 International Journal of Epidemiology 2001;**30**:341–349

Prostate cancer, benign prostatic hyperplasia and physical activity in Shanghai, China

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Background Studies suggest that increased levels of physical activity might decrease the risk of prostate cancer. We ascertained lifetime measures of activity in a population-based case-control study of prostate cancer in Shanghai, China to investigate physical activity in a population where the incidence of prostate cancer is low but rising.

Methods In all, 238 men with prostate cancer, diagnosed 1993–1995, were identified through a rapid reporting system. A second group of 206 men with benign prostatic hyperplasia (BPH) was matched to prostate cancer cases, and 471 age-matched and population-based controls were identified from urban Shanghai. Through personal interviews, we ascertained all daily, occupational, and recreational activities at ages 20–29, ages 40–49, and in 1988 to generate hours spent sleeping, sitting, in moderate activity, and in vigorous activity. Time spent per week in different activities was converted to metabolic equivalents (MET-h) and energy expended.

Results Time spent in, MET-h of, and energy expended in physical activities were not consistently related to either prostate cancer or BPH when compared to controls. Few men reported regular vigorous activity. Occupational activity, based on an energy expenditure index using job titles, was suggestively associated with a decreased risk of BPH, but not associated with prostate cancer. Associations did not vary according to age or stage of prostate cancer at diagnosis.

Conclusions Our results, based on regular physical activity, occupational activity, hours in activities, MET-h, and energy expended, did not support a protective role of physical activity in prostate cancer or BPH for men in a low-risk population.

Keywords Physical activity, prostate cancer, MET, energy expended, BPH, China

Accepted 4 July 2000

Incidence rates of prostate cancer are highest in US men but lowest among men in Shanghai, China.[1] Such variation suggests that cultural, lifestyle, genetic, or environmental differences contribute to prostate cancer incidence. While the introduction and utilization of screening[2] accounts for some of the incidence rate among US men,[3] the small absolute but large relative increase in incidence in Shanghai since 1972[4] cannot be attributed entirely to screening because regular screening is uncommon there. The recent rise in incidence rate in Shanghai indicates a changing prevalence of causal or contributing factors in this low-risk population.

Few causal factors for prostate cancer have been identified,[5] but physical activity has been associated with a reduced risk.[6] Some[7–14] but not all[15–17] epidemiological investigations found decreased risks of prostate cancer among physically active men, while a few studies noted increased risks in men with higher activity levels.[18–20] Methodological variation in these studies, which have used recreational activities, occupational activities, participation in athletics, energy expended, heart rate, and daily activity such as stair climbing to estimate physical activity, may account for some of the diverse findings. The best way to characterize activity is not known, and no gold standard exists for measuring physical activity.[21] Not only do different population groups participate in different activities, but relative levels of common activities may differ across populations and across age groups. At present, the type, intensity, and timing of physical activity that might confer benefit are not known.[22]

To overcome some of these methodological difficulties, we conducted a population-based case-control study in China that used a structured questionnaire to characterize all physical activity

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at three different periods in life. Because neither single activities nor multiple activities at one point in time can adequately identify lifetime activity, we queried all daily and occupational activities during young adulthood, middle adulthood, and later adulthood.

Materials and Methods

Study subjects

Cases

Details of the study methods are described elsewhere.[23] Men diagnosed with primary incident prostate carcinoma between 1993 and 1995 were identified through a rapid reporting system established between the Shanghai Cancer Institute and 28 collaborating hospitals in urban Shanghai. The institutional review boards at the National Cancer Institute and each institution in Shanghai approved this study. Permanent residents in ten urban districts of Shanghai who did not have a history of cancer were eligible. Of 268 eligible cases (who represent 95% of all prostate cancers diagnosed in Shanghai during the study period), 243 (91%) were interviewed. A second case group of 206 men with benign prostatic hyperplasia (BPH) who were undergoing prostatectomy were matched on age and hospital to the men with prostate cancer.

Pathology review

Pathologists in Shanghai and two pathologists from the Armed Forces Institute of Pathology (Washington, DC) independently reviewed biopsy slides from cases and BPH controls to confirm the original diagnosis and staging. After a consensus review with all pathologists, five men originally diagnosed as prostate cancer were considered to have BPH and excluded from the study.

Population controls

In all, 495 population controls were randomly selected from permanent residents of Shanghai and frequency-matched to the expected age distribution (in 5-year categories) of the prostate cancer cases. Information on potential controls was obtained from the personal identification cards maintained at the Shanghai Resident Registry, which contains personal registry cards for all residents 18 years or older in urban Shanghai. A total of 471 eligible identified controls completed the interview (95%), and 313 underwent digital rectal examination (DRE) and prostate specific antigen testing to identify prostate-related disorders.

Personal interview

Trained Chinese men (primarily retired male health professionals from Shanghai) personally interviewed participants, using a structured questionnaire that included demographic and residential characteristics, dietary history, cigarette use, alcohol and other beverage consumption, medical history, family history of cancer, occupation, physical activity, body size, and sexual behaviour. Men with prostate cancer or BPH were interviewed in the hospital, while healthy controls were interviewed in their home. On average, men with prostate cancer were interviewed less than 20 days after their diagnosis, and men with BPH less than 34 days after their surgery.

Assessment of physical activity

Occupational physical activity

Usual level of activity at work was ascertained for three different time periods: during ages 20–29, during ages 40–49, and in 1988 (median age in 1988 = 67 years) (hereafter referred to as the three time periods). Men were asked whether their main physical activity at work was sitting, light labour (standing, walking about, and light work), or heavy labour (carrying loads on foot, digging, and intense physical labour). We ascertained the job titles for men's occupations during the three time periods. Job titles were coded according to a modified version of the Standard Occupational Classification code system that included typical job titles for Shanghai. Based on a previously developed job-exposure matrix,[12] we assigned an energy expenditure index of sedentary activity (e.g. office work), moderate activity (e.g. walking or sweeping), and high activity (e.g. wall painting) based on occupation codes.[24]

Hours spent in physical activity

For each of the three time periods, men were asked whether their usual daily activities were the same all 7 days of the week or whether their usual activities differed during some days of the week. Men who did not have the same level of activities for all 7 days of the week divided the week into two patterns based on the number of days with similar levels of activity. For example, a respondent who was sedentary during the 5-day working week but highly active during the 2-day weekend was classified as spending 5 days on pattern 1 and 2 days on pattern 2. All combinations of days spent in each pattern during the week were allowed. All activity questions were asked twice for men who had two activity patterns during the week to assess total physical activity on each pattern; men whose activity did not change during the week answered only one set of activity questions.

Men reported the number of hours per day spent in four activity categories: sleeping, sedentary activities, moderate activities, and vigorous activities. Sedentary activities included sitting, having a meal, talking or chatting, office work (typing or writing), watching TV or movies, listening to music, reading, playing board games, and 'crafts and other sedentary leisure activities'. Moderate activities included work in a standing position, tidying up rooms, cooking, shopping, strolling, driving a car, house cleaning, dancing, climbing stairs, billiards, and badminton. Vigorous activities included swimming, jogging, running, ascending heights or climbing slopes, shovelling and mixing, loading, lifting loads and similar labour, and bicycle riding. Men with only one pattern of activity reported the number of hours per day spent in each activity category, and these totals were multiplied by seven to generate hours spent in each activity category per week. Men who had two activity patterns reported the number of hours per day in each activity category separately for each pattern, which was multiplied by the number of days in that pattern and summed across both patterns to generate the number of hours per week in each activity category. Weekly activity was calculated for each of the three time periods.

Metabolic equivalents

Metabolic equivalents (MET) represent the number of kilocalories per hour per kilogram of bodyweight expended in activities. Sleeping expends one kilocalorie per hour per kilogram of body weight, and serves as the referent group for other activities. We assigned MET scores of 1.5, 3.0, and 5.0 for sedentary, moderate, and vigorous activities, respectively, to generate weighted estimates of time spent each week in activity categories.[15] Weekly estimates of time spent in activity categories were multiplied by MET to generate a measure of weighted hours of physical activity during the three time periods.

Energy expended

We converted the time spent in each activity category into weekly energy expended. The number of hours per week in each activity category (h/week) was multiplied by the MET score (converted to J/[h][kg]) and by each subject's self-reported weight (kg) at that time period to estimate weekly energy expended (in J/week). Weekly energy expended was calculated for all moderate and vigorous activities combined, and for all activities combined (sleeping, sitting, moderate activities, and vigorous activities) for each of the three time periods. For each activity category, the distribution of weekly energy expended among controls was used to generate quartile cutpoints. The distribution of MET-h per week in activities among controls was divided into tertiles rather than quartiles because of clustered observations (i.e. most estimates were multiples of 7) whose quartile cutpoints yielded uneven numbers of men in each category.

Statistical analysis

Unconditional logistic regression[25] in the SAS statistical package[26] generated odds ratios (OR) and 95% CI to estimate the risk of prostate cancer or BPH relative to the controls. The lowest quartile (or tertile) served as the referent group for risk associated with activity in higher quartiles (or tertiles). Other continuous and calculated variables were categorized into quartiles based on the distribution among controls. Final models included age and education, marital status, average number of calories consumed per week (in quartiles), body mass index (BMI, calculated as weight divided by the square of height) during that time period, and waist-to-hip ratio (WHR, measured at interview) as potential confounders. We assessed potential interactions with BMI and WHR through stratification. Tests for trend were based upon regression models that included activity as an ordinal variable.

Table 1 Descriptive factors among 238 men with prostate cancer, 206 men with benign prostatic hyperplasia (BPH), and 470 population controls

	Prostate cancer %	BPH %	Controls %
Age (years)			
50–69	32	50	28
69–74	24	31	29
74–79	25	13	28
79–94	19	6	16
Education			
No formal education	10	8	14
Elementary or middle school	58	52	60
High school or beyond	32	40	26
Marital status			
Married	90	98	93
Widowed or never married	10	2	7
Smoking level			
Never smoked	42	49	37
≤1 pack/day	33	30	31
>1 pack/day	25	21	32
Average daily caloric intake			
900–1915	17	15	25
1916–2249	26	28	25
2250–2654	31	29	25
>2655	26	28	25
Body mass index (kg/m^2) in 1988			
<19.82	22	23	25
19.82–21.80	24	23	25
21.81–24.03	27	21	25
>24.03	26	32	25
Waist-to-hip ratio			
0.73–0.86	14	13	24
0.87–0.89	17	26	25
0.90–0.92	31	27	26
0.93–1.12	37	34	25

Results

Men with prostate cancer were slightly older than men with BPH or controls (Table 1). Controls reported less education, fewer calories consumed on average per day, lower BMI, lower WHR, and more smoking than men with prostate cancer and men with BPH.

Most participants who worked indicated that their usual activity on the job was light or moderate labour (Table 2). The proportion of men in all three groups that participated in heavy labour on the job decreased with age. Relative to the few men whose usual job involved primarily sitting, light or moderate labour was positively associated for each time period with both prostate cancer and BPH. Heavy labour during ages 40–49 and in 1988 was positively associated with prostate cancer, while heavy labour during ages 20–29 and 40–49 was positively associated with BPH.

Table 3 shows the energy expenditure indexes for occupational activity. The assigned energy expenditure indexes based on job titles generated a much more equal distribution of activity. In contrast to Table 2, moderate or high energy expenditure on the job was not associated with prostate cancer for any of the three time periods. High energy expenditure was negatively associated with BPH at ages 40–49 (OR = 0.6, 95% CI : 0.4–0.97) and in 1988 (OR = 0.6, 95% CI : 0.3–1.2).

There were essentially no case-control differences in the number of hours per week spent in any of the activity categories for any of the three periods. One-third of prostate cancer cases and controls reported the equivalent of 12 hours per day spent in moderate activity in their 20s, and hours spent sitting or sleeping gradually increased for both groups after ages 20–29. Few men reported regular vigorous activities: 66%, 75%, and 95% of both groups reported no vigorous activities in their 20s, 40s, and in 1988, respectively. Men with BPH reported similar weekly activity patterns at each period (data not shown).

Because so few men reported vigorous activity, we collapsed vigorous and moderate activity for all regression analyses (Table 4). Relative to controls, at least 252 MET-h of moderate or vigorous activity per week during ages 20–29 and ages 40–49 were negatively associated with prostate cancer but not associated with BPH. This level of activity per week is equivalent to

Table 2 Odds ratios (OR[a]) and 95% CI for prostate cancer or benign prostatic hyperplasia (BPH) and usual occupational activity at ages 20–29, 40–49, and in 1988 in Shanghai, China

	Controls	Prostate cancer		BPH	
Usual activity at work	N	N	OR (95% CI)	N	OR (95% CI)
Ages 20–29					
Sitting	35	8	1.00 (ref.)	9	1.0 (ref.)
Light or moderate labour	337	172	2.2 (0.9–5.4)	153	2.1 (0.9–4.9)
Heavy labour	99	58	2.9 (1.1–7.5)	44	2.9 (1.1–7.3)
Ages 40–49					
Sitting	42	11	1.0 (ref.)	11	1.0 (ref.)
Light or moderate labour	352	188	2.7 (1.3–5.6)	170	2.4 (1.1–5.0)
Heavy labour	71	39	2.9 (1.3–6.8)	25	2.3 (0.9–5.5)
In 1988					
Sitting	37	14	1.0 (ref.)	5	1.0 (ref.)
Light or moderate labour	423	214	1.7 (0.8–3.4)	198	4.3 (1.7–10.9)
Heavy labour	10	9	3.2 [1.0–10.4]	2	1.3 [0.2–7.6]

[a] Adjusted for age, marital status, education, body mass index in that time period, caloric intake, and waist-to-hip ratio.

Table 3 Odds ratios (OR) and 95% CI for prostate cancer or benign prostatic hyperplasia (BPH) and energy expenditure index based on occupation code at ages 20–29, 40–49, and in 1988

	Controls	Prostate cancer				BPH			
Energy expenditure	%	%	OR[a]	OR[b]	95% CI	%	OR[a]	OR[b]	95% CI
Ages 20–29									
Sedentary	28	29	1.0	1.0	ref.	27	1.0	1.0	ref.
Moderate	38	34	0.9	0.9	0.6–1.4	39	0.9	1.0	0.6–1.6
High	35	37	1.0	1.1	0.7–1.7	34	0.9	1.1	0.7–1.8
P (trend):				0.58				0.65	
Ages 40–49									
Sedentary	29	29	1.0	1.0	ref.	41	1.0	1.0	ref.
Moderate	34	35	1.1	1.3	0.8–1.9	34	0.7	0.8	0.5–1.3
High	37	36	1.0	1.3	0.8–1.9	25	0.5	0.6	0.4–0.97
P (trend)				0.32				0.04	
In 1988									
Sedentary	11	15	1.0	1.0	ref.	19	1.0	1.0	ref.
Moderate	78	73	0.7	0.8	0.5–1.3	72	0.8	0.9	0.6–1.5
High	11	12	0.8	0.9	0.5–1.8	9	0.5	0.6	0.3–1.2
P (trend)				0.72				0.15	

[a] Adjusted for age only.

[b] Adjusted for age, marital status, education, body mass index in that time period, caloric intake, and waist-to-hip ratio.

36 MET-h per day (e.g. 3 hours of vigorous activity and 7 hours of moderate activity). All study participants spent less time in moderate and vigorous activities in 1988 than at younger ages; the highest tertile of 147 MET-h per week translates to 21 MET-h per day (e.g. 7 hours of moderate activity). MET-hours of moderate or vigorous activity in 1988 were not associated with either prostate cancer or BPH.

There were no linear or consistent associations between prostate cancer and energy expended in all activities or in moderate or vigorous activities (Table 5). None of the tests for trend indicated a linear association between increasing activity and prostate cancer. When compared again to the same control population (and therefore the same quartiles of energy expended per week), there was a weak and statistically non-significant association between BPH and increasing energy expended in ages 20–29. Associations between BPH and energy expended during ages 40–49 or in 1988 were close to the null.

We evaluated age as a potential effect modifier by stratifying the analyses using the mean age of 74. None of the associations between prostate cancer or BPH and increasing activity levels was changed (data not shown). Stratification according to stage of disease at diagnosis (local versus distant) yielded similar results for activity in ages 20–29 and 40–49 (data not shown). Increasing energy expended in moderate or vigorous activities or in all activities in 1988 was positively associated with local prostate cancer but not associated with distant prostate

Table 4 Odds ratios (OR[a]) and 95% CI for tertiles of weighted hours (MET-h) per week spent in moderate or vigorous activity and in all activity during ages 20–29, during ages 40–49, and in 1988

		Prostate cancer		BPH	
	Controls	N	OR [95% CI]	N	OR [95% CI]
Moderate or vigorous activity					
Ages 20–29					
<210	124	58	1.0 (ref.)	49	1.0 (ref.)
210–251	61	34	1.3 (0.8–2.4)	16	0.8 (0.4–1.6)
⩾252	286	146	1.1 (0.8–1.7)	141	1.6 (1.1–2.5)
P (trend)			= 0.67		= 0.01
Ages 40–49					
<169	190	82	1.0 (ref.)	78	1.0 (ref.)
169–252	200	118	1.4 (1.0–2.1)	96	1.2 (0.8–1.7)
>252	75	38	1.2 (0.7–2.0)	32	1.4 (0.8–2.4)
P (trend)			= 0.22		= 0.21
In 1988					
<63	149	66	1.0 (ref.)	48	1.0 (ref.)
63–146	165	78	1.2 (0.8–1.8)	65	1.2 (0.7–1.9)
⩾147	156	94	1.4 (0.9–2.1)	93	1.1 (0.7–1.8)
P (trend)			= 0.17		= 0.69
All activity					
Ages 20–29					
<329	123	55	1.0 (ref.)		1.0 (ref.)
329–360.5	189	110	1.4 (0.9–2.1)		1.2 (0.8–2.0)
⩾360.5	159	73	1.1 (0.7–1.8)		1.9 (1.2–3.1)
P (trend)			= 0.76		= 0.01
Ages 40–49					
<309	183	79	1.0 (ref.)		1.0 (ref.)
309–350	166	102	1.5 (1.0–2.1)		1.1 (0.7–1.6)
>350	116	57	1.2 (0.8–1.9)		1.3 (0.8–2.2)
P (trend)			= 0.24		= 0.27
In 1988					
<255.5	152	67	1.0 (ref.)		1.0 (ref.)
255.5–297.5	161	76	1.2 (0.8–1.8)		1.2 (0.7–1.9)
⩾297.5	157	95	1.4 (0.9–2.1)		1.1 (0.7–1.8)
P (trend)			= 0.17		= 0.66

[a] Adjusted for age, marital status, education, body mass index in that time period, caloric intake, and waist-to-hip ratio.

cancer. Removal of BMI or WHR as adjustment variables generated similar results, and activity associations were similar when stratified by median BMI or WHR (data not shown).

Discussion

Prostate cancer was not consistently associated with lifetime physical activity in this population-based study. Hours spent in physical activities, weighted hours per week spent in activities of different intensity or in all activities, and energy expended in physical activities during three different time periods were not associated with prostate cancer. When we compared a second group of men with BPH to the same population controls, similar null associations appeared.

Our two measures of physical activity at work generated conflicting results. Although increasingly non-sedentary occupational activity during the three time periods was positively associated with prostate cancer and BPH, we found no other associations between energy expended at work and prostate cancer or BPH for any of the three time periods. This suggests that the associations for the qualitative 'heavy labour' reflect some degree of inaccuracy in self-reported occupational activity. The small numbers of men who reported jobs that involved primarily 'sitting' may have generated spurious positive associations with the qualitative usual occupational activity measure. These few positive results warrant cautious interpretation because we noted substantial diversity in energy expended in those jobs when self-reported job titles were converted to a quantitative energy index based on job codes. The index of energy expenditure based on their reported job titles showed no associations. Previous studies in Turkey[12] and China[24] used this energy expenditure index to identify increased risks of multiple cancer sites among men and women with sedentary jobs, and thus our null results should not be due entirely to non-differential misclassification or an inability of the measurement tool to identify elevated or decreased risks. However, occupational activity may have limited

Table 5 Odds ratios (OR[a]) for total energy expended and energy expended in moderate or vigorous activities

Energy expended Joules/week	Controls N	Cancer N	Cancer OR (95% CI)	BPH[b] N	BPH[b] OR (95% CI)
Ages 20–29					
Total					
<18 200	116	65	1.0 (ref.)	46	1.0 (ref.)
18 200–20 212.5	118	52	0.6 (0.3–1.0)	45	0.8 (0.5–1.4)
20 212.5–23 407	117	58	0.7 (0.4–1.1)	59	1.2 (0.7–2.1)
⩾23 408	118	63	0.8 (0.5–1.4)	56	1.5 (0.8–2.7)
P (trend)			= 0.75		= 0.09
Moderate/vigorous					
<11 165	117	65	1.0 (ref.)	44	1.0 (ref.)
11 165–13 859	95	43	0.8 (0.5–1.4)	41	1.2 (0.7–2.1)
13 860–16 799	130	71	0.9 (0.6–1.4)	63	1.5 (0.9–2.5)
⩾16 800	127	59	0.9 (0.5–1.4)	58	1.7 (1.0–3.0)
P (trend)			= 0.59		= 0.04
Ages 40–49					
Total					
<18 480	113	53	1.0 (ref.)	41	1.0 (ref.)
18 480–20 159	117	53	0.7 (0.4–1.3)	43	0.8 (0.4–1.4)
20 160–23 099	111	60	1.0 (0.5–1.7)	59	0.9 (0.5–1.8)
>23 100	122	72	1.0 (0.5–1.8)	63	1.0 (0.5–2.0)
P (trend)			= 0.65		= 0.69
Moderate/vigorous					
<10 080	86	37	1.0 (ref.)	32	1.0 (ref.)
10 080–13 103	141	70	0.9 (0.5–1.5)	53	0.6 (0.3–1.1)
13 104–16 379	119	62	1.0 (0.6–1.8)	61	1.0 (0.5–1.8)
⩾16 380	117	69	1.1 (0.6–2.0)	60	0.9 (0.5–1.8)
P (trend)			= 0.48		= 0.34
In 1988					
Total					
<14 700	110	50	1.0 (ref.)	32	1.0 (ref.)
14 700–16 939	119	60	1.0 (0.6–1.7)	53	1.3 (0.7–2.4)
16 940–19 844	122	59	1.0 (0.6–1.8)	51	0.9 (0.4–1.6)
⩾19 845	118	69	1.0 (0.5–1.9)	69	0.9 (0.4–1.8)
P (trend)			= 0.97		= 0.35
Moderate/vigorous					
<2939	114	50	1.0 (ref.)	40	1.0 (ref.)
2940–5711	119	62	1.3 (0.8–2.1)	51	1.2 (0.7–2.0)
5712–10 079	105	56	1.4 (0.9–2.3)	34	0.7 (0.4–1.3)
⩾10 080	131	70	1.1 (0.6–1.9)	80	0.9 (0.5–1.5)
P (trend)			= 0.71		= 0.40

[a] Adjusted for age, marital status, education, body mass index in that time period, caloric intake, and waist-to-hip ratio.

[b] Benign prostatic hyperplasia.

impact on overall activity for men in China because daily activity levels are generally thought to be higher in China than in Western countries.

Studies that use only job titles, leisure time activity, or specific daily activities such as stair climbing to estimate activity suffer from misclassification because those activities change over time and other relevant activities may be missed.[21] When using activity categories, failure to incorporate all activities or the different intensity of certain activities will increase between-category misclassification. We asked about all activities during the day and allowed respondents to report different patterns of activity during a usual week. To explore whether activity early in life or later in life has different effects on prostate cancer risk, we collected information on all regular activity for three different time periods: young, middle, and later adulthood. Such measurement of activity at multiple time points should increase the precision of the activity measure.[21] Because body size and activity intensity influence the amount of energy required for activities, we converted time spent in activities to commonly-used MET and energy expended in the different activities. While these calculated measures may introduce some additional within-category misclassification or add unwarranted precision to inter-person differences, we believe that this approach improves the study's internal validity.

Other studies that employed MET-h or energy expended have produced conflicting results. A case-control study that used the same questionnaire as ours found no reduced risk associated with activity at work or with energy expended in youth, during middle-age, or later in life.[15] A large prospective cohort of US white male professionals reported a statistically significant risk reduction for older men with metastatic prostate cancers in the highest quintile of vigorous leisure-time activity per week.[7] Higher levels of energy expended in recreational activity had no impact on prostate cancer risk in a prospective study of US white male college alumni.[17] A cohort of Japanese men in Hawaii showed no reduction in risk with higher activity levels using weighted hours, but there was a suggestive decreased risk for men who reported that most of their leisure time at home was spent in moderate or heavy activity.[16]

Because our participants reported all of their regular weekly activities, their MET-h in activity and energy expended exceeded those reported by participants in other recent studies that evaluated leisure time activity[7] or occupational activity[8] only. Direct comparison of MET-h or energy expended to those studies is somewhat difficult because our categories included both leisure-time and occupational activity (e.g. moderate activities included dancing, badminton, and work in a standing position). The MET-h of activity among these Chinese men are similar to those reported for Japanese men living in Hawaii[16] and slightly greater than those reported for Chinese-American and Chinese-Canadian men.[15] Both of those studies assessed all activities but found no consistent association with prostate cancer.

Studies that did not use MET-h or energy expended found increased risks associated with more frequent leisure-time activity,[18] more time in sedentary jobs,[20] and higher levels of usual physical activity,[19] but their focus on specific yet diverse activities hinders their generalizability. Turkish men with higher levels of occupational physical activity were at reduced prostate cancer risk, but that protective effect disappeared after adjustment for socioeconomic markers.[12] Moderate or heavy occupational activity and increased walking during leisure activities decreased risk of prostate cancer among Finnish men,[8] and a Norwegian report identified lower prostate cancer risk among men over 60 years old who were active compared to sedentary men.[11] An early report[13] from a cohort study in which activity did not increase risk[17] noted essentially no reduction in risk with higher energy expended while walking, climbing stairs, or in recreational activities; a significantly reduced risk among highly active men was based on one exposed case. Lower levels of occupational physical activity have been previously associated with increased risks among men in Shanghai.[10]

One potential limitation of our analysis was the homogeneity of reported activity among men in China. Most participants held jobs that involved primarily light or moderate labour and would have held the same job throughout their adult life—job motility remains low in Shanghai. Change, when it occurred, brought reduced occupational activity: whereas 241 subjects reported heavy labour in their 20s, only 21 reported heavy labour in 1988. Regular recreational physical activity and exercise were uncommon before the mid-1980s in urban Shanghai,[10] but we nonetheless observed a dramatic decrease in reported activity among all three groups for year 1988 compared to the earlier time periods. Men with less education reported a slightly greater decline in activity, which may signal higher occupational activity levels during their working years. Whether the overall decline reflects overreporting at younger ages, underreporting at older ages, or simply the natural reduction in activity as men age is unknown.

Despite the similar activity levels in these men, we did see expected associations between physical activity and other lifestyle factors. For each of the three time periods and for the summary measures, higher levels of energy expended in moderate or vigorous activities were associated with more education, higher caloric intake, and higher BMI.

This study had several strengths. As a population-based study from a region in which cancer reporting and case ascertainment are nearly 100% complete,[27] the case sample adequately represented all incident cases in Shanghai during the study period. Selection of men with BPH from the same hospitals and of population controls from the same area served to mitigate selection bias. Completion of a DRE by two-thirds of the controls decreased the probability that undetected prostate cancer biased the risk estimates towards the null.[28] Such a bias would remain uncorrected, however, if refusal to participate in the DRE was associated with undetected prostate cancer; data were not available to evaluate that possibility.

Detection bias due to screening was minimal because routine screening for prostate cancer is relatively uncommon in Shanghai. Risk factor information collected near the time of diagnosis might have been subject to changes brought on by prostate cancer in the cases. We attempted to control for this by asking about usual information in 1988, which would have been at least 4 and up to 7 years before diagnosis in this population. Questionnaires can accurately capture long-term physical activity,[29,30] but recall of activity during ages 20–29 or ages 40–49 may be less accurate. Retrospective studies that attempt to assess activity that occurred years before interview will not be able to directly assess misclassification or inaccurate recall of activity, but recent reports[31,32] indicate questionnaires can accurately capture lifetime activity.

Few data exist regarding physical activity and BPH. Two large prospective US cohorts showed that men who exercised at least once per week had a lower risk of BPH than men who never or rarely exercised[33] and that increased recreational physical activities (estimated in MET-h) decreased the risk of BPH in a dose-dependent manner.[34] Neither time spent in nor weighted hours of activity decreased the risk of BPH in our data, and energy expended in vigorous activities or in all activities was not associated with BPH. Potential protective effects with weekly exercise or recreational activities may not have appeared in our data if those activities are associated with other factors that decrease the risk of BPH or if case-control differences in those specific activities are not present when all weekly activities are assessed.

In conclusion, physical activity was not consistently or significantly associated with prostate cancer or BPH for men in Shanghai, China. Two previous studies found no association between physical activity and prostate cancer in Asian men living in the US, and our results indicate that the same is true for men living in China. International variation in prostate cancer incidence rates implies that potentially modifiable factors that contribute to those differences exist, but our data do not identify physical activity as one of those factors for men in Shanghai.

Acknowledgement

The National Cancer Institute funded this study.

KEY MESSAGES

We investigated the association between physical activity and prostate cancer in a population-based case-control study from Shanghai, China, where prostate cancer incidence rates are among the lowest in the world. To address the difficult task of accurately measuring physical activity, we used a questionnaire that asked about activity at young adulthood, middle adulthood, and later adulthood. We summed all reported activities into measures of weekly time spent in different activity categories, multiplied by metabolic equivalents (MET), which reflect the intensity of activity, and multiplied by body weight to generate measures of energy expenditure. Among 238 men with prostate cancer, 206 men with benign prostatic hyperplasia (BPH), and 471 healthy, matched controls, physical activity at each of the three time periods consistently showed no association with prostate cancer or BPH. These data suggest that lifetime physical activity and physical activity at specific time periods have minimal impact on prostate cancer in this low-risk population.

References

1 Hsing AW, Tsao L, DeVesa SS. International trends and patterns of prostate cancer incidence and mortality. *Int J Cancer* 2000;**85:**60–67.

2 Brawley OW, Knopf K, Merrill R. The epidemiology of prostate cancer part I: Descriptive epidemiology. *Semin Urol Oncol* 1998;**16:**187–92.

3 Legler JM, Feuer EJ, Potosky AJ, Merrill RM, Kramer BS. The role of prostate-specific antigen (PSA) testing patterns in the recent prostate cancer incidence decline in the United States. *Cancer Causes Control* 1998;**9:**519–27.

4 Hsing AW, DeVesa SS, Jin F, Gao YT. Rising incidence of prostate cancer in Shanghai, China. *Cancer Epidemiol Biomarkers Prev* 1998;**7:** 83–84.

5 Brawley OW, Knopf K, Thompson I. The epidemiology of prostate cancer part II: The risk factors. *Semin Urol Oncol* 1998;**16:**193–201.

6 Oliveria SA, Lee IM. Is exercise beneficial in the prevention of prostate cancer? *Sports Med* 1997;**23:**271–78.

7 Giovannucci E, Leitzmann M, Spiegelman D *et al*. A prospective study of physical activity and prostate cancer in male health professionals. *Cancer Res* 1998;**58:**5117–22.

8 Hartman TJ, Albanes D, Rautalahti M *et al*. Physical activity and prostate cancer in the Alpha-Tocopherol, Beta-Carotene (ATBC) Cancer Prevention Study (Finland). *Cancer Causes Control* 1998;**9:**11–18.

9 Oliveria SA, Kohl HW III, Trichopoulos D, Blair SN. The association between cardiorespiratory fitness and prostate cancer. *Med Sci Sports Exerc* 1996;**28:**97–104.

10 Hsing AW, McLaughlin JK, Zheng W, Gao YT, Blot WJ. Occupation, physical activity, and risk of prostate cancer in Shanghai, People's Republic of China. *Cancer Causes Control* 1994;**5:**136–40.

11 Thune I, Lund E. Physical activity and the risk of prostate and testicular cancer: a cohort study of 53 000 Norwegian men. *Cancer Causes Control* 1994;**5:**549–56.

12 Dosemeci M, Hayes RB, Vetter R *et al*. Occupational physical activity, socioeconomic status, and risks of 15 cancer sites in Turkey. *Cancer Causes Control* 1993;**4:**313–21.

13 Lee IM, Paffenberger RS, Hsieh CC. Physical activity and risk of prostatic cancer among college alumni. *Am J Epidemiol* 1992;**135:** 169–79.

14 Albanes D, Blair A, Taylor PR. Physical activity and risk of cancer in the NHANES I population. *Am J Public Health* 1989;**79:**744–50.

15 Whittemore AS, Kolonel LN, Wu AH *et al*. Prostate cancer in relation to diet, physical activity, and body size in blacks, whites, and Asians in the United States and Canada. *J Natl Cancer Inst* 1995;**87:**652–61.

16 Severson RK, Nomura AM, Grove JS, Stemmermann GN. A prospective analysis of physical activity and cancer. *Am J Epidemiol* 1989; **130:**522–29.

17 Lee IM, Paffenberger RS. Physical activity and its relation to cancer risk: a prospective study of college alumni. *Med Sci Sports Exerc* 1994; **26:**831–37.

18 Cerhan JR, Torner JC, Lynch CF *et al*. Association of smoking, body mass, and physical activity with risk of prostate cancer in the Iowa 65+ Rural Health Study (United States). *Cancer Causes Control* 1997; **8:**229–38.

19 West DW, Slattery ML, Robison LM, French TK, Mahoney AW. Adult dietary intake and prostate cancer risk in Utah: a case-control study with special emphasis on aggressive tumors. *Cancer Causes Control* 1991;**2:**85–94.

20 Le Marchand L, Kolonel LN, Yoshizawa CN. Lifetime occupational physical activity and prostate cancer risk. *Am J Epidemiol* 1991;**133:** 103–11.

21 Oliveria SA, Christos PJ. The epidemiology of physical activity and cancer. *Ann N Y Acad Sci* 1998;79–90.

22 McTiernan A, Ulrich C, Slate S, Potter J. Physical activity and cancer etiology: associations and mechanisms. *Cancer Causes Control* 1998; **9:**487–509.

23 Hsing AW, Deng J, Stanczyk F *et al*. Body size and prostate cancer: a population-based case-control study in Shanghai, China. *Cancer Epidemiol Biomarkers Prev* 2000 (in press).

24 Chow W-H, Dosemeci M, Zheng W *et al*. Physical activity and occupational risk of colon cancer in Shanghai, China. *Int J Epidemiol* 1993;**22:**23–29.

25 Breslow NE, Day NE. *Statistical Methods in Cancer Research. Vol. I. The Analysis of Case-Control Studies*. Lyon: IARC, 1980.

26 SAS Institute Inc. *SAS Software: Changes and Enhancements, Release 6.11*. Cary NC: SAS, 1995.

27 Jin F, DeVesa SS, Zheng W *et al*. Cancer incidence trends in urban Shanghai, 1972–1989. *Int J Cancer* 1993;**53:**764–70.

28 Godley PA, Schell MJ. Adjusted odds ratios under nondifferential misclassification: application to prostate cancer. *J Clin Epidemiol* 1999; **52:**129–36.

29 Slatter ML, Jacobs DR Jr. Assessment of ability to recall physical activity of several years ago. *Ann Epidemiol* 1995;**5:**292–96.

30 Blair SN, Dowda M, Pate RR *et al*. Reliability of long-term recall of participation in physical activity by middle-aged men and women. *Am J Epidemiol* 1991;**133:**266–75.

31 Falkneer KL, Trevisan M, McCann SE. Reliability of recall of physical activity in the distant past. *Am J Epidemiol* 1999;**150:**195–205.

32 Friedenreich CM, Courneya KS, Bryant HE. The lifetime total physical activity questionnaire: development and reliability. *Med Sci Sports Exerc* 1998;**30:**266–74.

33 Gann PH, Hennekens CH, Longcope C *et al*. A prospective study of plasma hormone levels, nonhormonal factors, and development of benign prostatic hyperplasia. *The Prostate* 1995;**26:**40–49.

34 Platz EA, Kawachi I, Rimm EB *et al*. Physical activity and benign prostatic hyperplasia. *Arch Intern Med* 1998;**158:**2349–56.