cancer. Collection of information on both physical activity and sitting time permitted the evaluation of the independent and interactive effects of these behaviors in association with

colorectal cancer risk. The study also enabled the relationship between physical activity and sitting time and colorectal cancer risk to be evaluated by host factors and tumor characteristics (i.e. stage, subsite) to determine if there were stronger relationships between physical activity, sitting, and colorectal cancer among certain population subgroups. Given the numerous strengths of this evaluation, there are several limitations to consider (see Text, Supplemental Digital Content 5, discussion of limitations).

In conclusion, participation in higher levels of physical activity, especially strenuous-vigorous intensity activities such as jogging, swimming, or heavy manual labor, were associated with a reduced risk of colorectal cancer in a population of Singapore Chinese. In addition to what we know from previous studies in Western Europe and the U.S., this study supports the role of physical activity as a means to reduce colorectal cancer risk. Further examination of physical activity, independently and in combination with sitting time, while considering other host factors and the risk for colorectal cancer is needed to add understanding to the observed relationships and to guide public health recommendations for physical activity and cancer prevention.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1
 Baseline Participant Characteristics by Physical Activity Level in the Singapore Chinese Health Study, 1993–1996

Characteristic	Overall Physical Activity Level ^a				
	Total	None	Low	Medium	High
% (n)	100 (61,321)	67.0 (41,083)	19.3 (11,820)	10.9 (6,711)	2.8 (1,707)
Follow-up (person-years)	754,248	501,212	11,820	83,887	21,337
Age at Interview; mean (sd)	56.4 (8.0)	56.7 (8.0)	57.9 (8.1)	52.6 (6.5)	53.4 (7.0)
Sex; % Female	55.5	62.3	53.3	24.0	30.2
Education; %					
No formal school	27.2	31.7	22.5	11.8	11.8
Primary school	44.4	44.8	42.7	47.3	35.1
Secondary school or higher	28.4	23.5	34.8	40.9	53.1
Diabetes; %	8.9	9.3	10.2	5.4	5.0
Family History of Colorectal Cancer; %	2.2	2.0	2.5	2.5	3.1
Cigarette Smoking ^b ; %					
None	69.4	70.7	71.4	58.7	68.2
Light	26.8	25.6	25.2	36.2	29.1
Heavy	3.8	3.7	3.3	5.1	2.8
Alcohol Use; %					
0 drinks/week	81.0	83.7	81.9	66.5	66.2
<7 drinks/week	14.3	12.0	14.4	25.4	26.5
7 drinks/week	4.7	4.4	3.7	8.0	7.3
Body Mass Index; %					
<18.5 kg/m ²	6.3	6.5	5.7	6.0	5.4
18.5–27.4 kg/m ²	85.1	84.6	86.1	85.9	86.1
27.5 kg/m ²	8.7	8.9	8.2	8.1	8.5

Characteristic	Overall Physical Activity Level ^a				
	Total	None	Low	Medium	High
Sleep Duration; %					
<6 or 9 hrs/day	16.5	17.3	16.3	12.8	13.2
6-8 hrs/day	83.5	82.7	83.7	87.2	86.8
Time sitting watching TV; %					
2 hrs/day	61.3	60.2	58.4	70.9	69.1
3 hrs/day	38.7	39.8	41.6	29.1	30.9
Other sitting; %					
None	18.6	21.8	14.1	9.4	7.2
<1 hr/day	31.6	31.7	31.8	31.1	29.9
1-2 hrs/day	35.1	32.0	38.7	44.5	49.4
3 hrs/day	14.7	14.5	15.4	15.1	13.5

^aLow: Moderate Physical Activity Only (1/2 hr/week); Medium: Strenuous-Vigorous Physical Activity Only (1/2 hr/week); High: Moderate and Strenuous-Vigorous Physical Activity (1hr/week)

^bLight: <13 cigarettes/day or smoking at age 15; Heavy: 13 cigarettes/day or smoking at age <15 years

Table 2

Physical Activity, Sitting, and Risk for Colorectal Cancer in the Singapore Chinese Health Study, 1993–2014

	Person-years	Cases, n	HR (95% CI) ^a
Moderate Intensity			
None	802,507	1504	1.0 (ref)
Any ($\frac{1}{2}$ hrs/week)	229,695	477	0.98 (0.88–1.09)
Strenuous-Vigorous Intensity			
None	884,598	1762	1.0 (ref)
Any ($\frac{1}{2}$ hrs/week)	147,604	219	0.85 (0.74–0.99) [*]
Overall Physical Activity Level ^b			
None	684,909	1329	1.0 (ref)
Low	199,689	433	0.98 (0.88–1.10)
Medium	117,598	175	0.86 (0.73–1.01)
High	30,007	44	0.81 (0.60–1.10)
P for trend	0.045		
Sitting Watching Television			
2 hrs/day	639,190	1176	1.0 (ref)
3 hrs/day	393,012	805	1.04 (0.95–1.14)
Other Sitting Activities			
None		416	1.0 (ref)
< 1 hr/day		623	0.99 (0.87–1.13)
1–2 hrs/day		662	1.00 (0.87–1.15)
3 hrs/day		280	0.99 (0.84–1.17)
P for trend	0.99		

^aHazard ratios (HRs) were adjusted for age, dialect group, interview year, education level, BMI, sex, cigarette smoking, alcohol use, sleep, dietary fiber, family history of colorectal cancer, and diabetes

^bLow: Moderate Physical Activity Only ($\frac{1}{2}$ hr/week); Medium: Strenuous-Vigorous Physical Activity Only ($\frac{1}{2}$ hr/week); High: Moderate and Strenuous-Vigorous Physical Activity (1hr/week)

^{*} $p < 0.05$

Table 3

Physical Activity and Colorectal Cancer Risk in the Singapore Chinese Health Study, 1993–2014; by Time Spent Sitting Watching Television

Time Spent Sitting Watching Television	2 hrs/day (n=37,607)		3 hrs/day (n=23,714)	
Cases, n	HR (95% CI) ^a		Cases, n	HR (95% CI) ^a
Moderate Intensity				
None	884	1.0 (ref)	620	1.0 (ref)
Any (½ hrs/week)	292	1.08 (0.94–1.24)	185	0.86 (0.72–1.01)
P interaction				0.042
Strenuous-Vigorous Intensity				
None	1020	1.0 (ref)	742	1.0 (ref)
Any (½ hrs/week)	156	0.88 (0.74–1.05)	63	0.79 (0.61–1.04)
P interaction				0.51
Overall Physical Activity Level ^b				
None	757	1.0 (ref)	572	1.0 (ref)
Low	263	1.11 (0.96–1.28)	170	0.84 (0.70–0.99) *
Medium	127	0.93 (0.76–1.13)	48	0.74 (0.55–1.00)
High	29	0.82 (0.57–1.20)	15	0.81 (0.48–1.36)
P for trend		0.54		0.013
P interaction				0.10

^aHazard ratios (HRs) were adjusted for age, dialect group, interview year, education level, BMI, sex, cigarette smoking, alcohol use, sleep, dietary fiber, family history of colorectal cancer, and diabetes.

^bLow: Moderate Physical Activity Only (1/2 hr/week); Medium: Strenuous-Vigorous Physical Activity Only (1/2 hr/week); High: Moderate and Strenuous-Vigorous Physical Activity (1hr/week)

* $p < 0.05$