IJE vol.33 no.4 © International Epidemiological Association 2004; all rights reserved. International Journal of Epidemiology 2004;33:759–767
Advance Access publication 24 March 2004 doi:10.1093/ije/dyh042

Physical activity and risk of coronary heart disease in India

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Accepted 7 October 2003

Background Physical exercise has been inversely associated with coronary heart disease (CHD) risk in Western populations; however, the association has not been examined in India where physical inactivity levels in urban areas are now comparable with the West.

Methods We conducted a hospital-based case-control study and collected data from 350 cases of acute myocardial infarction and 700 controls matched on age, gender, and hospital in New Delhi and Bangalore. We used conditional logistic regression to control for the matching and other risk factors.

Results Of the controls, 48% participated in some form of leisure-time exercise compared with 38% of cases. In age- and sex-adjusted analyses, people in the highest level of leisure-time exercise (>145 metabolic equivalents [MET]-minutes per day, equivalent to 36 minutes of brisk walking per day) had a relative risk of 0.45 (95% CI: 0.31, 0.66) compared with non-exercisers. Multivariate adjustment for other risk factors did not substantially alter the association. We observed a positive association between non-work sedentary activity and CHD risk; people with >3.6 hours per day of sedentary activity (for example, television viewing) had an elevated risk of 1.88 (95% CI: 1.09, 3.20) compared with <70 minutes per day in multivariate analysis.

Conclusion Leisure-time exercise, including as much as 35–40 minutes per day of brisk walking, was protective for CHD risk and sedentary lifestyles were positively associated with risk of CHD. Given limited resources for care of CHD in India and the important role of physical exercise in disease risk in urban India, improvements in physical activity should be promoted.

Keywords Physical activity, leisure-time exercise, sedentary lifestyles, coronary heart disease, India, developing countries

Cardiovascular disease (CVD) is the leading cause of death in India,[1] and its contribution to mortality is rising; deaths due to CVD are expected to double between 1985–2015.[2–4] Regular physical activity reduces the risk of obesity, blood lipid abnormalities, hypertension, and non-insulin dependent diabetes mellitus,[5,6] and has been shown to reduce substantially the risk of coronary heart disease (CHD). Conversely, measures of sedentary lifestyles or physical inactivity have been associated with a 1.5- to 2.4-fold elevation in CHD risk.[5] It is estimated that US$24 billion or 2.4% of the US health care expenditure is directly related to a lack of physical activity.[7]

As a result of economic changes and increased mechanization, the prevalence of physical inactivity is increasing in India, particularly in urban areas, to levels comparable with the West.[6,8,9] However, the association between leisure-time exercise, sedentary lifestyles, and risk of CHD has not been assessed within India. We conducted a hospital-based case-control study of acute myocardial infarction (AMI) in two major cities in India to address the relation between leisure-time exercise and sedentary activity and risk of CHD. To our

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knowledge, this is one of the first investigations to date, if not the first, into the relation between physical activity and CHD risk in India.

Methods

Study participants

Cases

Eligible cases were all patients 21–74 years of age hospitalized with a diagnosis of incident AMI in one of eight urban hospitals in New Delhi and Bangalore between January 1999 and January 2000. The initial three participating hospitals were also part of an investigation of the Indian Council of Medical Research (ICMR), so case subjects were selected according to ICMR study criteria. Definite diagnosis of AMI was based on clinical examination, electrocardiogram (ECG), and cardiac enzymes.[10] Research assistants identified cases by visiting participating hospitals on a daily or biweekly basis and by consulting physicians on duty. Patients were excluded if they had any previous history of myocardial infarction or CHD (including bypass surgery, angina, or stroke) because such prior diagnoses may have altered their exposure history. We also excluded patients if they were pregnant, had a history of cancer, or had a chronic disease of the kidney, liver, gastrointestinal tract, or thyroid. Individuals who suffered an acute viral infection in the 4 weeks prior to admission were also excluded, as were those who failed to provide informed consent. Patients were interviewed approximately 2–5 days after admission. Eligibility criteria were met by 419 cases, and 350 were included in the study. Reasons for exclusions were death (n = 25) or discharge (n = 23) before the interviews could be completed, being too sick to be interviewed (n = 13), or no consent to participate (n = 8).

Controls

For each case, two controls matched by age (within 5 years), gender, and hospital were obtained from non-cardiac outpatient clinics or inpatient wards. The same exclusion criteria utilized for cases were applied for control selection. We identified approximately 707 eligible control subjects, of whom 7 declined to be interviewed. Controls were relatively healthy individuals with minor ailments or conditions and were obtained from the following wards and clinics (% of total controls): eye (37%), ear, nose, and throat (21%), dermatology (14%), orthopaedic (10%), surgery (7%), general medicine (7%), gynaecology (3%), other (<1%).

Controls were selected using one of two methods depending on the hospital. In the first method, research assistants were assigned to accompany a particular physician during an outpatient clinic, following a weekly schedule of clinics and wards. At the end of each consultation, the physician or the physician's assistant invited the patient to speak with the research assistants about their lifestyle and diet. Patients that were eligible according to study criteria were then informed of the study and asked to participate. In these situations, participation was 100%. In the second method, research assistants independently identified control patients from clinics and wards. Assistants attempted to approach all individuals present during a particular outpatient clinic or in a specified ward. In large clinics, patients were screened for eligibility and invited to participate according to their queue number (highest number first). This method was used to prevent arbitrariness in the selection of controls. Basic demographic information was collected from all those approached. If an individual was eligible, assistants briefly explained the study and asked if they were willing to participate. Among those approached, only seven individuals who were eligible refused to participate.

Data collection

The study was approved by the relevant institutional review boards. Interviews were conducted in hospital wards or clinics by one of four research assistants and lasted approximately 25 minutes. Research assistants collected data on socioeconomic status, smoking history, history of hypertension, diabetes, hypercholesterolaemia, family history of CVD (including CHD, angina, myocardial infarction, hypertension, diabetes, stroke, sudden death, bypass surgery), dietary intake, types of fat or oils used in cooking, nutritional supplement use, and physical activity. Next, anthropometric measures (height, weight, hip and waist circumferences) were obtained and body mass index (BMI) (weight (kg)/height (m^2)) and waist to hip ratio (WHR) were calculated. Waist and hip measures were assessed using a standardized tape measure with waist measures taken at the midpoint between the costal margin and iliac crest and hip measures taken at the widest circumference. Study questionnaires were coded and double entered.

Physical activity questionnaire

Physical activity levels were assessed using a validated physical activity questionnaire specific for the Indian population that focused on occupational and other non-leisure time activities, in addition to leisure-time exercise.[11] It was validated by comparing energy expenditure (determined by the questionnaire) with energy intake as measured by 24-hour dietary recalls. A significant positive correlation was reported (r = 0.33, $P = 0.02$) which was comparable with other validation studies where energy expenditure was assessed using a physical activity questionnaire.[11–13] Subjects were asked to report the average time spent at work and average frequency of activities related to leisure or recreation, household chores, as well as sedentary and daily activities over the last month. The intensity or metabolic equivalents (MET) of the reported activities were obtained from the Compendium of Physical Activities.[14] For those activities not listed in the Compendium, the MET of a similar activity was assigned. The questionnaire provided an estimate of overall energy expenditure per day and the energy expenditure of specific categories of activities (work, leisure-time exercise, hobbies, chores, and sedentary activities). Metabolic equivalent-minutes (MET-min), a measure of both intensity and duration of specific activities, were also derived to assess levels of leisure-time exercise.

Statistical analysis

To assess the potential for confounding, mean values of CHD risk factors were examined across levels of leisure-time exercise (assessed in met-minutes), sedentary activity (minutes), and work-related activities (minutes) among controls. Continuous covariates were categorized to avoid assumptions of linear associations with the outcome and to minimize the effect of outlying values. Participants were grouped into quartiles (sedentary activity), or into tertiles (leisure time exercise), or two categories depending on the distribution of each variable and the number of subjects within each category. To evaluate the relation between leisure-time exercise and risk of CHD, we used conditional logistic regression, first controlling only for the matching factors (age, sex, hospital), and then, in addition, other potential risk factors. Analysis of leisure-time exercise compared risk associated with different levels of exercise to non-exercisers. Similar analyses were performed for sedentary (non-work) and work-related activities. For work-related activities, total time spent at work, and average time spent sitting, standing, walking, and in strenuous activities at work were assessed. We also examined whether the associations observed with leisure-time exercise and sedentary activity and CHD risk were modified by: age, gender, cigarette and bidi smoking, BMI, WHR, alcohol intake, education, or income. All analyses were conducted in *Statistical Analysis Software* (version 8).

Results

We enrolled 350 cases and 700 controls, equally recruited from New Delhi and Bangalore. The mean age was 52 years (standard deviation, 11) and 12% were women.

The mean 24-hour energy expenditure among control subjects was 10 536 kJ (standard deviation 2939). Men had higher energy expenditure than women (10 844 compared with 8356 kJ/day). On average, the relative contributions of major type activities to total energy expenditure among controls were 32.2% for work-related activity, 7.7% for sedentary activity, and 4.3% for leisure-time exercise. Approximately, 48% of all controls were participating in some form of leisure-time exercise. This included walking, jogging, yoga, gardening, as well as sports and games such as badminton, swimming or those recreational activities that had MET ranging from 3 to 8. On the other hand, cases spent more time in sedentary activities or behaviours such as watching television, listening to music, reading and writing, or other activities with MET of ⩽2. The majority of sedentary time was spent watching television (47%).

Table 1 Distribution of coronary heart disease (CHD) risk factors according to leisure-time physical activity, sedentary activity and work (occupational) activity status (lowest and highest levels) among control subjects in New Delhi and Bangalore (n = 655)

	Leisure-time exercise		**Sedentary activity**		**Work activity**	
n = 655	Level 1 0	Level 3 >145MET-min	Level 1 ⩽70 min	Level 4 >215 minutes	Level 1 0	Level 4 ⩾494 minutes
Median (MET-min or min/day)	0	234	45	291	0	600
No. of controls	339	189	169	147	202	151
Mean values						
Age (years)	49.6	55.0	50.7	56.6	61.4	46.6
Body mass index (kg/m^2)	23.6	22.7	21.7	24.1	23.6	23.2
Height (m) (males/females)	1.67/1.53	1.68/1.55	1.68/1.55	1.67/1.53	1.67/1.54	1.68/1.48
Weight (kg) (males/females)	65.1/59.1	63.45/60.50	60.46/55.76	66.44/61.54	63.09/60.93	65.36/48.25
Waist to hip ratio	0.941	0.936	0.944	0.933	0.925	0.948
Alcohol intake, servings/day	0.18	0.09	0.17	0.15	0.09	0.12
Household income, rupees/ month	7809	9965	7629	9696	9458	10 374
Leisure-time exercise, MET-min/day	–	–	100	112	42	63
Sedentary activity, min/day	140	153	–	–	211	103
Work activities: total duration, min/day	390	255	418	173	–	–
1 Sitting, min/day	185	137	187	82	–	–
2 Standing, min/day	80	52	84	48	–	–
3 Walking, min/day	90	54	88	43	–	–
4 Strenuous activity, min/day	35	11	58	1	–	–
Percentage values						
Female	15	7	12	16	33	1
⩾12 years of schooling	39	47	28	54	30	48
Current cigarette smokers	15	11	10	15	9	19
Current bidi smokers	12	11	20	3	6	14
Family history of CHD	33	25	15	44	26	37
History of hypertension	14	20	10	31	28	10
History of diabetes	8	22	5	20	19	7
Religion, Hindu	82	90	83	84	85	82
Manual labourer	8	5	14	1	2	7

The mean values of CHD risk factors across levels of leisure-time physical activity, sedentary, and work-related activity are presented in Table 1. People in the highest level of leisure-time exercise were older, more educated, consumed fewer cigarettes, and had less family history of CHD, and lower BMI and WHR than non-exercisers. The higher prevalence of history of hypertension and diabetes among exercisers may reflect doctors' recommendations to hypertensives and diabetics to improve physical activity. People with the most sedentary lifestyles were older, had higher socioeconomic status and increased BMI, and consumed more cigarettes yet less bidis (small unfiltered cigarettes) and were less likely to be involved in manual labour than the least sedentary. They also spent less time in work-related activity, and had higher prevalences of hypertension, diabetes, and family history of CHD than the least sedentary. People in the highest level of work activity were usually younger, more educated men who smoked more and were involved in less sedentary activity, but also in less leisure-time exercise than those who had no work-related activity.

Age- and sex-adjusted as well as multivariate-adjusted relative risks (RR) for CHD risk factors are presented in Table 2. Cigarette and bidi smoking, history of high cholesterol, family history of CHD, history of hypertension, and both higher WHR and BMI levels were significant determinants of CHD in this population.[15]

In age- and sex-adjusted analyses of leisure-time exercise (Table 3A), people in the highest level (>145 MET-min of exercise per day or an equivalent of 36 minutes of brisk walking per day) had a 55% lower risk compared with those who did not exercise (RR = 0.45; 95% CI: 0.31, 0.66; *P*-value for trend <0.0001). The association remained similar in multivariate analysis (Figure 1). Further adjustment for duration at work and in sedentary activity did not alter the association. We found that the association with leisure-time exercise was significantly modified by cigarette smoking status (*P* = 0.03). While both cigarette smokers and non-cigarette smokers were at reduced risk with increased leisure-time exercise, the apparent protective effect was greater among non-smokers.

In age- and sex-adjusted analysis of sedentary activity (Table 3A), people in the highest level (⩾3.6 hours per day of sedentary activity such as sitting or television viewing) had an RR of 1.58 (95% CI: 1.05, 2.36; *P*-value for trend = 0.02) compared with those in the lowest level (<70 minutes per day of sedentary activity). The association strengthened in multivariate analysis, with those leading the most sedentary lifestyles having an 88% greater risk compared with the least sedentary individuals (RR = 1.88; 95% CI: 1.05, 3.07; *P*-value for trend = 0.02). Control for leisure-time exercise and duration at work slightly strengthened this association. In further analysis limited specifically to television viewing, people watching a median of 3 hours per day of television were at a marginal, yet not significant, elevation in risk compared with those who did not watch television (RR = 1.22, 95% CI: 0.62, 2.41; *P*-value for trend = 0.1).

Leisure-time exercise and sedentary activity variables were not highly correlated in our study population (r = 0.09 among controls and r = 0.16 among cases), we therefore were able to examine their joint effect. We conducted this analysis using a multivariate model that included indicator variables for each combination of leisure-time exercise and sedentary activity. Figure 2 illustrates the relation of leisure-time exercise to CHD risk across levels of sedentary activity: people in our study population with the highest amount of leisure-time exercise and the least amount of sedentary activity had over a 70% reduction in risk in multivariate analysis compared with people who were the most sedentary with the least amount of leisure-time exercise. This finding was not altered after further control for work-related activity.

Table 2 Relative risk (RR) of acute myocardial infarction according to potential risk factors

	Age- and sex-adjusted RR[a] (95% CI)	**Multivariate RR[b] (95% CI)**
Cigarette smoking (>10 cig/day versus never smokers)	7.6 (4.5, 12.8)	7.5 (4.0, 14.0)
Bidi smoking (>10 bidis/day versus never smokers)	8.0 (4.8, 13.3)	6.7 (3.7, 12.3)
Body mass index (⩾25 kg/m^2 versus <20 kg/m^2)	2.5 (1.6, 3.9)	2.6 (1.4, 4.7)
Waist to hip ratio (>1.0 versus ⩽0.9)	3.2 (1.9, 5.2)	2.5 (1.3, 4.8)
Family history of CHD[c] (yes versus no)	1.9 (1.4, 2.5)	2.3 (1.6, 3.5)
History of hypertension (yes versus no)	2.6 (1.9, 3.7)	2.2 (1.5, 3.5)
History of high cholesterol (yes versus no)	6.3 (1.9, 21.0)	4.5 (0.7, 27.7)
History of diabetes (yes versus no)	1.5 (1.0, 2.2)	1.3 (0.8, 2.2)
Education (none versus highest level)	2.1 (1.1, 4.1)	2.5 (1.0, 6.0)
Household income (<3000 versus >10 000 rupees/month)	1.6 (1.1, 2.5)	1.6 (0.9, 3.0)
Religion, Hindu (yes versus no)	0.7 (0.5, 1.0)	0.9 (0.6, 1.4)

[a] Also adjusted for hospital.

[b] Covariates that were controlled for in multivariate model include: the matching factors: age, sex, hospital; and cigarette smoking (never, past, current: ⩾2 cigarettes per day, >2–6, >6–12.5, >12.5), bidi smoking (never, past, current: ⩽5.5 bidis per day, >5.5–10, >10–20, >20), body mass index (<21 kg/m^2, ⩾21–23, ⩾23–26, ⩾26), waist to hip ratio (⩽0.91, >0.91–0.95, >0.95–0.98, >0.98), history of hypertension (no, yes), history of diabetes (no, yes), history of high cholesterol (no, yes), family history of coronary heart disease (no, yes), alcohol intake (no intake, any intake), education (none, primary school, middle, secondary, higher secondary, college, graduate/professional), household income (<3000 rupees per month, 3000–6000, 6000–10 000, >10 000), and being Hindu (no, yes).

[c] Coronary heart disease.

Table 3A Relative risk (RR) of acute myocardial infarction by leisure-time exercise and sedentary activity

				Relative risks (95% CI)		
(N = 960)	Median	No. of cases	No. of controls	Age- and sex-adjusted RR[a]	Age-, sex- and smoking-adjusted RR[a]	Multivariate RR[b]
Leisure-time exercise						
0 MET-min per day	0	189	339	1.0	1.0	1.0
>0–145	75	65	127	0.85 (0.59, 1.23)	1.02 (0.67, 1.55)	0.96 (0.59, 1.55)
⩾145	234	51	189	0.45 (0.31, 0.66)	0.51 (0.33, 0.78)	0.44 (0.27, 0.71)
P-value, test for trend				<0.0001	0.002	0.001
Sedentary activity (non-work)						
<70 min per day	45	73	169	1.0	1.0	1.0
70–30	100	70	174	0.93 (0.63, 1.39)	1.07 (0.68, 1.68)	1.15 (0.68, 1.95)
>130–< 215	177	67	165	0.96 (0.64, 1.44)	1.03 (0.65, 1.63)	1.04 (0.61, 1.76)
⩾215	291	95	147	1.58 (1.05, 2.36)	1.67 (1.06, 2.63)	1.88 (1.09, 3.21)
P-value, test for trend				0.02	0.03	0.02

[a] Also adjusted for hospital.

[b] Covariates that were controlled for in multivariate model include: the matching factors: age, sex, hospital; and cigarette smoking (never, past, current: ⩾2 cigarettes per day, >2–6, >6–12.5, >12.5), bidi smoking (never, past, current: ⩽5.5 bidis per day, >5.5–10, >10–20, >20), body mass index (<21 kg/m^2, ⩾21–23, ⩾23–26, ⩾26), waist to hip ratio (⩽0.91, >0.91–0.95, >0.95–0.98, >0.98), history of hypertension (no, yes), history of diabetes (no, yes), history of high cholesterol (no, yes), family history of coronary heart disease (no, yes), alcohol intake (no intake, any intake), education (none, primary school, middle, secondary, higher secondary, college, graduate/professional), household income (<3000 rupees per month, 3000–6000, 6000–10 000, >10 000), and being Hindu (no, yes).

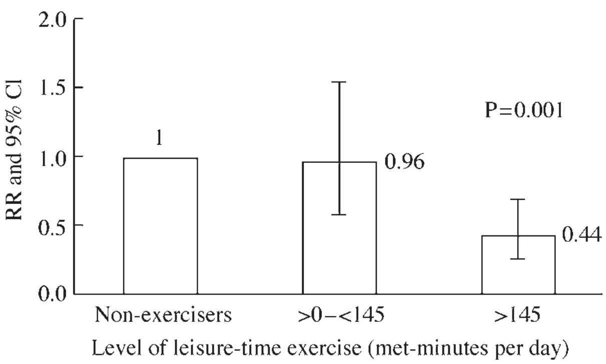

Figure 1 Relative risk of acute myocardial infarction by level of leisure-time physical exercise[a]

[a] Covariates that were controlled for in multivariate model include: the matching factors: age, sex, hospital; and cigarette smoking (never, past, current: ⩾2 cigarettes per day, >2–6, >6–12.5, >12.5), bidi smoking (never, past, current: ⩽5.5 bidis per day, >5.5–10, >10–20, >20), body mass index (<21 kg/m^2, ⩾21–23, ⩾23–26, ⩾26), waist to hip ratio (⩽0.91, >0.91–0.95, >0.95–0.98, >0.98), history of hypertension (no, yes), history of diabetes (no, yes), history of high cholesterol (no, yes), family history of coronary heart disease (no, yes), alcohol intake (no intake, any intake), education (none, primary school, middle, secondary, higher secondary, college, graduate/professional), household income (<3000 rupees per month, 3000–6000, 6000–10 000, >10 000), and being Hindu (no, yes).

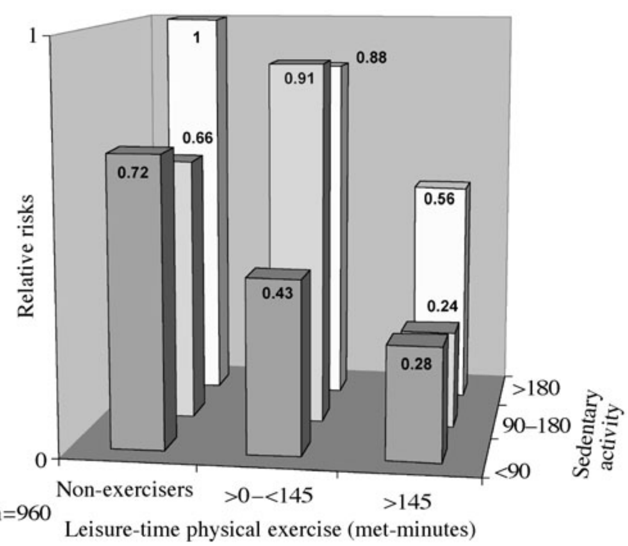

Figure 2 Relative risk of acute myocardial infarction by categories of leisure-time physical exercise across sedentary activity levels[a,b]

[a] Reference group consists of people in the lowest category of leisure-time physical exercise who were the most sedentary.

[b] Multivariate adjusted for the matching factors: age, sex, hospital; and cigarette smoking (never, past, current: ⩾2 cigarettes per day, >2–6, >6–12.5, >12.5), bidi smoking (never, past, current: ⩽5.5 bidis per day, >5.5–10, >10–20, >20), body mass index (<21 kg/m^2, ⩾21–23, ⩾23–26, ⩾26), waist to hip ratio (⩽0.91, >0.91–0.95, >0.95–0.98, >0.98), history of hypertension (no, yes), history of diabetes (no, yes), history of high cholesterol (no, yes), family history of coronary heart disease (no, yes), alcohol intake (no intake, any intake), education (none, primary school, middle, secondary, higher secondary, college, graduate/professional), household income (<3000 rupees per month, 3000–6000, 6000–10 000, >10 000), and being Hindu (no, yes).

Duration of work per day was associated with an elevation in risk although it was not significant (Table 3B). People spending a median of 10 hours per day at work had an RR of 1.9 (95% CI: 1.01, 3.56; *P*-value for trend = 0.1) compared with those not working. Further adjustment for leisure-time exercise and

Table 3B Relative risk (RR) of acute myocardial infarction by work-related activities

				Relative risks (95% CI)		
(n = 960)	**Median**	**No. of cases**	**No. of controls**	Age- and sex-adjusted RR[a]	Age-, sex- and smoking-adjusted RR[a]	Multivariate RR[b]
Duration at work						
0 minutes per day	0	87	202	1.0	1.0	1.0
>0–<480	360	53	124	1.14 (0.70, 1.82)	1.11 (0.66, 1.88)	1.22 (0.67, 2.20)
⩾480–<494	480	76	178	1.19 (0.73, 1.95)	1.09 (0.63, 1.90)	1.31 (0.71, 2.43)
⩾491	600	89	151	1.58 (0.97, 2.58)	1.51 (0.87, 2.62)	1.90 (1.01, 3.56)
P-value, test for trend				0.2	0.5	0.1
Duration of sitting at work						
0 minutes per day	0	108	234	1.0	1.0	1.0
<160	108	72	131	1.23 (0.80, 1.91)	1.07 (0.64, 1.78)	1.30 (0.74, 2.30)
>160–< 360	240	59	145	0.91 (0.59, 1.42)	0.85 (0.52, 1.40)	0.95 (0.54, 1.67)
⩾360	420	66	145	0.99 (0.64, 1.53)	0.99 (0.61, 1.63)	1.10 (0.63, 1.92)
P-value, test for trend				0.4	0.5	0.9
Duration of standing at work						
0 minutes per day	0	152	336	1.0	1.0	1.0
⩽120	60	82	217	0.86 (0.61, 1.23)	0.93 (0.62, 1.39)	1.00 (0.64, 1.57)
>120	240	71	102	1.58 (1.06, 2.35)	1.73 (1.08, 2.76)	1.85 (1.00, 3.12)
P-value, test for trend				0.05	0.07	0.05
Duration of walking at work						
0 minutes per day	0	147	329	1.0	1.0	1.0
<120	60	74	132	1.31 (0.89, 1.92)	1.68 (0.56, 1.64)	1.88 (1.13, 3.12)
⩾120	179	84	194	1.00 (0.69, 1.46)	1.07 (0.69, 1.64)	1.00 (0.61, 1.64)
P-value, test for trend				0.6	07	0.7
Duration of strenuous activity at work						
0 minutes per day	0	81	619	1.0	1.0	1.0
>0	120	41	309	1.02 (0.67, 1.55)	1.03 (0.63, 1.66)	1.23 (0.70, 2.15)

[a] Also adjusted for hospital.

[b] Covariates that were controlled for in multivariate model include: the matching factors: age, sex, hospital; and cigarette smoking (never, past, current: ⩾2 cigarettes per day, >2–6, >6–12.5, >12.5), bidi smoking (never, past, current: ⩽5.5 bidis per day, >5.5–10, >10–20, >20), body mass index (<21 kg/m^2, ⩾21–23, ⩾23–26, ⩾26), waist to hip ratio (⩽0.91, >0.91–0.95, >0.95–0.98, >0.98), history of hypertension (no, yes), history of diabetes (no, yes), history of high cholesterol (no, yes), family history of coronary heart disease (no, yes), alcohol intake (no intake, any intake), education (none, primary school, middle, secondary, higher secondary, college, graduate/professional), household income (<3000 rupees per month, 3000–6000, 6000–10 000, >10 000), and being Hindu (no, yes).

sedentary activities did not alter the association. The time at work spent sitting (MET = 1.5), standing (MET = 2.0), walking (MET = 3.5), and in strenuous activities (MET = 4.5) were assessed separately (Tables 3B). People spending an average of ⩾2 hours per day standing had an 85% elevation in risk (RR = 1.85; 95% CI: 1.00, 3.12; *P*-value for trend = 0.05) compared with those who did not spend any time standing at work. No association with total 24-hour energy expenditure or other categories of activities including household chores was observed.

Discussion

In this urban population of Indian men and women, we observed a strong and dose-dependent inverse association between leisure-time exercise and non-fatal CHD. Risk for CHD decreased across levels of leisure-time exercise, with people exercising the equivalent of 36 minutes of brisk walking per day having less than half the risk of non-exercisers. We also found an association between increased sedentary activity and CHD risk, the equivalent of 3.6 hours per day of sedentary activities such as television viewing was associated with nearly a 90% increase in risk. As well, we observed that increased duration of standing at work was associated with an elevation in risk.

Potential sources of bias in our investigation include the selection of controls and a differential recall among cases compared with control subjects. While the use of population-based controls would be ideal, we addressed selection bias that may arise with use of hospital-based controls by obtaining control subjects from seven different outpatient clinics and inpatient wards in hospitals. Therefore, if an association exists between the exposure of interest and the disease status of one control group, the bias that may result would be diluted.[16] Additionally, we used a systematic method of control selection that would avoid arbitrary selection of controls within wards and clinics. To the extent that physical activity is also protective for these conditions, such bias would attenuate the association observed between physical activity and CHD risk in our study. Selection bias among case subjects, where only cases who survived long enough to be interviewed were included, would also be minimized as only 25 cases did not survive to be included in the study. Although health conscious individuals may have been more likely to give consent for the study, overall participation was high, and bias from this source is likely to be modest. Controls in our population were slightly more educated and had lower incomes than cases, but controlling for socioeconomic factors did not alter our findings. Differential recall of physical activity is also a potential concern; however, research assistants asked case subjects to specifically report on their level of activity and exercise prior to their myocardial infarction. While the potential for recall bias may exist, awareness of heart disease prevention and health consciousness may not be as high among our study population in India as its is in Western countries; hence the likelihood of recall bias may be lower. We also excluded all those with any prior heart disease from the study. As well, while we cannot exclude the possibility that not all activities were reported, interviewers were trained to conduct thorough interviews on all activities done during the day including leisure-time and activities of daily living. While future prospective research within India will adequately address these biases, the case-control design had the advantage of being cost, resource, and time efficient.

The apparent protective effect we observe with moderate-intensity exercises such as brisk walking at a frequency of 35–40 minutes per day is consistent with US recommendations stating that individuals 'accumulate at least 30 minutes or more of moderate-intensity physical activity on most, or preferably all, days of the week'.[5,6,9] As well, findings from a large prospective study of US women indicate that approximately ⩾3 hours per week of brisk walking was associated with a 30–40% reduction in CHD risk,[17] and in a cohort of US men, individuals expending the equivalent of 30 minutes in moderate-intensity activities had a 20% lower risk for CHD.[18] Moreover, recent findings from a cohort of post-menopausal US women indicate that the reduction in CVD risk that is associated with vigorous exercise is similar for walking.[19] The elevation in risk observed with increased sedentary activity independent of leisure-time exercise is consistent with research that has described physical activity and physical inactivity (such as television viewing) as different risks.[20,21] While reduced levels of physical activity lead to lower energy expenditure and lower lean body mass, physical inactivity or sedentary activities may be related to obesity and risk for chronic disease through increase in energy intake and not just lower energy expenditure. Research on work-related activity has generally not shown an association with risk. Data from the Israeli Ischemic Heart Disease Study indicated that among middle-age men leisure-time exercise, but not work-related activity, was associated with a significant reduction in risk for CHD and all-cause mortality.[22] Work-related activity was also associated with a slightly higher all-cause mortality risk among a cohort of Swedish men, but the association did not remain after further control for smoking, occupational class, and alcohol abuse.[23]

Several biological mechanisms could explain the beneficial effects of physical activity on CVD risk, including lowering of blood pressure, elevation in high density lipoprotein levels, increased insulin sensitivity, improved endothelial function, and reduced atherogenic cytokine production.[5,6,24–34]

Our findings are the first to highlight the adverse health consequences of physical inactivity and the importance of leisure-time exercise in the prevention of CHD risk among Indians. Given limited resources for the care of CHD and the potential benefit of exercise in urban India where physical inactivity levels are now comparable with the West, population-based health strategies should focus on promoting regular physical exercise.

Acknowledgements

We thank Dr Anura Kurpad, Division of Nutrition, St John's Medical College (SJMC) in Bangalore and Dr D Prabhakaran, Department of Cardiology, All India Institute of Medical Sciences (AIIMS) in New Delhi for their support. We are also indebted to the participating hospitals in this multi-center investigation: Dr Prem Pais (SJMC), Dr Subash Chandra (Manipal Heart Foundation), Dr Dinesh K Dhanwal (Lok Nayak JP Hospital), Dr Sushum Sharma (Railways Hospital), Dr Sr Teresita, (St Martha's Hospital), Dr Nagaraj Desai, (Ramaiah Medical College), Dr BP Singh (Mata Chanan Devi Hospital). We thank research assistants, Nisha Punni, Savita Dhatwalia, Smitha JT and AM Anamika; and appreciate the assistance provided by staff at AIIMS (Arti Kohli, Monika Arora, Dr Lakshmi) and SJMC (Sumithra Muthayya, Dr Shobana). This project was supported in part by the Unilever Corporation.

KEY MESSAGES

- Physical inactivity levels in urban India, where cardiovascular diseases have become the leading cause of death, are now comparable with levels observed in the West.
- Approximately 145 metabolic equivalents (MET)-minutes per day of leisure-time exercise, equivalent to 35–40 minutes per day of brisk walking was associated with over a 50% reduction in risk for coronary heart disease (CHD) in this study.
- Sedentary lifestyles were associated with an increase in risk; approximately 3.5 hours of, for example, television viewing per day being associated with an 88% elevation in CHD risk.
- The protective effect of leisure-time exercise was most beneficial among those who also had the least sedentary lifestyle.
- The study findings were consistent with US recommendations stating that individuals 'accumulate at least 30 minutes or more of moderate-intensity physical activity on most, or preferably all, days of the week'.

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Advance Access publication 24 March 2004

International Journal of Epidemiology 2004;**33**:767–768
doi:10.1093/ije/dyh104

Commentary: Prevention of coronary heart disease in South Asia—containing the physical inactivity epidemic

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Cardiovascular disease is becoming a major health burden in developing countries.[1] The prevalence of coronary heart disease (CHD) in India has more than doubled in the past two decades and the prevalence in urban Indians is approaching the figures reported in migrant Asian Indians.[2,3] With increasing rates of urbanization in India, major changes in lifestyle patterns have occurred for a large proportion of individuals. This has led to a trend towards decreasing physical activity due to improved transportation and availability of energy saving devices, increasing weight and consequently increasing rates of diabetes, hypertension, and dyslipidaemia in urban populations.[3] Comparisons of CHD risk factor prevalence between low-risk rural populations and urban populations in India,[3] and studies among emigrant South Asians,[4] suggest that increased physical activity would be an important measure for prevention of coronary artery disease in South Asians.

Physical inactivity is a well-established risk factor for CHD in Western populations and is associated with about a twofold increase in risk of CHD.[5] A crucial question of public health relevance concerns the differences in level of risk factors between populations and the generalizability of Western guidelines for the prevention of CHD in the Indian population. It has been postulated that people of Indian ethnicity have an increased susceptibility to CHD due to both genetic factors predisposing to high levels of metabolic cardiovascular risk factors associated with insulin resistance e.g. central adiposity, glucose intolerance, hyperinsulinaemia, and dyslipidaemia (metabolic syndrome), as well as to environmental influences which lead to weight gain, rise in blood cholesterol, and blood pressure.[1] Whether the cardiovascular effects of physical activity are similar in the Indian population has yet to be clarified. Epidemiological data on risk factors in India are limited. As prospective cohort studies for evaluation of CHD risk factors do not exist in India, case-control studies can provide important information regarding CHD risk factors despite their limitations. Pais *et al*. has shown that traditional risk factors such as smoking, hypertension, cholesterol, and abdominal obesity are important risk factors in subjects in India.[6] The case-control study carried out by Rastogi *et al*. investigating the relationship between physical activity and CHD in urban Indian populations published in this issue of the *International Journal of Epidemiology* provides additional information on the epidemiology of risk factors in India.[7]

The authors conducted a hospital-based case-control study and collected data from 350 cases of acute myocardial infarction and 700 controls matched in age, gender, and hospital in New Delhi and Bangalore. Physical activity levels were assessed using a validated physical activity questionnaire which focused on occupational and other non-leisure time activities, in addition to leisure-time exercise. One of the main findings is that

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