ORIGINAL INVESTIGATION

Leisure-Time Physical Activity and the Risk of Primary Cardiac Arrest

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Background: Because the risks of sudden cardiac death and myocardial infarction are transiently increased during acute bouts of high-intensity activity, it is an important question from the public health perspective whether regular participation in moderate-intensity activity confers overall protection from sudden cardiac death.

Participants and Methods: We used data from a population-based case-control study to assess the associations of regular high-intensity and moderate-intensity leisure-time physical activity with primary cardiac arrest. Cases were patients with primary cardiac arrest, aged 25 to 74 years, attended by paramedics between 1988 and 1994 in King County, Washington (n = 333). Controls were randomly identified from the same community (n = 503), matched for age and sex. All case patients and controls were free of prior clinical heart disease, major comorbidity, and self-reported poor health. Spouses of case patients and controls were interviewed to assess participation in 15 high-intensity and 6 moderate-intensity physical activities during the prior year.

Results: Compared with subjects who performed none of the activities, the odds ratio for primary cardiac arrest from matched analyses was 0.34 (95% confidence interval, 0.13-0.89) among subjects who performed only gardening activities for more than 60 minutes per week; 0.27 (95% confidence interval, 0.11-0.67) among subjects who walked for exercise for more than 60 minutes per week; and 0.34 (95% confidence interval, 0.16-0.75) among subjects who engaged in any high-intensity activities, after adjustment for age, smoking, education, diabetes, hypertension, and health status.

Conclusions: The results suggest that regular participation in moderate-intensity activities, such as walking and gardening, are associated with a reduced risk of PCA and support current exercise recommendations.

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WHETHER REGULAR exercise is associated with an overall reduction in the risk of coronary heart disease, including sudden cardiac death, is no longer a source of controversy.[1-5] However, less understood is the exercise intensity required to achieve the cardiac benefit of regular exercise. In early epidemiological studies,[1,2,6-8] vigorous exercise was associated with a decreased risk of sudden cardiac death, while nonvigorous exercise was not. More recently, modest levels of energy expended in leisure-time physical activities (LTPAs) were found to be associated with a decreased risk of sudden cardiac death among middle-aged men participating in the Multiple Risk Factor Intervention Trial.[3] While only total LTPA was considered, the activities reported by the men in the cohort were mostly low- and moderate-intensity LTPA. Because during acute bouts of high-intensity activity the risks of both sudden cardiac death and myocardial infarction are transiently increased,[9-11] whether regular participation in moderate-intensity activity confers overall protection from sudden cardiac death is an important question from the clinical and public health perspective.

We used data from a population-based case-control study to investigate whether the intensity and the time spent in LTPAs are associated with a reduced risk of primary cardiac arrest (sudden cardiac death). In addition, we investigated whether 2 specific moderate-intensity LTPAs, gardening and walking for exercise, are associated with a decreased risk of primary cardiac arrest (PCA).

RESULTS

Traditional risk factors for PCA—current smoking, diabetes, hypertension, and family history of myocardial infarction or sudden death—were more prevalent in case patients than in controls (**Table 1**). In addition, case patients were on average heavier than controls, drank more coffee and alcohol, and were less likely to be in excellent or very good health.

More case patients than controls engaged in no LTPA, and fewer case patients than controls engaged in high-

PARTICIPANTS AND METHODS

The study methods have been described in detail[12] and are summarized herein.

PARTICIPANTS

From emergency service incident reports, we identified all case patients of out-of-hospital PCA attended by paramedics in Seattle and suburban King County, Washington, between October 1988 and June 1994. We defined PCA as a sudden pulseless condition in the absence of evidence a noncardiac cause of cardiac arrest. In addition to emergency service incident reports, we reviewed death certificates, medical examiner reports, and autopsy reports when available, to exclude patients with cardiac arrest of noncardiac origin. The term *primary cardiac arrest* refers to a cardiac arrest that was a result of heart disease and not secondary to trauma, drug overdose, respiratory failure, renal failure, end-stage liver disease, cancer, or other noncardiac causes.[12,13] We restricted case patients with PCA to married residents of King County between the ages of 25 and 74 years. Because the focus of the study was on individuals who appeared healthy until their cardiac arrest, we excluded case patients with a history of clinically recognized heart disease or life-threatening comorbidities. The spouses of 355 eligible case patients (83% of eligible case patients) participated in an in-person interview. Spousal data were used because of the high case patient fatality rate. For this article, we excluded 18 case patients who were reported by their spouse to be in poor health during the previous year, 3 with missing values of key covariates, and 1 case patient whose spouse reported more than 50 hours of LTPAs per week.

Control subjects, individually matched to case patients on age (within 7 years) and sex at a ratio of about 2, were randomly selected from the community by the sampling technique of random-digit dialing.[14] Ninety-five percent of the known residential households that we called were successfully screened to determine if residents were eligible for the study. We selected eligible controls in order of contact: as we accrued case patients in the study, we screened residences for eligible controls to match to these case patients and invited them to participate in the study. Inclusion criteria for the controls included King County residency, married status, and absence of clinically recognized heart disease and major comorbidity. The spouses of 516 eligible control subjects participated in an in-person interview (68% of eligible controls) for an overall response rate of 64%. To ensure comparability of the information obtained on case patients and controls, we used spousal data for the controls as well. For this article, we excluded 1 control who was reported by his spouse to be in poor health, 11 with missing values of key covariates, and 1 control whose spouse reported more than 50 hours of LTPAs per week.

LTPA ASSESSMENT

Information on LTPA was collected from case patient and control spouses during an in-person interview using an instrument derived from the Minnesota Leisure-Time Activity Questionnaire.[15] Participation in 21 LTPAs during the year before the reference date (date of cardiac arrest for the case patients, interview date for the controls) was recorded. Activities were considered high intensity if the estimated energy expenditure to perform the activities was 6 kcal/min or more ($\geq$25 kJ).[15] The questionnaire included 6 moderate-intensity activities (walking for exercise, golf, calisthenics or general exercise, mowing the lawn, weeding or gardening, and raking the lawn), and 15 high-intensity activities (biking, exercise cycle, aerobics, jogging, weight lifting, swimming, skating, downhill skiing, cross-country skiing, tennis [doubles and singles], racquetball, paddleball, handball, or squash). Participation in other physical activities not specified on the list was also recorded. For each LTPA, the interviewer asked the number of months the activity was performed in the prior year, the number

Continued on next page

intensity LTPA (**Table 2**). Compared with subjects who engaged in no LTPA, the estimated risk of PCA was 0.36 (95% confidence intereval [CI], 0.17-0.77) both among subjects who engaged only in moderate-intensity LTPA and among subjects who engaged in high-intensity LTPA, after adjustment for age, smoking, hypertension, diabetes, education, and health status (Table 2). The relatively large effect of adjustment on the estimated relative risk for high-intensity LTPA was largely due to a greater proportion of never smokers and of subjects in self-reported excellent health among the subjects who engaged in high-intensity LTPA (51% never smokers and 43% subjects in excellent health among controls in high-intensity LTPA category compared with 44% and 33%, respectively, among controls in the no LTPA category). Addition of a continuous term for total time spent in LTPA did not improve the model with categorical variables for both moderate-intensity and high-intensity activity shown in Table 2 (P = .48).

The 2 moderate-intensity LTPAs that were reported most often were gardening activities and walking for exercise. To investigate the association of gardening and walking to PCA to and to contrast these activities with high-intensity LTPA, we split the category of moderate-intensity LTPA into 5 subcategories of gardening, walking, and other, for a total of 7 mutually exclusive categories. The type of activities performed by the subjects in each of the 7 categories and the average time spent in these activities are illustrated in **Table 3**.

Among subjects who engaged in only gardening activities for more than 60 min/wk, the estimated adjusted risk of PCA was 0.34 (95% CI, 0.13-0.89) compared with subjects who engaged in no LTPA (**Table 4**). Among subjects who engaged in walking for exercise, with or without gardening, for more than 60 min/wk, the estimated relative risk of PCA was 0.27 (95% CI, 0.11-0.67). A similar reduction in risk of PCA was observed among subjects who engaged in high-intensity LTPAs in combination with any other activities (Table 4). Adjustment for total time spent in LTPA or for total kilocalories of energy expended in LTPA did not improve the categorical model shown in Table 4 and did not materially change the estimated relative risks (data not shown), suggesting

of times per month, and the usual amount of time spent on each occasion.

DEFINITION OF LTPA VARIABLES

We estimated the average time per week spent in each LTPA in the year before the reference date. The times spent in each LTPA were summed across moderate-intensity LTPAs and across high-intensity LTPAs for estimates of the time spent in moderate-intensity and high-intensity LTPAs, respectively. We also estimated total energy expenditure using published estimates of kilocalories expended per minute for each LTPA.[16]

We first defined 3 levels of LTPA: participation in no activities during the year before the reference date, participation in moderate-intensity LTPA only, and participation in high-intensity LTPA. We then split the moderate-intensity LTPA category into 5 subcategories for a total of 7 mutually exclusive categories of LTPA: (1) no activity; (2) gardening activities only, up to 60 min/wk, (3) gardening activities only, more than 60 min/wk; (4) walking for exercise, with or without gardening activities, up to 60 min/wk of walking, (5) walking for exercise, with or without gardening, more than 60 min/wk; (6) moderate-intensity LTPA other than walking for exercise or gardening activities; and (7) high-intensity LTPA with or without gardening, walking for exercise, and other moderate-intensity LTPA.

RELIABILITY OF SPOUSAL DATA

To assess the reliability of spousal reports of LTPA, we interviewed 55 survivors of PCA and their spouses and 489 controls and their spouses. Percentage agreement between subjects and spouses in classifying subjects in 3 mutually exclusive categories of LTPA (inactive, moderate-intensity LTPA only, high-intensity LTPA) was 86% for controls and 80% for case patients (κ statistics, 0.7 for both case patients and controls). When moderate-intensity LTPA was further subdivided into 5 categories, percentage agreement between subjects and spouses in classifying subjects into the resulting 7 categories of LTPA was 77% for controls, and 60% for case patients (κ statistics, 0.6 and 0.5, respectively). Spearman correlation coefficients between spouse and subject estimates of the time spent in high-intensity activity among subjects who engaged in high-intensity LTPA were 0.76 for controls (n = 285) and 0.80 for case patients (n = 24); for estimates of the time spent in moderate-intensity activity among subjects who engaged in moderate-intensity LTPA, Spearman correlation coefficients were 0.74 for controls (n = 457) and 0.62 for case patients (n = 47).

OTHER RISK FACTOR ASSESSMENT

The in-person interview of the subject spouses covered other risk factors for PCA including age, sex, race, weight, and height; physician-diagnosed diabetes mellitus, hypertension, and hypercholesterolemia; cigarette smoking; dietary saturated fat and intake of long-chain n-3 fatty acids; alcohol and caffeine consumption; family history of myocardial infarction or sudden death in a first-degree relative; and health status and education.

STATISTICAL ANALYSIS

The distribution of the case patients in the 3 or 7 mutually exclusive categories of LTPA was compared with that of the controls. Relative risks were estimated from odds ratios calculated for each category of LTPA compared with the category of no LTPA in models containing indicator variables for each category of LTPA. To control for confounding factors, odds ratios were adjusted for covariates simultaneously using conditional logistic regression analysis.[17] Covariates included in the final models were smoking (never, past, or current), diabetes, history of hypertension, education (formal education beyond high school, yes/no), and health status (fair, good, very good, or excellent).

no further benefits with increasing time spent in total LTPA beyond the benefits associated with longer time spent in walking for exercise and in gardening shown in this table.

Additional adjustment for family history of myocardial infarction or sudden cardiac death, body weight and height, hypercholesterolemia, alcohol and caffeine consumption, total dietary fat and intake of omega-3 fatty acids, and regular aspirin use only had trivial effects on the estimated relative risks shown in Tables 2 and 4 (data not shown).

With regard to walking for exercise and gardening, increased time spent on these activities appeared beneficial, although this benefit did not reach statistical significance. The risk of PCA among subjects who spent more than 60 min/wk walking for exercise was 0.60 (95% CI, 0.26-1.40) compared with subjects who walked less, and the risk of PCA among subjects who engaged in gardening for more than 60 min/wk was 0.65 (95% CI, 0.27-1.57) compared with subjects who did less gardening.

We did not observe a decreased risk of PCA in subjects who engaged in more than 60 min/wk of high-intensity LTPA compared with less (data not shown). Among the subjects who engaged in high-intensity LTPA, the median time spent in high-intensity LTPA was about 50 min/wk (Table 3). Since subjects who walked for exercise more than 60 min/wk spent far more time walking for exercise (median, 173 min/wk among controls) while experiencing a similar decrease in risk of PCA, it is possible that less time was needed to achieve maximum benefits with high-intensity LTPAs. On the other hand, 95% of controls and 89% of case patients who engaged in high-intensity LTPAs also engaged in moderate-intensity LTPAs and it was not possible to tease out the association of high-intensity LTPAs alone with PCA.

COMMENT

In this study, participation in moderate-intensity LTPA was associated with a reduced risk of PCA. When performed for more than 60 min/wk, walking for exercise or gardening was associated with a similar risk reduction to that of high-intensity LTPA.

It is important to note that we did not measure all physical activities. For example, home repair activities and walking for pleasure were not included. Instead, we assessed participation in activities that could be performed for the purpose of exercise together with gardening activities.

Early cohort studies[6-8] reported that vigorous exercise was needed to decrease the risk of sudden cardiac death. One reason for the lack of association with nonvigorous exercise might be that low- and moderate-intensity activities were reported with less accuracy than high-intensity activities.[15,18] Another possibility is that patterns of low- and moderate-intensity activities changed over the past 3 decades. In a previous case-control study[1] conducted in the same community a decade ago, we reported that high-intensity LTPA, but not moderate- and low-intensity LTPA, was associated with a reduction in risk of PCA. There are several possible reasons for the difference in the 2 study results: the previous case-control study assessed nonvigorous LTPAs more broadly including low- and moderate-intensity physical activities other than exercise. These activities might have masked the effect of moderate-intensity exercise. Additionally, the previous case-control study used a different reference group and was small, and the confidence limits surrounding the estimate of relative risk associated with low- and moderate-intensity LTPAs were wide and included the estimated 40% reduction in the risk of PCA observed in this study.

Our study is in agreement with results of the follow-up study of men participating in the Multiple Risk Factor Intervention Trial where modest levels of physical activity were associated with a 40% reduction in risk of sudden cardiac death.[3] In the Multiple Risk Factor Intervention Trial follow-up study, all physical activities were assessed, including home repair and walking for pleasure, and maximum benefits were achieved with a total duration of physical activities of 30 to 69 minutes per day.

The strengths of this study include the use of population-based controls and adjustment of the association of LTPA with PCA for other known risk factors. To address the possibility that case patients might have exercised less as a consequence of poor health leading to PCA,

Table 1. Characteristics of Case Patients and Controls

Characteristic	Case Patients* (N = 333)	Controls† (N = 503)	*P*
Age, y‡	59.5 (10.0)	58.1 (10.4)	.05
Men, %	79.6	78.3	.05
White, %	93.7	93.0	.05
Formal education beyond high school, %	60.7	77.1	<.05
Current smokers, %	35.1	10.3	<.05
Former smokers, %	37.5	43.5	.05
Diabetes mellitus, %	12.9	3.4	<.05
Hypertension, %	36.6	24.1	<.05
Hypercholesterolemia, %	25.8	21.8	.05
Family history of myocardial infarction or sudden death, %	54.9	39.5	<.05
Weight, kg‡	82.0 (16.4)	80.5 (15.8)	.05
Caffeine intake, mg/d‡	484.6 (534.9)	345.4 (405.1)	<.05
Alcohol intake, g/d‡	14.4 (29.4)	11.6 (19.3)	.05
Aspirin users, %	47.7	47.4	.05
Dietary eicosapentaenoic acid and docosahexaenoic acid, g/mo‡	4.1 (5.3)	5.2 (5.6)	<.05
Fat Intake Scale score‡	22.1 (3.8)	21.2 (4.0)	<.05
Self-reported health, %			
Excellent or very good	53.2	76.3	<.05
Good	28.5	19.3	
Fair	18.3	4.4	

**Missing values for family history of myocardial infarction or sudden death (n = 5), hypercholesterolemia (n = 7), weight (n = 6), aspirin use (n = 42), and Fat Intake Scale (n = 10).*

†Missing values for white race (n = 1), family history of myocardial infarction or sudden death (n = 2), hypercholesterolemia (n = 3), weight (n = 43), aspirin use (n = 48), and Fat Intake Scale (n = 18).

‡Values are mean (SD).

Table 2. Association of Leisure-Time Physical Activity (LPTA) With the Risk of Primary Cardiac Arrest

Type of LTPA	Case Patients, No. (%)	Controls, No. (%)	Odds Ratio (95% Confidence Interval) Unadjusted	Adjusted*
No activity	45 (14)	18 (4)	1.0 (Reference)	1.0 (Reference)
Moderate intensity	160 (48)	192 (38)	0.36 (0.20-0.65)	0.36 (0.17-0.77)
High intensity	128 (38)	293 (58)	0.19 (0.10-0.35)	0.36 (0.16-0.78)

**Adjusted for age, smoking, education, diabetes, hypertension, and health status.*

Table 3. Median Duration of Different Activities in Each Category of Leisure-Time Physical Activity (LPTA) Among Control Subjects*

Category	Moderate-Intensity LTPA, min/wk: Gardening Controls	Gardening Case Patients	Walking Controls	Walking Case Patients	Other Controls	Other Case Patients	High-Intensity LTPA, min/wk Controls	High-Intensity LTPA, min/wk Case Patients
No activity	...	...	...	...	...	...	...	...
Moderate intensity								
Gardening only								
≤60 min/wk	34	23	...	...	...	...	...	...
>60 min/wk	210	166	...	...	...	...	...	...
Walking for exercise								
≤60 min/wk	33	14	20	14	...	...	...	...
>60 min/wk	42	37	173	194	...	...	...	...
Other moderate-intensity activities	44	35	13	8	55	75	...	...
High intensity	27	18	12	0	0	0	46	51

**Ellipses indicate not applicable.*

Table 4. Association of Gardening and Walking for Exercise With the Risk of Primary Cardiac Arrest

Type of Activities	Case Patients, No. (%)	Controls, No. (%)	Odds Ratio (95% Confidence Interval)	
			Unadjusted	Adjusted*
No activity	45 (14)	18 (4)	1.0 (Reference group)	1.0 (Reference group)
Moderate intensity				
Gardening only				
≤60 min/wk	39 (12)	31 (6)	0.52 (0.25-1.08)	0.52 (0.21-1.28)
>60 min/wk	25 (8)	24 (5)	0.44 (0.20-0.98)	0.34 (0.13-0.89)
Walking for exercise				
≤60 min/wk	29 (9)	26 (5)	0.46 (0.21-1.02)	0.45 (0.17-1.19)
>60 min/wk	29 (9)	55 (11)	0.22 (0.10-0.46)	0.27 (0.11-0.67)
Other moderate-intensity activities	38 (11)	56 (11)	0.28 (0.14-0.56)	0.31 (0.13-0.74)
High intensity	128 (38)	293 (58)	0.18 (0.10-0.34)	0.34 (0.16-0.75)

**Adjusted for age, smoking, education, diabetes, hypertension, and health status.*

we took 3 steps: (1) we restricted the study to case patients with no history of clinically recognized heart disease and no life-threatening comorbidities; (2) we excluded case patients who were reported to be in poor health in the prior year; and (3) we adjusted all statistical analyses for health status.

This study has several limitations. To address the concern that the use of surrogate respondents introduced misclassification, we conducted a reliability study of spousal information. For both controls and surviving case patients, there was good agreement between spouses and the subjects themselves in categorizing the subjects as either inactive, engaged in moderate-intensity activity only, or engaged in high-intensity activity. A spurious association of either moderate-intensity or high-intensity LTPA with PCA is therefore not likely. The spouse-subject agreement was not as good when the category of moderate intensity was split into 5 subcategories. Random misclassification might have made difficult the detection of true differences between the subcategories of moderate-intensity LTPA. Differential misclassification might have occurred if the spouses of case patients had systematically underreported or spouses of controls systematically overreported participation in physical activity. There was no evidence of systematic overreporting of activity levels by the spouses of the controls; however, because of the small number of surviving case patients included in the reliability substudy, we cannot rule out the underreporting of activity levels by the spouses of case patients. The participation rate in the controls was 68%, and the study results might be affected if controls who declined to participate in the study exercised less than the controls who participated. Finally, this was an observational study and the possibility of confounding by an unmeasured factor cannot be eliminated.

In conclusion, the results suggest that moderate-intensity physical activity is associated with a reduced risk of PCA and support current exercise recommendations from the Centers for Disease Control and Prevention and the American College of Sports Medicine, to accumulate 30 minutes or more of moderate-intensity physical activity on most days.[19]

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