Physical Activity and Risk of Cancer in the NHANES I Population

DEMETRIUS ALBANES, MD, AARON BLAIR, PHD, AND PHILIP R. TAYLOR, MD, DSC

Abstract: We studied the relation between self-reported physical activity and cancer in the first National Health and Nutrition Examination Survey (NHANES I) cohort, originally examined between 1971–75, and followed prospectively through the Epidemiologic Follow-up Study (NHEFS), conducted between 1982–84. Among 5,138 men and 7,407 women 25–74 years old, for nonrecreational activity we observed increased risk of cancer among inactive individuals compared to very active persons (for men, relative risk [RR] 1.8, 95% confidence interval [CI] = 1.4, 2.4; for women RR 1.3, 95% CI = 1.0, 1.8). These findings were unchanged after adjustment for cigarette smoking, body mass index (BMI), and other potential confounders. Sites which demonstrated stronger inactivity-cancer associations included colorectum (RR 1.6,95% CI = 0.7, 3.5) and lung (RR 1.6; 95% CI = 1.2, 3.5) among men, and breast (postmenopausal) (RR 1.7; 95% CI = 0.8, 2.9) and cervix (RR 5.2; 95% CI = 1.4, 14.5) among women, although these findings for women were based on relatively few cases. The association between inactivity and cancer was greater among persons of moderate (or lower) BMI, those cases occurring three or more years after baseline, and, in women, those more than 60 years old. In contrast, recreational exercise showed little relation to cancer, with the exception of prostate cancer. The results suggest that inactive individuals are at increased risk of cancer. (*Am J Public Health* 1989; 79:744–750.)

Introduction

The beneficial effects of physical activity on cardiovascular disease risk have been well documented.[1] Persons with other chronic illnesses such as osteoporosis and diabetes mellitus have likewise shown improved clinical status while on exercise regimens.[2,3] To a lesser degree, physical activity has also been studied with respect to risk of cancer. Early studies provided evidence for an inactivity-cancer relation,[4–6] but there have been conflicting data.[7,8] More recently, a population-based study of men[9] demonstrated an inverse association between incidence of colon cancer and level of occupational physical activity, which was corroborated by two subsequent reports.[10,11] Although these studies, and one of female cancers among former college athletes,[12] support the notion that greater physical activity is associated with reduced cancer risk, they have been limited to group estimates of physical activity based upon occupational classification or athletic status.

We examined the relation between self-reported activity level and the subsequent development of cancer in a large cohort of US men and women. The present investigation extends previous research by assessing the role of both recreational and nonrecreational physical activity, by evaluating relative body weight and other potential confounders of the activity-cancer association, and by including men and women.

Methods

We analyzed data available on public use tapes from the first US National Health and Nutrition Examination Survey (NHANES I) and the NHANES I Epidemiologic Follow-up Study (NHEFS). Details of their design have been presented elsewhere.[13,14] Between 1971 and 1975, 14,407 men and women ages 25–74 participated in NHANES I which was conducted by the National Center for Health Statistics (NCHS) and was designed to characterize a variety of health and nutrition-related parameters in a representative sample of the U.S. civilian population. Of the participants, 12,554 (87 per cent) were successfully traced and reinterviewed (14 per cent by proxy) during the period 1982–84 by NCHS as part of the NHEFS. All persons for whom baseline data existed concerning age, physical activity, stature and body weight, and who were without cancer at study entry (35 prevalent cases were identified through the baseline medical history interview and hospital records) were included in this investigation. Thus, the analytic cohort was comprised of 5,141 men (41 per cent) and 7,413 women (59 per cent), of whom 84 per cent were White. The median age at study entry was 48 years for women and 52 years for men.

Incident cases of cancer (excluding nonmelanoma skin cancer), confirmed through hospital record or death certificate review, served as endpoints for this study. Pathology reports were obtained for all cases. During the follow-up period (median length 10 years), 460 cancers developed among men (including 114 lung, 95 prostate, and 62 colorectum), and 399 among women (122 breast and 67 colorectum). Because relatively few cases (i.e., <35) occurred for specific cancer sites other than lung, prostate and colorectum in men, and breast and colorectum in women, they were not initially analyzed separately. Similarly, cancer of the colon and rectum were left combined because of very small case numbers (for men and women, respectively: colon, 36 and 48; rectum, 26 and 18), and the lack of any material difference between their respective associations with activity.

Two questions concerning physical activity were asked during the baseline evaluation. The first, dealing with nonrecreational activity, was: "In your usual day, aside from recreation, how active are you?" The possible responses were: "very active", "moderately active", or "quite inactive". The second question ("recreational exercise") asked: "Do you get much exercise in things you do for recreation?" "Much exercise", "moderate exercise", or "little or no exercise" were the available responses. Information concerning potential confounding risk factors was also obtained. Height and weight were measured at baseline using standard methods,[15] and the body mass index (BMI, weight (kg)/height $(m)^2$) was used as a measure of relative body fatness. Race was classified as White, Black, or other at baseline; because there were relatively few persons in the latter two categories, they were combined (i.e., non-Whites) for the present investigation. Maximum education attained was queried in the

Address reprint requests to Demetrius Albanes, MD, Cancer Prevention Studies Branch, Division of Cancer Prevention and Control, National Cancer Institute, National Institutes of Health, EPN 211, 9000 Rockville Pike, Bethesda, MD 20892. Dr. Taylor is also with that Branch; Dr. Blair is with the Environmental Epidemiology Branch, Division of Cancer Etiology, NCI, NIH. This paper, submitted to the Journal September 16, 1988, was revised and accepted for publication November 25, 1988.

baseline interview, and relative economic status was estimated through the use of the NHANES I poverty index ratio, a measure of adjusted family income which compares a person's income, residence, and family size to the poverty level. Cigarette smoking status (never, former, current) and total pack-years were derived from either the baseline interview, or at follow-up interview. Pack-years was the product of the duration of smoking (in years) and the usual number of cigarettes smoked daily (divided by 20). Reproductive and gynecologic history (age of menarche, menopausal status, parity, and age at first live birth) and family history of breast cancer came from both baseline and follow-up interviews. Self-reported employment status, general health ("excellent" to "poor"), and history of a recent hospitalization (during the past year) were obtained at baseline, as was dietary energy and total fat intake information derived from a 24-hour recall questionnaire.

Relative risk estimates were computed using the proportional hazards model of SAS (PHGLM) in which incident cases of cancer served as study events.[16,17] Indicator variables were used for the two lower physical activity levels, leaving persons in the highest activity category as the reference group for both recreational and nonrecreational activity analyses. Age was included in all models as an independent, continuous variable. As indicated in the text, some analyses included adjustment (using indicator variables) for cigarette smoking status and pack-year history, economic status (using the poverty index ratio), reproductive and family breast cancer history, BMI, or dietary fat or energy intake, and for these analyses persons with missing data were excluded. In order to assess the potential impact of early stage, undiagnosed cancer on the physical activity-cancer relationship, we conducted stratified analyses based on length of follow-up i.e., <3 years versus ≥ 3 years. For the later follow-up period, cancers occurring within three years of study entry were excluded. Because none of the factors was found to be a significant confounder in these data, and covariate information was not available for all cases and noncases, only age-adjusted relative risks are presented in the Tables. Trend tests were based on the significance of a model trend variable for activity (scored 0,1,2).

TABLE 1—Age-adjusted[a] Mean (or distribution of) Baseline Characteristics According to Level and Category of Physical Activity by Sex

Nonrecreational Activity	Very Active	Moderately Active	Quite Inactive
Males	(2267)[b]	(2291)	(580)
Age (years)	49.7	54.0	55.4
% Current smokers	28.7	32.4	25.5
% Non-White	14.1	13.7	15.5
% Education >HS	17.7	30.3	31.9
Wt/ht^2 (kg/m^2)	25.6	25.8	25.6
Height (cm)	173.8	173.9	173.5
Energy intake (kcal)	2281	2077	1943
Females	(3102)	(3558)	(747)
Age (years)	45.4	49.4	52.6
% Current smokers	12.2	12.8	14.4
% Non-White	15.5	15.4	22.5
% Education >HS	19.6	23.1	16.8
Wt/ht^2 (kg/m^2)	25.1	25.8	27.3
Height (cm)	161.2	161.3	160.3
Energy intake (kcal)	1485	1463	1410
Recreational Exercise	**Much Exercise**	**Moderate Exercise**	**Little or no Exercise**
Males	(1191)	(2024)	(1922)
Age (years)	48.6	51.7	55.1
% Current smokers	29.9	32.5	27.4
% Non-White	9.8	11.2	19.8
% Education >HS	27.3	27.2	21.1
Wt/ht^2 (kg/m^2)	25.4	25.8	25.8
Height (cm)	174.3	174.0	173.3
Energy intake (kcal)	2328	2148	2067
Females	(1027)	(2736)	(3645)
Age (years)	45.6	46.5	49.9
% Current smokers	15.1	13.6	11.4
% Non-White	9.2	10.9	22.0
% Education >HS	27.8	24.9	16.2
Wt/ht^2 (kg/m^2)	24.4	25.0	26.5
Height (cm)	161.6	161.3	161.0
Energy intake (kcal)	1567	1453	1450

[a]Except mean age.
[b]Number of participants for activity categories in parentheses. For some subjects, information concerning smoking status, education, or energy intake was missing.

Results

Baseline characteristics of the study participants according to type and level of activity appear in Table 1. Most of the men and women participating in the study reported being either very active or moderately active in their nonrecreational activity, with only approximately 10 per cent being inactive. In contrast, over one-third of the men and nearly half of the women received little or no exercise in their recreational activities. Individuals reporting more daily activity or exercise tended to be younger and of lower BMI (the latter, primarily in women), while the least active persons were in general more likely to be other than White, less educated, and somewhat shorter in stature. One interesting exception concerns the smaller proportion of nonrecreationally very active men (17.7 per cent) with any education beyond high school compared with less active men. Energy intake was directly related to both types of activity, particularly among men, who also exhibited a much greater range in kilocalorie intake across activity categories.

Age-adjusted relative risk of cancer (all sites) was inversely related to nonrecreational physical activity level among men, demonstrating a nearly two-fold risk increase in the inactive group (Table 2). The increase in risk was smaller among women. Among men, the inverse association with nonrecreational activity was strongest for lung cancer, although it was also suggested for colorectal and prostate cancer. There was no similar association for either colorectal or breast cancer in women. Among inactive women, when breast cancer was analyzed according to menopausal status, an inverse association was seen in postmenopausal women [relative risk (CI) among the least active of 1.5 (0.7, 2.8)], while a direct association was suggested for premenopausal women [relative risk (CI) of 0.4 (0.1, 1.8) based on 46 cases]. In addition, there was an increase in risk for cancer of the cervix (n = 20 cases) by decreasing activity levels [relative risk (CI) = 1.0, 2.3 (0.7, 7.2), and 5.2 (1.4, 14.5)].

The findings concerning recreational activity were generally less impressive than for nonrecreational activity (Table 2). The risk of prostate cancer increased with decreasing levels of exercise, and there was a small, nonsignificant increase in risk of colorectal cancer among women receiving moderate or less exercise. Similar to the findings for nonrecreational activity, there was a suggestion of increased risk of breast cancer among postmenopausal women in the low exercise group [relative risk (CI) = 1.7 (0.8, 2.9)], with an

TABLE 2—Relative Risk[a] of Cancer According to Level and Category of Physical Activity by Sex

Nonrecreational Activity	# Cases	Very Active[b]	Moderately Active	Quite Inactive	Test for Trend p-value
Males					
All Sites	460	1.0	1.1 (0.9, 1.4)*	1.8 (1.4, 2.4)	0.0002
Colorectum	62	1.0	1.2 (0.7, 2.1)	1.6 (0.7, 3.5)	0.24
Lung	114	1.0	1.3 (0.9, 2.0)	2.0 (1.2, 3.5)	0.02
Prostate	95	1.0	0.9 (0.6, 1.3)	1.3 (0.7, 2.4)	0.78
Females					
All sites	399	1.0	1.0 (0.8, 1.3)	1.3 (1.0, 1.8)	0.16
Colorectum	66	1.0	1.3 (0.8, 2.2)	0.7 (0.3, 2.0)	0.98
Breast	122	1.0	0.9 (0.6, 1.3)	1.1 (0.6, 2.0)	0.92
Recreational Exercise	**# Cases**	**Much Exercise[b]**	**Moderate Exercise**	**Little or no Exercise**	
Males					
All sites	460	1.0	1.1 (0.9, 1.4)	1.2 (1.0, 1.6)	0.08
Colorectum	62	1.0	1.0 (0.5, 1.9)	1.0 (0.5, 1.9)	0.93
Lung	114	1.0	1.0 (0.6, 1.6)	0.9 (0.6, 1.5)	0.80
Prostate	95	1.0	1.2 (0.6, 2.2)	1.8 (1.0, 3.3)	0.02
Females					
All sites	399	1.0	1.0 (0.7, 1.3)	1.0 (0.7, 1.3)	0.82
Colorectum	66	1.0	1.2 (0.5, 2.7)	1.2 (0.6, 2.8)	0.63
Breast	122	1.0	0.9 (0.5, 1.6)	1.0 (0.6, 1.6)	0.98

[a]Relative risk estimated from the proportional hazards regression models which include age as an independent variable.
[b]Reference categories.
*95% confidence interval in parentheses.

TABLE 3—Relative Risk[a] of Cancer (all-sites) According to Level of Nonrecreational Activity and Recreational Exercise by Sex

	Males				Females			
Recreational Exercise	# Cases	Very Active	Moderately Active	Quite Inactive	# Cases	Very Active	Moderately Active	Quite Inactive
Much	88	1.0[b]	1.1 (0.7, 1.9)*	1.7 (0.4, 7.0)	53	1.0[b]	1.0 (0.5, 2.1)	1.3 (0.2, 9.3)
Moderate	168	1.0 (0.7, 1.4)	1.1 (0.8, 1.5)	1.4 (0.7, 2.9)	137	1.0 (0.7, 1.5)	1.0 (0.7, 1.4)	1.9 (0.8, 4.5)
Little or None	204	1.0 (0.7, 1.5)	1.2 (0.8, 1.6)	1.9 (1.3, 2.7)	209	0.8 (0.6, 1.3)	1.0 (0.7, 1.4)	1.2 (0.8, 1.8)

[a]Relative risk estimated from the proportional hazards regression models which include age as an independent variable.
[b]Reference category (very active and much exercise).
*95% confidence interval in parentheses.

opposite association premenopausally [relative risk (CI) = 0.6 (0.3, 1.2)].

Adjustment for potential confounding risk factors [race, economic and smoking status, BMI, and energy intake (all sites); BMI and dietary fat intake (colorectum); smoking status and cigarette pack-year history (lung); age at menarche and menopause, parity, age at first birth, as well as family history of breast cancer, BMI (or stature), and dietary fat intake (breast cancer); economic status (cervix)] did not materially alter any of the findings concerning either activity type.* For example, the multivariate adjusted relative risk of all sites cancer remained unchanged: 1.0, 1.1, 1.8 for the decreasing levels of nonrecreational activity in men; 1.0, 1.1, 1.2 for women. Similarly, the results were not affected by adjustment for employment status (working versus not) or general health status (subjective report of health or a hospitalization in the past year).

Table 3 shows that compared to persons who claimed to be both very active and exercised, it was generally only those reporting being less active who were at increased cancer risk. (Cancer incidence (per 100,000 person-years) for the reference category was 817 for men and 560 for women.) Joint classification for nonrecreational activity and exercise therefore yielded relative risk estimates comparable to those for nonrecreational activity alone, without evidence of synergism.

Because many of the above results implicated nonrecreational inactivity specifically as a cancer risk factor, stratified analyses for age, BMI, and follow-up time (factors possibly related to inactivity) were conducted and are shown in Tables 4 and 5. In addition, Whites and all others were analyzed separately (Table 4). The risk increase associated with diminished activity was observed in both younger (25–59 years of age) and older men regardless of race (Table 4).

*Data available on request to author.

TABLE 4—Relative Risk[a] of Cancer (all-sites) According to Level of Nonrecreational Activity by Sex and Subgroups of Age, Race, Body Mass Index, and Follow-up Time

	Males					Females				
	# Cases	Very Active[b]	Moderately Active	Quite Inactive	Trend Test p-value	# Cases	Very Active[b]	Moderately Active	Quite Inactive	Trend Test p-value
Age										
≤60 years	119	1.0	1.5 (1.0, 2.3)*	1.6 (1.1, 2.2)	0.004	159	1.0	1.2 (0.7, 1.9)	0.9 (0.7, 1.3)	0.75
>60 years	341	1.0	1.1 (0.8, 1.3)	1.9 (1.3, 2.4)	0.007	240	1.0	1.0 (0.8, 1.3)	1.5 (1.0, 2.3)	0.11
Race										
White	388	1.0	1.0 (0.8, 1.3)	1.8 (1.4, 2.5)	0.002	346	1.0	1.0 (0.8, 1.2)	1.2 (0.9, 1.8)	0.47
non-White	72	1.0	1.7 (1.0, 2.9)	1.8 (0.9, 3.8)	0.05	53	1.0	1.7 (0.9, 3.4)	2.1 (1.0, 4.8)	0.05
Body Mass Index										
low (<22.0)	107	1.0	1.4 (0.9, 2.2)	3.1 (1.9, 5.2)	<0.0001	92	1.0	1.1 (0.7, 1.7)	1.8 (0.9, 3.4)	0.19
moderate (22–26)	163	1.0	1.5 (1.1, 2.2)	1.9 (1.1, 3.0)	0.005	124	1.0	1.1 (0.8, 1.7)	2.0 (1.2, 3.5)	0.03
high (>26.0)	190	1.0	0.8 (0.6, 1.1)	1.2 (0.7, 1.3)	0.83	183	1.0	0.9 (0.7, 1.3)	0.9 (0.5, 1.4)	0.57
Follow-up time										
< 3 years	122	1.0	0.9 (0.6, 1.4)	1.4 (0.8, 2.4)	0.38	114	1.0	0.9 (0.6, 1.4)	1.3 (0.8, 2.4)	0.61
≥ 3 years	338	1.0	1.2 (0.9, 1.5)	2.0 (1.4, 2.8)	0.0002	285	1.0	1.1 (0.8, 1.4)	1.3 (0.9, 1.9)	0.21

[a]Relative risk estimated from the proportional hazards regression models which include age as an independent variable.
[b]Reference categories.
*95% confidence interval in parentheses.

The association was restricted, however, to older women who were not White, and to low and moderate relative weight men and women, with a three-fold risk increase among inactive lean men compared to very active lean men. While length of follow-up did not affect the inactivity-cancer association in women, a somewhat stronger inverse relation was seen among men for cancers occurring three or more years after baseline.

Additional evidence for effect modification by age and BMI appears in Table 5. There was an inverse cancer-activity association only among younger and older men who were of average BMI or less, and in younger, heavier men. Among women, an effect was observed only for the older and leaner category.

The combined effects of race and either age or BMI were also evaluated. Among men, a somewhat stronger association between inactivity and cancer was observed in younger (versus older) Whites, and in other than older White women (Table 6). In both race groups, the association was essentially restricted to those in the lower BMI category. Adjustment for cigarette smoking did not alter the latter finding. Table 7 shows that the inverse activity-cancer association was evident primarily among non-White women, of either age group, and women of lower BMI.

TABLE 5—Relative Risk of Cancer (all-sites)[a] According to Nonrecreational Activity Level Stratified by Age, Body Mass Index, and Sex

Age (yrs)	Body Mass Index (kg/m²)	# Cases	Very Active[b]	Moderately Active	Quite Inactive	Test for Trend p-value
Males						
≤60	≤26	63	1.0	2.2 (1.3, 3.8)*	2.0 (0.9, 4.6)	0.01
	>26	56	1.0	1.0 (0.6, 1.8)	2.2 (1.0, 4.8)	0.17
>60	≤26	207	1.0	1.3 (1.0, 1.8)	2.5 (1.7, 3.7)	<0.0001
	>26	134	1.0	0.7 (0.5, 1.0)	0.9 (0.5, 1.6)	0.30
Females						
≤60	≤26	101	1.0	1.2 (0.8, 1.8)	0.9 (0.4, 2.2)	0.72
	>26	58	1.0	1.2 (0.7, 2.1)	1.0 (0.4, 2.5)	0.76
>60	≤26	115	1.0	1.2 (0.8, 1.8)	2.8 (1.7, 4.8)	0.001
	>26	125	1.0	0.8 (0.6, 1.2)	0.8 (0.5, 1.4)	0.37

[a]Relative risk estimated from the proportional hazards regression models which include age as an independent variable.
[b]Reference category.
*95% confidence interval in parentheses.

Discussion

Most previous investigations of this area have examined either occupational history or involvement in athletics. Several studies demonstrate an inverse association between occupational physical activity, based on job classification, and the development of malignancy.[4,6,9–11] Siversten and Dahlstrom,[4] in a historically interesting report, showed that the death rate from carcinoma was higher among the unemployed, and inversely related to estimated occupational "muscular activity." The authors attributed their observations to metabolic products of deficient muscular activity which altered body fluids and, therefore, adult epithelial tissue. The effect of age and the tendency for ill individuals to be unemployed or reduce their activity were not, however, adequately addressed. Among railroad workers, Taylor[6] demonstrated approximately one-third lower cancer death rates for "section men" (those involved in heavy manual

TABLE 6—Relative Risk[a] of Cancer (all-sites) According to Level of Nonrecreational Activity Stratified by Race, Age, and Body Mass Index, for Males

	White					All Others				
	# Cases	Very Active[b]	Moderately Active	Quite Inactive	Trend Test p-value	# Cases	Very Active[b]	Moderately Active	Quite Inactive	Trend Test p-value
Age (years)										
≤60	98	1.0	1.4 (0.9, 2.1)*	2.2 (1.2, 4.0)	0.008	21	1.0	2.3 (0.9, 5.9)	1.0 (0.1, 7.7)	0.28
>60	290	1.0	1.0 (0.7, 1.2)	1.7 (1.2, 2.4)	0.03	51	1.0	1.5 (0.8, 2.8)	1.9 (0.8, 4.4)	0.10
Body mass index (kg/m²)										
≤26	223	1.0	1.3 (1.0, 1.8)	2.3 (1.6, 3.3)	0.0001	47	1.0	2.8 (1.3, 6.0)	3.6 (1.4, 9.3)	0.003
>26	165	1.0	0.8 (0.6, 1.1)	1.3 (0.8, 2.2)	0.91	25	1.0	0.8 (0.4, 1.9)	0.5 (0.1, 2.4)	0.38

[a]Relative risk estimated from the proportional hazards regression models which include age as an independent variable.
[b]Reference category.
*95% confidence interval in parentheses.

TABLE 7—Relative Risk[a] of Cancer (all-sites) According to Level of Nonrecreational Activity Stratified by Race, Age, and Body Mass Index, for Females

	White					All Others				
	# Cases	Very Active[b]	Moderately Active	Quite Inactive	Trend Test p-value	# Cases	Very Active[b]	Moderately Active	Quite Inactive	Trend Test p-value
Age (years)										
≤60	139	1.0	1.1 (0.8, 1.6)*	0.8 (0.4, 1.6)	0.90	20	1.0	1.9 (0.7, 5.3)	2.1 (0.5, 8.6)	0.19
>60	207	1.0	0.9 (0.7, 1.3)	1.4 (1.0, 2.2)	0.24	33	1.0	1.6 (0.7, 3.8)	2.0 (0.7, 5.6)	0.17
Body mass index (kg/m²)										
≤26	190	1.0	1.1 (0.8, 1.4)	1.6 (1.0, 2.6)	0.12	26	1.0	1.9 (0.7, 5.1)	4.6 (1.6, 13.6)	0.006
>26	156	1.0	0.8 (0.6, 1.2)	0.9 (0.5, 1.5)	0.50	27	1.0	1.6 (0.7, 4.0)	0.9 (0.2, 3.5)	0.85

[a]Relative risk estimated from the proportional hazards regression models which include age as an independent variable.
[b]Reference categories.
*95% confidence interval in parentheses.

labor) compared to less active clerks and switchmen. In three more recent studies,[9–11] the risk of colon cancer was increased by between 30 and 100 per cent among men employed in sedentary occupations. Garabrant, *et al*,[9] suggested that reduced stimulation of colonic peristalsis among those least active could account for the association.

All of the above investigations involved working men, and utilized estimated physical activity based on occupational categories. Our demonstration of a nearly two-fold risk increase among inactive men relative to those more active is consistent with these previous studies, both in terms of the magnitude of the association and the specific implication of inactivity or "sedentariness". The present findings concerning nonrecreational activity are also consistent with the specific association most recently reported[9–11] between colon cancer in men and occupational inactivity. In our study, however, the relation exists for cancer of the rectum as well, but was not observed in women. Nonrecreational activity was positively related to employment in the present data: 79 per cent of the "very active" men were employed compared with only 67 and 51 per cent of the moderately active and inactive men, respectively (49, 39, and 35 per cent for women in the same activity categories). Conversely, only 7 per cent of men with jobs reported being inactive, compared with 19 per cent of the unemployed men. These apparent similarities notwithstanding, our study demonstrated an activity-cancer association which is independent of employment status, since adjustment for this factor did not affect our results, and the nonrecreational activity association was observed in both the employed and unemployed (data not presented). Therefore, while inactive persons were less likely to be working, it was not their lack of work which increased their risk of cancer.

The study of athletes, another approach to investigating the relation between cancer and physical activity (or more specifically, fitness) has yielded conflicting data.[5,7,8,12] Two early studies[5,7] lacked control groups, and may have suffered both from biased samples and inadequate consideration of age. A retrospective cohort study based on death certificates and athletic status in college showed a small excess of age-stratified (by 10-year birth cohorts) cancer mortality, particularly for cancer of the prostate, among Harvard "letter men" (varsity athletes) compared to either athletes not having received a "letter", or to students who had applied for (but did not receive) a gymnasium locker.[8] The authors could not rule out other confounding effects such as smoking or body size, however. In a similar investigation, female college alumni who had actively participated in one or more team sports during college reported less subsequent cancer of the breast, uterus (including cervix), and ovary than did nonathlete alumni.[12] This association, which persisted after adjustment for several breast cancer risk factors, was evident primarily in women 50–70 years old. However, the number of cancers was small (69 breast, 37 all others combined). One other recent report demonstrated a direct relation between heart rate and total cancer mortality that was unchanged after adjustment for several factors.[18] The authors interpret their findings in light of theories concerning adrenergic activity and psychological stress, although they do not exclude the effects of habitual exercise or sedentary life-style. Interestingly, two sites showing a strong, positive association in this study were lung and colon (a finding similar to ours) but only for the latter site did it remain significant after adjustment for smoking and serum cholesterol.

We demonstrated a positive association with recreational exercise only for prostate cancer, a finding opposite that observed among Harvard athletes.[8] The suggestion of decreased breast cancer risk among postmenopausal women receiving much exercise in our study is consistent with the study of female college athletes mentioned.[12] In that investigation, earlier athletic status provided some risk reduction in the postmenopausal age range only, with no demonstrable athlete-nonathlete difference premenopausally. We did observe increased risk for the high exercise category among premenopausal women. Also, data for cancer of the cervix and endometrium (not shown) are suggestive of a protective effect for a high level of exercise, similar to that observed previously for female athletes,[12] and not accounted for by race, economic status, or body mass index. Unfortunately, the number of cases does not permit a more detailed evaluation of these associations in women, which must therefore remain tentative until investigated by others. The latter associations notwithstanding, given the positive findings for nonrecreational activity, the lack of a stronger overall association for exercise in the present investigation is somewhat surprising. It is possible that the effects of recreational activity are diminished because the duration of daily exercise (and hence its potential influence on disease) is generally much shorter than either athletic training or work-related activity. Alternatively, the observed association for nonrecreational activity may be unrelated to physical fitness; the implication of inactivity *per se* could be interpreted as being supportive of this. It has already been pointed out that the two questions used in the NHANES surveys reflect different aspects of daily activity.[19] Interestingly, we did find that the relation between cancer and nonrecreational inactivity was suggested at all levels of reported daily exercise in men, and for the moderate and little or no exercise groups in women.

The implication of inactivity as a risk factor also suggested to us a possible role for characteristics or illnesses which would both reduce activity and predispose to the development of cancer. Although the appearance of a somewhat stronger inactivity-cancer association among leaner individuals and older women could be interpreted as supporting such a role, several of our findings argue against confounding by prior illness or infirmity. The activity association was observed among: 1) those followed for at least three years before developing cancer (in men, the association was even greater in this subgroup); 2) younger as well as older men; 3) the actively employed (excluding the unemployed and homemakers); 4) nonsmokers; and, possibly most importantly, 5) persons reporting good or excellent general health as well as those denying any hospitalization during the year preceding study entry (data not shown). Thus, it is unlikely that ill health could account for our findings.

The present investigation is unique in the collection of self-reported information concerning daily nonrecreational activity and physical exercise. Such data offer the advantage of individual estimates which may be more specific than job categories or athletic status decades earlier. While an effect from the subjective interpretation of the interview questions cannot be excluded, misclassification from this should only have caused our risk estimates to be reduced. It is noteworthy that we demonstrated increased cancer risk among inactive individuals in spite of this. One level of validation of the NHANES I activity classification is afforded by the caloric intake data which are available. Both age-adjusted mean energy intake (Table 1) and energy not used for resting metabolic rate (RMR) (energy intake minus predicted RMR,[20] a crude estimate of physical activity energy expenditure) increased with activity level. Furthermore, as already discussed, nonrecreational activity was positively related to employment status. Therefore, while direct validation of activity was not feasible in the present study, these indirect data support the value of the self-reports.

In contrast to (and an advantage over) most previous studies, the potential confounding effects of several relevant factors were also evaluated in the present investigation. We observed only relatively weak and inconsistent relations between activity level and most factors studied, and there was no evidence for confounding. Residual confounding due to factors we could not evaluate remains possible, however. It has been suggested that BMI has this potential, especially with respect to colon cancer.[21] While increased BMI is a risk factor for selected sites (including colon) in this cohort,** we observed little change to the relative risk estimates for activity groups upon adjustment for BMI. A stronger inactivity-cancer association was evident primarily among low or moderate BMI individuals for both men and women, particularly among non-Whites. Relative body mass may therefore modify either the effect or level of activity. That is, leanness may be necessary for activity to affect the development of cancer; for example, through an altered metabolic characteristic. Alternatively, it may only be leaner individuals who are active enough to achieve the protective influence, or who more accurately classify their activity level and afford a better test of the hypothesis.

Studies providing more detailed assessment of individual physical activity, and which include women, are needed. Research aimed at elucidating the relevant mechanism(s) would also be useful.

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International Conference on Emergency Health Care Development Invites Papers

The International Conference on Emergency Health Care Development, to be held August 15–18, 1989 at the Hyatt-Regency Hotel, Crystal City at National Airport, in the Washington, DC metropolitan area, invites interested persons to submit abstracts on work related to emergency and disaster health care development. Topics on organization, administration, and management will be considered. The conference is intended to serve as a forum and training ground for fostering the discussion of methods for improving emergency health care worldwide.

Attendees wishing to present papers or studies must admit an abstract on the form provided by the conference organizer. To obtain an abstract form, instructions, and a preliminary agenda, contact Medical Care Development International (MCDI), Conference Organizer, 1742 R Street, NW, Washington, DC 20009, telephone: 202/462-1920. Abstracts must be received by June 15, 1989 to be considered for the conference agenda. To speed receipt, prospective participants are encouraged to send a copy of the abstract by telefax in care of MCDI, 202/265-4078, at the same time the original is mailed.

The conference will focus on the development of emergency health care systems, both pre-hospital and in-hospital health care services that respond to sudden illness or injury. The objectives of the international conference are to:

- Clarify the linkages between emergency health care, local and national health care services, and national disaster management systems;
- Present concrete methods for developing or improving emergency health care and disaster response management capabilities within societies which differ widely in resources and characteristics;
- Demonstrate processes by which different emergency health care services have been developed; and
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