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Age-specific Physical Activity and Prostate Cancer Risk Among White Men and Black Men

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Abstract

Background—The relationship of physical activity across the lifespan to risk of prostate cancer has not been thoroughly investigated, particularly among Black men. We investigated physical activity, including activity during different age periods and of varying intensities, in relation to prostate cancer incidence among White and Black men.

Methods—A total of 160,006 White men and 3,671 Black men aged 51–72 years in the National Institutes of Health-AARP Diet and Health Study reported time spent per week engaging in physical activity during ages 15–18, 19–29, 35–39 years, and the past 10 years. Cox regression models were used to examine physical activity, categorized by intensity (moderate or vigorous, light, and total), in relation to prostate cancer risk.

Results—During 7 years of follow-up, 9,624 White men and 371 Black men developed prostate cancer. Among White men, physical activity had no association with prostate cancer, regardless of age period or activity intensity. Among Black men, engaging in four or more hours of moderate/vigorous intensity physical activity vs. infrequent activity during ages 19–29 years was related to a 35% lower risk of prostate cancer (relative risk=0.65; 95% confidence interval= 0.43–0.99; $P_{\text{trend}}=0.01$). Frequent moderate/vigorous physical activity at ages 35–39 years was also potentially related to reduced prostate cancer risk (relative risk=0.59; 95% confidence interval= 0.36–0.96; $P_{\text{trend}}=0.15$).

Conclusion—Regular physical activity may reduce prostate cancer risk among Black men, with activity during young adulthood possibly yielding the greatest benefit. This novel finding needs confirmation in additional studies.

Keywords

Physical activity; prostate; cancer; epidemiology

INTRODUCTION

Physical activity, or lack thereof, has been proposed as a modifiable risk factor for prostate cancer. In randomized exercise trials, physical activity increases levels of sex hormone-binding globulin (SHBG) (1) and SHBG levels have, in turn, been related to modest reductions in prostate cancer risk (2). However, despite a biologically plausible relation, a

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recent systematic review of 38 epidemiologic studies reported that physical activity was inconsistently associated with prostate cancer risk (3). The review also noted that, in order to resolve these inconsistent findings, it is necessary to conduct further large-scale etiological studies which assess the physical activity and prostate cancer relation among racial/ethnic minorities, such as Black men, and which examine physical activity over the entire lifespan. To date, only three studies have examined physical activity in relation to prostate cancer among Black men (4–6), with one prospective study finding a 3-fold risk of prostate cancer among inactive Black men (4) and two case control studies finding no association (5,6). Four studies have examined physical activity over the entire lifespan in relation to prostate cancer (7–11), with no strong evidence emerging for a protective effect of physical activity during earlier life.

In order to assess whether the physical activity and prostate cancer association varies by race/ethnicity and age period, we prospectively examined physical activity, according to age period and physical activity intensity, in relation to prostate cancer among ~165,000 White and Black men enrolled in the National Institutes of Health (NIH)-AARP Diet and Health Study.

METHODS

Study population

The NIH-AARP Diet and Health Study was established in 1995–1996 when 566,402 AARP members residing in one of six states (California, Florida, Pennsylvania, New Jersey, North Carolina, and Louisiana) or two metropolitan areas (Atlanta, GA and Detroit, MI) responded to a questionnaire soliciting information on demographic traits, physical activity, and other health-related behaviors. Selection of these sites was based on presence of high-quality cancer registries, minority representation, and large AARP memberships (12). To those who responded to the baseline questionnaire and who did not have a self-reported history of prostate, breast, or colorectal cancer, we mailed a second questionnaire within six months requesting further information on physical activity and other lifestyle factors. Participants in the current study responded to both questionnaires and were alive and had not moved out of the study area before returning their second questionnaire (N= 334,908). We excluded participants whose questionnaires were completed by proxy (N=10,383), females (N=136,408), individuals with a self-reported prevalent cancer (N=7,396), or any cancer diagnosis prior to the second questionnaire (N=2,157) or who were missing physical activity data (N=7,992). We excluded men who were neither Black (African-American) nor White (Caucasian) because of small case numbers (there were only 153 cases among Hispanics and 104 cases among Asians / Pacific Islanders). In total, our analytic cohort consisted of 160,006 White men and 3,671 Black men aged 51 to 72 years at the start of our follow-up.

The NIH-AARP Diet and Health Study was approved by the Special Studies Institutional Review Board of the National Cancer Institute. All participants provided written informed consent.

Assessment of physical activity

On the second questionnaire, participants were asked to report the amount of time spent engaging in moderate/vigorous activities (e.g. biking, fast walking, aerobics, and jogging/running) and light activities (e.g. light housework, slow walking, and light gardening) at ages 15–18, 19–29, 35–39 years, and during the past 10 years. In a published compendium, our examples of moderate intensity activity and light intensity activity corresponded approximately to metabolic equivalent (MET) values of 5 and 3, respectively (13). Participants selected their level of activity from six pre-established response options: never,

rarely, weekly but less than 1 hour per week, 1–3 hours per week, 4–7 hours per week, more than 7 hours per week (i.e. “frequent activity”).

In order to assess total physical activity at each age, we calculated age-specific indices of physical activity using the formula: moderate/vigorous activity * 5 METs + light physical activity * 3 METs. We also calculated an overall lifetime total physical activity index by averaging the age-specific physical activity indices.

Ascertainment and Classification of Prostate Cancer Cases

Incident, first primary prostate cancer cases (International Classification of Diseases 9th version, rubric 185 or 10th version, rubric C61) were identified through December 31, 2003 by linking the NIH-AARP cohort data with the eight state cancer registries serving our cohort and three additional states (AZ, NV, and TX). In a previous validation study, the sensitivity of cancer identification in our cohort was estimated at ~90% and the specificity was 99.5% (14). Deaths due to prostate cancer were, in addition, identified through linkage to the National Death Index Plus.

Statistical Analysis

Participants were followed from the date of return of the second questionnaire in late 1996 until the diagnosis of first cancer, a move from the cancer registry ascertainment areas, death, or until the date of last follow-up on December 31, 2003. The participants were thus followed for a maximum of 7 years and most (74%) were still being followed as of the end of 2003. Relative risks (RR) and 95% confidence intervals (95% CI) for prostate cancer were estimated using proportional hazards regression. In analyses of moderate/vigorous activity and light activity, the bottom two categories of physical activity (i.e. “never” and “rarely” engaging in moderate/vigorous or light physical activity) were collapsed into a new category (“infrequent” physical activity) to ensure sufficient numbers of cases in the reference category. For lifetime physical activity analyses, participants were categorized according to approximate quintiles of total MET-hr of activity per week (i.e. 11.5 or fewer, 11.6 to 26.5, 26.6 to 41.5, 41.6 to 51.5, 51.6 or greater MET-hr per week). The same groupings were utilized for each age-specific physical activity analysis. For tests of trend, each moderate/vigorous physical activity category was assigned a single value indicating approximate number of hours of activity per week (never / rarely = 0.125, weekly but less than 1 hour per week = 0.5, 1–3 hours per week = 2.0, 4–7 hours per week = 5.5, and more than 7 hours per week = 8.0).

Covariates were included in multivariate models if prior studies consistently found an association with prostate cancer, or if the covariate was a statistically significant predictor of prostate cancer in this cohort. In addition, models for ages 15–18, 19–29, and 35–39 years were adjusted for moderate/vigorous physical activity and light physical activity during the past 10 years. For covariates for which information was not complete, we assigned a missing indicator variable to model the non-response.

Linear trend tests were conducted using the midpoint value of each physical activity category (e.g. for the category of one to three hours of activity per week, a value of two hours was assigned). We formally tested for interactions of the physical activity and prostate cancer association by using the likelihood ratio test, i.e. comparing the likelihood of models with and without multiplicative interaction terms. Interaction terms were calculated as the cross product of physical activity, modeled as a continuous variable using category midpoints, and the factor of interest (e.g. race). Tests of the proportional hazards assumption did not reveal any departure from proportionality.

All p-values were based upon two sided tests with an alpha of 0.05. Analyses were performed using Statistical Analysis System (SAS) release 9.1.3 (SAS Institute, Cary, NC).

RESULTS

During up to 7 years of follow-up, 9,624 prostate cancer cases were identified in White men and 371 cases in Black men. Physical activity levels were correlated across the lifespan, with strong correlations (greater than 0.7) between adjacent age periods and moderate to weak correlations between non-adjacent age periods. The pairwise correlation coefficients of total physical activity during the ages of 15–18 with physical activity ages during ages 19–29, 35–39 years, and during the past 10 years were 0.75, 0.56, and 0.31, respectively. Similar patterns of correlation were observed among White and Black men alike. The respondents to our questionnaire were more educated than the general population, with 48 percent of White men and 36 percent of Black men having at least a college degree, as compared to 19 percent of White men and 6 percent of Black men of the same age-range in the general population (15).

The baseline characteristics among the least and most active White and Black members of our cohort are shown in Table 1. Frequent physical activity during ages 15–18 and 19–29 years was not related to participant demographics, lifestyle factors, or screening habits among either White or Black men. In contrast, frequent physical activity during ages 35–39 years and during the past 10 years was related to many participant factors, including more frequent rectal and PSA examinations, a lower body mass index, a lower likelihood of diabetes, and a greater dietary lycopene intake. Among Black men, physical activity during the past 10 years was additionally related to family history of prostate cancer (10.1 percent in active vs. 7.6 percent in inactive Black men). The proportion of men who engaged in the highest level of activity at ages 15–18 was slightly greater among Blacks (37%) than Whites (33%). In contrast, the proportion of men who engaged in the highest level of activity during the most recent 10 years was lower among Blacks (14%) than Whites (19%).

Table 2 shows the association of moderate/vigorous physical activity during different age periods with prostate cancer risk. Among White men, there was no association between time spent in physical activity of a moderate/vigorous intensity and incidence of prostate cancer, regardless of the age period examined (all $P_{\text{trend}} > 0.05$). For frequent moderate/vigorous physical activity during ages 15–18 years, the 95 percent confidence interval excluded one (95% CI=1.01–1.21), but the trend was not statistically significant ($P_{\text{trend}}=0.80$).

Among Black men, moderate/vigorous physical activity during specific age periods was related to prostate cancer risk, with the benefit most evident for activity during ages 19–29 (Table 2). The multivariate relative risks of prostate cancer for frequent vs. infrequent moderate/vigorous physical activity performed during specific ages were as follows: ages 15–18: RR=0.78 (95% CI= 0.52–1.17; $P_{\text{trend}}=0.39$); ages 19–29: RR=0.67 (95% CI= 0.43–1.05; $P_{\text{trend}}=0.02$), ages 35–39: RR=0.59 (95% CI= 0.36–0.96; $P_{\text{trend}}=0.15$), and, for activity during the past 10 years: RR=1.28 (95% CI= 0.85–1.92; $P_{\text{trend}}=0.04$). Because the results for moderate/vigorous physical activity during ages 19–29 years suggested a potential threshold effect, we reanalyzed the data by grouping the two highest activity levels. In this reanalysis, the relative risk for engaging in four or more hours per week of moderate/vigorous physical activity vs. infrequent activity was 0.65 (95% CI= 0.43–0.99; $P_{\text{trend}}=0.01$). We also examined whether the association of moderate/vigorous physical activity during ages 19–29 years to prostate cancer differed between White and Black men but the difference was only of borderline statistical significance ($P_{\text{interaction}}=0.10$). Among Black men, moderate/vigorous activity during the past 10 years was modestly associated with increased prostate

cancer risk ($P_{\text{trend}}=0.04$), but the point estimates for distinct physical activity categories were not statistically significant.

In Table 3, we show that physical activity of a light intensity was not related to prostate cancer risk among either White or Black men (all $P_{\text{trend}} > 0.05$). Among White men, the multivariate relative risks of prostate cancer for frequent vs. infrequent light physical activity during ages 15–18, 19–29, 35–39 years, and during the past 10 years were 0.97, 0.95, 0.91, and 0.96, respectively. Among Black men, the corresponding multivariate relative risks were 0.99, 0.96, 1.25, and 0.84.

Table 4 indicates the association of total physical activity (i.e. moderate/vigorous and light activity combined) during different age periods with prostate cancer risk. Total physical activity was not related to prostate cancer risk among White men (all $P_{\text{trend}} > 0.05$). Among Black men, total physical activity during ages 19–29 was associated with a modest reduction in prostate cancer risk (high vs. low total physical activity; $HR=0.75$, $P_{\text{trend}}=0.045$). This association likely reflects vigorous physical activity, as light physical activity was unrelated to prostate cancer risk.

To further explore the association of moderate/vigorous intensity physical activity during young adulthood to prostate cancer among Black men, table 5 shows analyses stratified according to age at baseline (<65 vs. ≥ 65), age at diagnosis (<65 vs. ≥ 65), and body mass index at baseline (<25 vs. ≥ 25). Among Black men younger than age 65 at baseline, frequent moderate/vigorous physical activity during young adulthood was related to a 56 percent reduced risk of prostate cancer relative to infrequent exercise at this age ($RR=0.44$; 95% $CI=0.26-0.76$; $P_{\text{trend}} < 0.01$; $P_{\text{interaction}}=0.03$). Similar, but somewhat less robust, findings were found for analyses of prostate cancers diagnosed before age 65 ($RR=0.43$; 95% $CI=0.21-0.88$; $P_{\text{trend}}=0.09$). For Black men with a body mass index less than 25 at baseline, frequent moderate/vigorous physical activity was related to a 57 percent reduction in prostate cancer risk among active men ($RR=0.43$; 95% $CI=0.18-1.00$; $P_{\text{trend}}=0.02$; $P_{\text{interaction}}=0.08$).

We also conducted analyses stratified by whether men had or had not received a PSA blood test in the past 3 years. However, we found no evidence that relative risks for moderate/vigorous intensity, light intensity, and total activity differed by PSA screening (all $P_{\text{interaction}} > 0.05$).

DISCUSSION

In this large prospective cohort study of men of 51 to 72 years of age at study baseline, we examined physical activity, according to age period and intensity of activity, in relation to prostate cancer among U.S. Whites and U.S. Blacks. Similar to previous studies (3), we found little evidence of a relationship between physical activity and prostate cancer among White men. However, among Black men, we found that frequent physical activity of a moderate to vigorous intensity during young adulthood (i.e. ages 19 to 29 years) was related to a statistically significant 35 percent reduction in prostate cancer risk. This relation was particularly pronounced among Black men who were younger than 65 years of age and who were light weight at baseline. A suggestive association was also observed for physical activity of a moderate/vigorous intensity during ages 35–39 years but the trend did not reach statistical significance. These results provide some evidence that physical activity, particularly during young adulthood, may reduce the risk of prostate cancer among Black men. However, given that our findings are novel and that physical activity was only moderately linked with reduced risk, these findings require confirmation in future studies.

Contrary to what we expected, frequent activity of a moderate/vigorous intensity during the last 10 years was related to modestly increased prostate cancer risk among Black men. The confidence intervals for each physical activity category were quite wide, suggesting a possible chance finding. To the best of our knowledge, there is no prior biological rationale for such an association and therefore further data is required to interpret this finding.

Although speculative, there are several potential biological reasons for why physical activity may reduce prostate cancer risk among Black but not White men. Genetic variants that predispose to prostate cancer are known to be as much as 20 times more common among Black men than White men (16), suggesting different underlying biological susceptibilities to this disease. The microenvironment of prostate tumors has been found to differ between Black men and White men, with higher expression of genes related to inflammation and immune function among prostate tumors of Black men (17). Because physical activity reduces inflammation and improves immune function (3), exercise may arguably reduce prostate cancer risk more among Black men than White men. Black men have been observed to have higher levels of testosterone during young adulthood than White men (18). Physical activity increases levels of the binding hormone for testosterone, sex hormone-binding globulin (SHBG) (1), and therefore could be of particular importance among Black men for modulating free testosterone levels. Resting energy expenditure is known to be lower in Blacks by about 50 to 160 kcal as compared with Whites, even after adjusting for body size differences (19). Regular physical activity may help to offset this racial/ethnic difference in energy balance. The roles of inflammation (20), sex steroid levels (2), and energy balance (21) in prostate carcinogenesis are currently under investigation, and it is therefore difficult at this time to evaluate the relative importance of each mechanism.

To date, physical activity has been examined in relation to prostate cancer among Black men in only three prior studies (4–6). Of these studies, one study reported that physical inactivity was associated with a 3-fold risk of prostate cancer (4) but the others reported null results (5,6). These studies did not examine physical activity during young adulthood, they also included few cases (in the smallest study, only 47 cases were identified), and did not examine the same types and intensities of physical activity. These differences prevent any clear conclusions on the physical activity and prostate cancer relation among Black men.

Young adulthood may be a period of particular interest with respect to prostate cancer risk as prostate cancer precursors (i.e. prostatic intraepithelial neoplasias) often develop early in life, including during young adulthood (22). The relationship between physical activity during young adulthood and prostate cancer has been examined previously in only two case-control studies (7,8); neither found a link between physical activity during young adulthood and prostate cancer. Three additional studies examined physical activity over the lifespan, albeit at older ages (9–11). In two prospective studies, neither recreational activity at age 30 (10) nor at age 40 (11) was linked with prostate cancer risk. In the case-control study, occupational but not leisure activity during ages 30–39 was associated with reduced prostate cancer risk (9).

Among Black men, the reduction in prostate cancer risk conferred by physical activity during young adulthood was especially robust among men younger than 65 years of age at baseline. This may reflect that prostate cancers diagnosed at a young age may be of different subtypes than prostate cancers diagnosed later in life (23). Alternately, differing associations by age could be due to birth cohort effects. The younger men in our study were born between 1931 and 1945, which coincides with the period of the Great Depression and World War II. These men would likely have had highly restricted diets during childhood and this restriction may act in combination with physical activity during young adulthood to reduce prostate cancer risk.

Our study includes several limitations that argue for caution in interpreting the results reported herein. Our assessment of physical activity was based upon self-report. The assessment of physical activity during young adulthood therefore required participants to recall activity from a period 20 to 30 years in the past. Such distant recall may have resulted in imprecise assessment and some error in the estimation of relative risks. In previous research, physical activity recalled 15 years into the past was correlated at the level of $r=0.30$ with physical activity measured objectively at that time (24). We are not aware of data indicating the validity of physical activity recalled over periods longer than 15 years. The proportion of men in our study who were Black (2.2 percent) was relatively low when compared with that of the general population in this age-range (approximately 7–8 percent) (15). This may reflect, at least in part, the tendency of our cohort to attract men of a relatively high education level. Due to disparities in education, there are fewer Black men proportionately to recruit at these higher education levels. While our study included many cases among Black men, we did not have sufficient case numbers to examine advanced or fatal prostate cancers. In a previous study within our cohort, physical activity was similarly related to total prostate cancer, advanced prostate cancer, and fatal prostate cancer (25). Although we adjusted for many potential confounding variables, unknown factors associated with both physical activity and prostate cancer may partly explain the associations observed. Given the modest association between physical activity and prostate cancer, our results could be due to chance and need to be confirmed in additional studies.

The strengths of our study include the prospective design, the large number of prostate cancer cases which allowed us to separately analyze White and Black men, and the extensive data collected on intensity and frequency of physical activity across the entire lifespan. In addition, extensive data on possible confounding factors was collected for our participants. This allowed us to carefully control for many important lifestyle factors, such as diet, body weight, supplement use, that are correlated with physical activity.

In conclusion, our study demonstrated a relationship between frequent physical activity of a moderate to vigorous intensity during young adulthood and reduction in subsequent prostate cancer risk among Black men. Additional research is needed to confirm our findings and to further elaborate upon the potential mechanisms responsible for this association.

Condensed abstract

Regular physical activity may reduce prostate cancer risk among Black men, with activity during young adulthood possibly yielding the greatest benefit. This novel finding needs confirmation in additional studies.

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Table 1

Demographic and lifestyle characteristics among those participants who were least and most active during ages 15–18, 19–29, 35–39 years, and in the past 10 years.

Characteristic	Level of physical activity							
	Age 15–18		Age 19–29		Age 35–39		Past 10 yrs	
	Least active ^d	Most active	Least active	Most active	Least active	Most active	Least active	Most active
White men								
Participants, No.	24,531	53,192	28,848	40,298	33,483	29,842	32,903	29,988
Age, y	63.1	63.1	62.8	63.4	62.8	63.5	62.4	63.8
Family history of prostate cancer, %	8.5	9.0	8.8	8.8	8.7	8.8	8.5	8.9
Rectal examination during past 3 yrs								
None, %	14.6	14.7	14.0	15.2	14.8	15.0	17.0	13.6
Once, %	27.9	27.0	27.3	27.0	28.0	26.8	29.8	25.2
More than once, %	57.5	58.3	58.7	57.7	57.2	58.3	53.2	61.2
PSA blood test during past 3 yrs								
None, %	22.8	22.8	22.2	23.5	23.1	23.3	26.2	21.0
Once, %	26.4	26.4	26.0	26.2	26.2	26.1	28.2	24.9
More than once, %	50.8	50.8	51.7	50.3	50.7	50.6	45.6	54.1
Body mass index, Kg/M ²	26.9	27.4	26.9	27.4	27.3	27.1	28.2	26.4
History of diabetes, %	9.7	9.6	9.7	9.4	11.2	8.5	13.1	7.1
Lycopene intake (Mcg/ day)	7,351	8,035	7,359	8,109	7,388	8,158	7,431	8,182
Black men								
Participants, No.	589	1,344	647	1,052	955	673	1,185	499
Age, y	62.2	61.4	62.0	61.6	61.6	61.6	61.5	61.8
Family history of prostate cancer, %	9.6	8.5	9.0	9.2	8.8	9.0	7.6	10.1
Rectal examination during past 3 yrs								
None, %	14.9	13.5	16.2	13.2	17.8	13.2	19.6	11.6
Once, %	30.4	26.5	30.4	25.4	29.5	24.9	30.5	25.0
More than once, %	54.7	59.9	53.4	61.4	52.7	61.9	49.8	63.4
PSA blood test during past 3 yrs								
None, %	26.3	24.4	25.4	24.9	26.0	23.8	28.2	18.4

Characteristic	Level of physical activity							
	Age 15–18		Age 19–29		Age 35–39		Past 10 yrs	
	Least active ^I	Most active	Least active	Most active	Least active	Most active	Least active	Most active
Once, %	30.5	27.5	30.2	27.2	30.2	25.7	32.5	26.9
More than once, %	43.2	48.0	44.4	47.9	43.8	50.4	39.3	54.7
Body mass index, Kg/M ²	28.2	28.0	28.2	27.9	28.4	27.5	28.7	26.9
History of diabetes, %	20.0	17.3	19.4	17.6	21.0	15.5	20.0	14.4
Lycopene intake (Mcg/ day)	5,728	6,083	5,509	6,216	5,485	6,610	5,417	6,271

^I Participants who were the least active are those who engaged in less than the equivalent of 11.5 MET-h of light, moderate, and/or vigorous activity combined. Participants who were the most active are those who engaged in 51.6 MET-h or more of light, moderate, and/or vigorous activity.

Relative risks (RR) of prostate cancer as related to moderate/vigorous physical activity by age period.

Table 2

		Frequency of moderate/vigorous activity					
	Infrequent	Weekly, <1 hour/ week	1–3 hours/ week	4–7 hours/ week	≥ 7 hours/ week	P for Trend	
White men							
Age 15–18 years							
Cases	627	512	1,628	2,104	4,753		
Age-adjusted RR	1 (Ref)	1.13 (1.01–1.27)	1.16 (1.06–1.27)	1.15 (1.05–1.26)	1.14 (1.05–1.24)	0.23	
Multivariate ^f RR	1 (Ref)	1.12 (0.99–1.26)	1.15 (1.05–1.27)	1.13 (1.03–1.24)	1.11 (1.01–1.21)	0.80	
Age 19–29 years							
Cases	744	755	2,146	2,719	3,260		
Age-adjusted RR	1 (Ref)	1.03 (0.93–1.14)	1.03 (0.95–1.12)	1.04 (0.96–1.13)	1.00 (0.93–1.09)	0.58	
Multivariate RR	1 (Ref)	1.01 (0.91–1.12)	1.02 (0.93–1.11)	1.01 (0.93–1.11)	0.97 (0.89–1.07)	0.28	
Age 35–39 years							
Cases	915	950	2,585	2,755	2,419		
Age-adjusted RR	1 (Ref)	0.96 (0.88–1.06)	1.01 (0.94–1.09)	1.00 (0.93–1.08)	1.01 (0.94–1.09)	0.55	
Multivariate RR	1 (Ref)	0.95 (0.86–1.04)	0.99 (0.90–1.08)	0.96 (0.87–1.05)	0.98 (0.88–1.08)	0.73	
Past 10 years							
Cases	1,213	926	2,365	2,620	2,500		
Age-adjusted RR	1 (Ref)	1.02 (0.93–1.11)	1.06 (0.99–1.14)	1.11 (1.04–1.19)	1.09 (1.02–1.17)	0.003	
Multivariate RR	1 (Ref)	0.99 (0.90–1.08)	1.01 (0.94–1.09)	1.04 (0.97–1.12)	1.03 (0.96–1.11)	0.19	
Black men							
Age 15–18 years							
Cases	39	20	60	71	181		
Age-adjusted RR	1 (Ref)	0.82 (0.48–1.41)	0.81 (0.54–1.21)	0.81 (0.54–1.19)	0.84 (0.59–1.19)	0.71	
Multivariate RR	1 (Ref)	0.84 (0.48–1.47)	0.81 (0.52–1.24)	0.74 (0.48–1.14)	0.78 (0.52–1.17)	0.39	
Age 19–29 years							
Cases	40	35	73	92	131		
Age-adjusted RR	1 (Ref)	1.09 (0.69–1.72)	0.80 (0.55–1.18)	0.74 (0.51–1.07)	0.80 (0.56–1.14)	0.13	
Multivariate RR	1 (Ref)	1.12 (0.69–1.83)	0.78 (0.51–1.21)	0.61 (0.40–0.95)	0.67 (0.43–1.05)	0.02	
Age 35–39 years							

		Frequency of moderate/vigorous activity					
	Infrequent	Weekly, <1 hour/ week	1–3 hours/ week	4–7 hours/ week	≥ 7 hours/ week	P for Trend	
Cases	56	35	90	106	84		
Age-adjusted RR	1 (Ref)	0.75 (0.49–1.15)	0.82 (0.59–1.15)	0.97 (0.70–1.34)	0.87 (0.62–1.22)	0.74	
Multivariate RR	1 (Ref)	0.75 (0.47–1.20)	0.69 (0.45–1.04)	0.69 (0.45–1.07)	0.59 (0.36–0.96)	0.15	
Past 10 years							
Cases	73	36	97	97	68		
Age-adjusted RR	1 (Ref)	0.81 (0.54–1.21)	1.14 (0.84–1.54)	1.26 (0.93–1.70)	1.20 (0.86–1.67)	0.06	
Multivariate RR	1 (Ref)	0.76 (0.50–1.16)	1.14 (0.81–1.61)	1.34 (0.94–1.91)	1.28 (0.85–1.92)	0.04	

I Multivariate models are adjusted for age at baseline, age-squared, history of digital rectal exam during past three years (none, once, more than once), history of PSA exam during past three years (none, once, more than once), body mass index at baseline (<25, 25–29.9, 30.0–34.9, 35.0–39.9, 40+), body mass index at age 18 (<25, 25–29.9, 30.0–34.9, 35.0–39.9, 40+), waist circumference (<35 inches, 35–38, 39–41, 42–44, 44+), history of diabetes (yes/no), highest level of education (did not complete high school, completed high school, some college, completed college and/or graduate school), marital status (married, divorced, separated, widowed, unmarried), smoking history (current smoker, former smoker, non-smoker), family history of prostate cancer (yes/no), multivitamin use (yes/no), supplemental zinc use (yes/no), alcohol intake (quintiles), and quintiles of energy-adjusted intakes of red meat, processed meats, alpha-linolenic acid, gamma-tocopherol, lycopene, fish, calcium (from the combination of food and supplements), and vitamin D (from the combination of food and supplements). In addition, models for ages 15–18, 19–29, and 35–39 years were adjusted for light physical activity during each of the respective periods, as well as moderate/vigorous physical activity and light physical activity during the past 10 years. Models for physical activity during the past 10 years were not adjusted for physical activity during earlier ages but were adjusted for light physical activity during the same period.

Table 3

Relative risks of prostate cancer as related to time spent in light physical activity by age period.

		Frequency of light physical activity				
	Infrequent	Weekly, <1 hour/ week	1–3 hours/ week	4–7 hours/ week	≥ 7 hours/ week	P for Trend
White men						
Age 15–18 years						
Cases	1,695	860	2,131	1,738	3,200	
Age-adjusted RR	1 (Ref)	1.00 (0.92–1.09)	0.99 (0.93–1.06)	0.94 (0.88–1.01)	0.97 (0.92–1.03)	0.19
Multivariate ¹ RR	1 (Ref)	0.98 (0.90–1.07)	0.97 (0.90–1.03)	0.92 (0.86–0.99)	0.97 (0.91–1.04)	0.33
Age 19–29 years						
Cases	1,235	958	2,380	2,318	2,733	
Age-adjusted RR	1 (Ref)	1.00 (0.92–1.09)	0.95 (0.88–1.01)	0.94 (0.88–1.01)	0.94 (0.88–1.01)	0.06
Multivariate RR	1 (Ref)	0.98 (0.90–1.07)	0.93 (0.86–0.99)	0.92(0.85–1.00)	0.95 (0.87–1.03)	0.46
Age 35–39 years						
Cases	1,062	982	2,612	2,566	2,402	
Age-adjusted RR	1 (Ref)	0.99 (0.91–1.08)	0.93 (0.87–1.00)	0.93 (0.86–1.00)	0.94 (0.88–1.01)	0.13
Multivariate RR	1 (Ref)	0.98 (0.89–1.08)	0.90 (0.82–0.98)	0.89 (0.81–0.97)	0.91 (0.82–1.01)	0.17
Past 10 years						
Cases	1,213	926	2,365	2,620	2,500	
Age-adjusted RR	1 (Ref)	0.98 (0.89–1.08)	1.01 (0.93–1.09)	1.02 (0.94–1.10)	1.01 (0.94–1.09)	0.50
Multivariate RR	1 (Ref)	0.97 (0.88–1.07)	0.98 (0.91–1.06)	0.97 (0.90–1.05)	0.96 (0.89–1.04)	0.33
Blackmen						
Age 15–18 years						
Cases	61	27	79	73	131	
Age-adjusted RR	1 (Ref)	1.03 (0.65–1.62)	0.94 (0.67–1.31)	1.06 (0.76–1.49)	0.92 (0.68–1.24)	0.66
Multivariate RR	1 (Ref)	1.07 (0.66–1.72)	1.00 (0.70–1.44)	1.18 (0.81–1.72)	0.99 (0.70–1.41)	0.94
Age 19–29 years						
Cases	49	35	81	101	105	
Age-adjusted RR	1 (Ref)	0.93 (0.60–1.43)	0.86 (0.60–1.22)	0.98 (0.69–1.37)	0.83 (0.59–1.17)	0.53
Multivariate RR	1 (Ref)	0.95 (0.60–1.50)	0.95 (0.64–1.42)	1.17 (0.78–1.74)	0.96 (0.63–1.47)	0.70
Age 35–39 years						

Frequency of light physical activity						
	Infrequent	Weekly, <1 hour/ week	1–3 hours/ week	4–7 hours/ week	≥ 7 hours/ week	P for Trend
Cases	49	39	96	99	88	
Age-adjusted RR	1 (Ref)	0.91 (0.60–1.38)	0.91 (0.64–1.28)	1.03 (0.73–1.46)	1.00 (0.71–1.42)	0.51
Multivariate RR	1 (Ref)	0.89 (0.56–1.43)	1.02 (0.67–1.55)	1.22 (0.78–1.91)	1.25 (0.76–2.06)	0.14
Past 10 years						
Cases	54	45	106	82	84	
Age-adjusted RR	1 (Ref)	1.17 (0.79–1.74)	1.07 (0.77–1.48)	0.98 (0.70–1.39)	1.09 (0.78–1.54)	0.94
Multivariate RR	1 (Ref)	1.18 (0.78–1.79)	0.92 (0.64–1.32)	0.78 (0.53–1.15)	0.84(0.56–1.26)	0.13

¹ Multivariate models are adjusted for covariates indicated in Table 2. In addition, models for ages 15–18, 19–29, and 35–39 years were adjusted for moderate/vigorous physical activity during each of the respective periods, as well as light physical activity and moderate/vigorous physical activity during the past 10 years. Models for physical activity during the past 10 years were not adjusted for physical activity during earlier ages but were adjusted for light physical activity during the same period.

Relative risk of prostate cancer as related to MET-h of physical activity per week by age period.

Table 4

	MET-h of physical activity per week					P for Trend
	≤ 11.5	11.6–26.5	26.6–41.5	41.6–51.5	51.6+	
White men						
Age 15–18 years						
Cases	1,417	1,192	2,105	1,713	3,197	
Age-adjusted RR	1 (Ref)	1.07 (0.99–1.15)	1.08 (1.00–1.15)	1.04 (0.97–1.11)	1.04 (0.98–1.11)	0.67
Multivariate ¹ RR	1 (Ref)	1.05 (0.97–1.14)	1.03 (0.96–1.10)	1.00 (0.93–1.08)	1.02 (0.95–1.09)	0.88
Age 19–29 years						
Cases	1,726	1,717	1,798	1,965	2,418	
Age-adjusted RR	1 (Ref)	0.99 (0.93–1.06)	1.04 (0.97–1.11)	0.97 (0.91–1.03)	0.97 (0.91–1.03)	0.16
Multivariate RR	1 (Ref)	0.98 (0.91–1.05)	1.00 (0.93–1.07)	0.94 (0.88–1.01)	0.95 (0.88–1.01)	0.06
Age 35–39 years						
Cases	2,010	2,201	1,523	2,026	1,864	
Age-adjusted RR	1 (Ref)	0.97 (0.91–1.03)	1.00 (0.94–1.07)	0.96 (0.90–1.02)	0.99 (0.93–1.05)	0.67
Multivariate RR	1 (Ref)	0.93 (0.88–1.00)	0.94 (0.87–1.01)	0.91 (0.84–0.97)	0.95 (0.88–1.03)	0.12
Past 10 years						
Cases	1,749	2,336	1,524	2,097	1,918	
Age-adjusted RR	1 (Ref)	1.05 (0.99–1.12)	1.13 (1.05–1.21)	1.10 (1.03–1.17)	1.07 (1.00–1.14)	0.02
Multivariate RR	1 (Ref)	1.02 (0.95–1.08)	1.06 (0.99–1.13)	1.03 (0.97–1.10)	1.01 (0.94–1.08)	0.71
Lifetime activity (averaged)						
Cases	808	2,172	2,902	1,746	1,996	
Age-adjusted RR	1 (Ref)	1.01 (0.93–1.09)	1.03 (0.96–1.12)	1.01 (0.93–1.10)	1.02 (0.94–1.11)	0.66
Multivariate RR	1 (Ref)	0.98 (0.90–1.06)	0.99 (0.91–1.07)	0.97 (0.89–1.05)	0.98 (0.90–1.06)	0.59
Black men						
Age 15–18 years						
Cases	64	52	60	60	135	
Age-adjusted RR	1 (Ref)	1.00 (0.70–1.45)	0.84 (0.59–1.19)	0.95 (0.67–1.36)	0.93 (0.69–1.26)	0.69
Multivariate RR	1 (Ref)	0.99 (0.67–1.44)	0.74 (0.51–1.07)	0.89 (0.61–1.28)	0.85 (0.62–1.17)	0.36
Age 19–29 years						

	MET-h of physical activity per week						P for Trend
	≤ 11.5	11.6–26.5	26.6–41.5	41.6–51.5	51.6+		
Cases	72	66	60	70	103		
Age-adjusted RR	1 (Ref)	0.95 (0.68–1.33)	0.92 (0.65–1.30)	0.82 (0.59–1.14)	0.87 (0.64–1.17)		0.25
Multivariate RR	1 (Ref)	0.93 (0.66–1.31)	0.81 (0.57–1.16)	0.72 (0.51–1.02)	0.75 (0.54–1.05)		0.045
Age 35–39 years							
Cases	92	81	48	82	68		
Age-adjusted RR	1 (Ref)	0.98 (0.73–1.32)	1.02 (0.72–1.44)	1.17 (0.87–1.58)	1.02 (0.75–1.40)		0.53
Multivariate RR	1 (Ref)	0.93 (0.68–1.27)	0.86 (0.59–1.26)	1.01 (0.72–1.42)	0.91 (0.62–1.35)		0.84
Past 10 years							
Cases	103	93	49	75	51		
Age-adjusted RR	1 (Ref)	1.11 (0.84–1.47)	1.35 (0.96–1.90)	1.33 (0.99–1.79)	1.12 (0.80–1.56)		0.15
Multivariate RR	1 (Ref)	1.04 (0.78–1.39)	1.26 (0.89–1.79)	1.27 (0.94–1.73)	1.06 (0.75–1.50)		0.29
Lifetime activity (averaged)							
Cases	53	80	98	65	75		
Age-adjusted RR	1 (Ref)	0.80 (0.56–1.13)	0.73 (0.52–1.02)	0.85 (0.59–1.22)	0.94 (0.66–1.33)		0.90
Multivariate RR	1 (Ref)	0.76 (0.53–1.08)	0.69 (0.49–0.97)	0.78 (0.54–1.13)	0.88 (0.61–1.27)		0.85

[†] Multivariate models are adjusted for covariates indicated in Table 2. In addition, models for ages 15–18, 19–29, and 35–39 years were adjusted for total physical activity during the past 10 years.

Table 5

Relative risk of prostate cancer as related to time spent in vigorous physical activity at ages 19–29 among Black men¹.

	Frequency of vigorous physical activity at ages 19–29					P for Trend
	Infrequent	Weekly, <1 hour/ week	1–3 hours/ week	4–7 hours/ week	≥ 7 hours/ week	
Age (years) at baseline						
< 65						
Cases	28	23	49	64	85	
Age-adjusted RR	1 (Ref)	0.93 (0.53–1.61)	0.65 (0.41–1.04)	0.62 (0.40–0.96)	0.62 (0.40–0.96)	0.048
Multivariate ² RR	1 (Ref)	0.84 (0.46–1.52)	0.55 (0.32–0.93)	0.46 (0.27–0.77)	0.44 (0.26–0.76)	>0.01
≥ 65						
Cases	12	12	24	28	46	
Age-adjusted RR	1 (Ref)	1.42 (0.64–3.17)	1.15 (0.58–2.31)	1.01 (0.51–1.99)	1.25 (0.66–2.36)	0.83
Multivariate RR	1 (Ref)	1.51 (0.63–3.62)	1.32 (0.61–2.83)	0.92 (0.42–2.04)	1.32 (0.60–2.89)	0.99
Age (years) at prostate cancer diagnosis						
< 65						
Cases	15	13	25	36	50	
Age-adjusted RR	1 (Ref)	0.90 (0.43–1.88)	0.56 (0.30–1.07)	0.60 (0.33–1.09)	0.62 (0.35–1.11)	0.55
Multivariate RR	1 (Ref)	0.78 (0.35–1.73)	0.42 (0.21–0.87)	0.40 (0.20–0.82)	0.43 (0.21–0.88)	0.09
≥ 65						
Cases	25	22	48	56	81	
Age-adjusted RR	1 (Ref)	1.22 (0.69–2.17)	0.97 (0.60–1.58)	0.82 (0.51–1.32)	0.92 (0.58–1.44)	0.31
Multivariate RR	1 (Ref)	1.19 (0.64–2.18)	0.97 (0.57–1.66)	0.70 (0.40–1.21)	0.78 (0.44–1.36)	0.10
Body Mass Index at baseline						
< 25						
Cases	13	7	27	28	28	
Age-adjusted RR	1 (Ref)	0.89 (0.35–2.23)	0.97 (0.50–1.88)	0.61 (0.31–1.17)	0.54 (0.28–1.04)	0.01
Multivariate RR	1 (Ref)	0.69 (0.25–1.89)	0.76 (0.35–1.66)	0.41 (0.18–0.93)	0.43 (0.18–1.00)	0.02
≥ 25						
Cases	26	26	42	61	99	
Age-adjusted RR	1 (Ref)	1.16 (0.67–1.99)	0.68 (0.42–1.12)	0.77 (0.48–1.22)	0.89 (0.58–1.37)	0.84
Multivariate RR	1 (Ref)	1.07 (0.60–1.91)	0.60 (0.35–1.04)	0.58 (0.34–0.98)	0.63 (0.37–1.08)	0.10

¹ $P_{\text{interaction}}$ for age at baseline=0.03. $P_{\text{interaction}}$ for BMI=0.08

² Multivariate models are adjusted for age at baseline, age-squared, history of digital rectal exam during past three years (none, once, more than once), history of PSA exam during past three years (none, once, more than once), body mass index at baseline (<25, 25–29.9, 30.0–34.9, 35.0–39.9, 40+), body mass index at age 18 (<25, 25–29.9, 30.0–34.9, 35.0–39.9, 40+), smoking history (current smoker, former smoker, non-smoker), family history of prostate cancer (yes/no), quintiles of energy-adjusted intakes of gamma-tocopherol, calcium (from the combination of food and supplements), light physical activity during ages 19–29, moderate/vigorous physical activity during the past 10 years, and light physical activity during the past 10 years.