Effects of Physical Activity and Sedentary Time on the Risk of Heart Failure

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Background—Although the benefits of physical activity for risk of coronary heart disease are well established, less is known about its effects on heart failure (HF). The risk of prolonged sedentary behavior on HF is unknown.

Methods and Results—The study cohort included 82,695 men aged ≥45 years from the California Men’s Health Study without prevalent HF who were followed up for 10 years. Physical activity, sedentary time, and behavioral covariates were obtained from questionnaires, and clinical covariates were determined from electronic medical records. Incident HF was identified through International Classification of Diseases, Ninth Revision codes recorded in electronic records. During a mean follow-up of 7.8 years (646,989 person-years), 3,473 men were diagnosed with HF. Controlling for sedentary time, sociodemographics, hypertension, diabetes mellitus, unfavorable lipid levels, body mass index, smoking, and diet, the hazard ratio (95% confidence interval [CI]) of HF in the lowest physical activity category compared with those in the highest category was 1.52 (95% CI, 1.39–1.68). Those in the medium physical activity category were also at increased risk (hazard ratio, 1.17 [95% CI, 1.06–1.29]). Controlling for the same covariates and physical activity, the hazard ratio (95% CI) of HF in the highest sedentary category compared with the lowest was 1.34 (95% CI, 1.21–1.48). Medium sedentary time also conveyed risk (hazard ratio, 1.13 [95% CI, 1.04–1.24]). Results showed similar trends across white and Hispanic subgroups, body mass index categories, baseline hypertension status, and prevalent coronary heart disease.

Conclusions—Both physical activity and sedentary time may be appropriate intervention targets for preventing HF.

Key Words: exercise • heart failure • prevention & control

Heart failure (HF) is a major cardiovascular disease, affecting ≈5.7 million Americans with >600,000 yearly incident cases.1 Approximately 20% of adults will be diagnosed with HF during their lifetime.2 More than 8 million people may be living with HF by 2030, a 23% increase in prevalence.3 Total medical costs are projected to increase from $20.9 billion in 2010 to $53.1 billion by 2030.3 Blacks and Hispanic subgroups, body mass index categories, baseline hypertension status, and prevalent coronary heart disease.

Clinical Perspective on p 27

Regular physical activity reduces risk of coronary heart disease (CHD), myocardial infarction, hypertension, obesity, and diabetes mellitus—conditions associated with HF. However, few investigations have examined its effects on HF. Those that have indicate that regular physical activity may be protective. Of note, these studies included primarily white populations. Although evidence is accumulating that excessive sedentary behavior may increase risk for overall mortality and cardiovascular outcomes, independent of physical activity, the risk of sedentary behavior on HF has not been established.

The present study assessed the association between physical activity and HF incidence and sedentary behavior and HF incidence. With a large multiethnic cohort, the California Men’s Health Study (CMHS), we assessed the potential benefit of these behaviors in reducing HF incidence in a diverse population of middle-aged and older men.

Methods

Study Cohort

The CMHS was established in 2002 to 2003 and is a sociodemographically diverse cohort of >84,000 men who were members of Kaiser Permanente Southern or Northern California health plans.18 Men between the ages of 45 and 69 years in January 2000 were eligible if they had been members for ≥1 year. The institutional review boards of both organizations approved the study. Men provided informed consent.

The cohort consists of men who completed a screener and baseline questionnaire. Follow-up is passive, with use and diagnostic outcomes obtained from the Kaiser Permanente electronic medical

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record systems. Race/ethnicity, educational attainment, marital status, and body mass index (BMI: kg/m²) are comparable with similarly aged men living in California in 2001.¹⁸

**Questionnaire Data**

Sociodemographics (age, education, marital status, annual household income) and lifestyle behaviors were obtained through 2 questionnaires. Physical activity and sedentary time were assessed from self-report. Men categorized their usual participation in physical activity by frequency and duration during the previous 3 months in 17 moderate and vigorous intensity activities. Frequency categories were as follows: never or less than once per month, 1x to 3x per month, 1x to 2x per week, 3x to 4x per week, and ≥5x per week. Duration categories included <15 minutes, 15 to 30 minutes, 31 to 60 minutes, and ≥60 minutes. The assessment was based on a reliable and valid questionnaire.¹⁹,²⁰ It was revised in the following ways: adapted from interviewer to self-assessment, added 4 activities, and queried on duration in increments <1 hour. We scored the instrument by applying metabolic equivalent (MET) intensity weights for each activity, where 1 MET is 3.5 mL oxygen/kg body weight per minute,²¹ and multiplying this by the duration and frequency to calculate a weekly MET-weighted moderate-to-vigorous physical activity score. We divided the sample distribution into tertiles: low activity, ≤470 MET-minutes of weekly moderate-to-vigorous physical activity (31%); medium activity, between 471 and 1584 MET-minutes per week (33%); and high activity, ≥1585 MET-minutes per week (36%). Sedentary time was determined from the response to the question, outside of work, how many hours a day do you spend watching television, sitting at a computer, or reading? Response categories were <1 hour, 1 to 2 hours, 3 to 4 hours, and ≥5 hours. Categories were created for low (≤2 hours), medium (3–4 hours), and high (≥5 hours) daily sedentary time.

Height and weight were self-reported; BMI was calculated. Participants were classified as normal weight (18.5–24.9 kg/m²), overweight (25.0–29.9 kg/m²), and obese (≥30.0 kg/m²). We found 80.6% agreement between self-report and electronic records classification.²²

Dietary pattern was ascertained from a semiquantitative food frequency adapted from the Women's Health Initiative questionnaire.²²-²⁴ Daily percent calories from fat, servings of fruits and vegetables, and grams of alcohol intake were calculated.

Age, race/ethnicity, marital status, education, income, and smoking status were determined using standard questions. Race/ethnicity was categorized as non-Hispanic white, black, Hispanic, Asian, and other.

Information from electronic medical records was used to identify baseline hypertension, diabetes mellitus, triglycerides and fasting glucose, high-density lipoprotein cholesterol, and prevalent CHD. Records were examined 12 months before and 6 months after completing baseline questionnaires to identify prevalent conditions.

Hypertension was defined as follows: 2 diagnoses of hypertension International Classification of Diseases, Ninth Revision (ICD-9) codes 401.XX, 402.XX, 403.XX, 404.XX; 1 hypertension diagnosis and filling 1 prescription for an antihypertensive medication; 1 hypertension diagnosis and a medical visit with systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg; or 3 consecutive medical visits with elevated blood pressure but no hypertension diagnosis. This definition was adapted from the Hypertension Registry of the Cardiovascular Disease Research Network.²⁵ Diabetes mellitus was defined as having an ICD-9 diagnosis code of 250.XX. Lipid values were considered unfavorable if high-density lipoprotein cholesterol was ≤40 mg/dL, triglycerides were ≥200 mg/dL, or fasting glucose was ≥110 mg/dL. Prevalent CHD was defined as having ≥2 diagnoses of CHD or having undergone coronary artery revascularization from 3 years baseline to each participant’s study end date. ICD-9 diagnosis codes for CHD were 410.xx-414.xx, 429.2. ICD-9 procedure codes for coronary artery bypass graft surgery and percutaneous coronary intervention were 36.01 to 36.03, 36.05 to 37.07, 36.10 to 36.17, 36.19, and 36.31 to 36.34. Corresponding Current Procedural Terminology codes were 92982, 92984, 92995, 92996, 92980, and 92981. This method for identifying CHD cases has a sensitivity of 0.85, specificity of 0.99, and positive predictive value of 0.89.²⁶

**Determination of HF**

HF was identified from electronic records using the criteria described by Goyal et al.,²⁷ including ≥1 hospitalization with an ICD-9 diagnosis code of HF (codes 402.X1, 404.X1, 404.X3, and 428.XX) or ≥2 outpatient diagnoses of HF. Validity of an inpatient discharge diagnosis of HF was assessed from 200 randomly selected hospital charts to determine the extent to which Framingham criteria for HF were met; results indicated a positive predictive value of 97%.²⁸ Outpatient diagnosis codes may be less accurate; hence, we required ≥2 separate outpatient diagnoses.²⁹ In a systematic review of validated methods for identifying HF using administrative data, Saczynski et al.³⁰ recommended, including outpatient codes, to maximize sensitivity because many patients with HF are identified and managed in the outpatient setting. Incident cases were defined as receiving a diagnosis from baseline to May 1, 2012. Prevalent cases were defined from 3 years before the baseline date.

**Analysis**

Cohort characteristics were described using percentages. Characteristics were compared across physical activity and sedentary time categories using the χ² test.

Kaplan–Meier curves, time-dependent analyses, and Schoenfeld residuals were used to assess the proportionality of variables to be included in models. The Cox proportional hazards model was used to assess the effects of physical activity and sedentary activity on HF, controlling for baseline age, education, income, BMI category, smoking status, race/ethnicity, hypertension and diabetes mellitus status, high-density lipoprotein cholesterol, triglycerides, fasting glucose, daily percent of calories from fat, daily fruit servings, daily vegetable servings, and alcohol intake.

To assess multiplicative interaction, we used a fully adjusted model that included the physical activity by sedentary time interaction term. It was not significant and not included in the final models. To assess additive interaction, we used Poisson regression to calculate adjusted rates for each combination of physical activity and sedentary time. We then calculated the relative excess risk due to interaction score in the original Cox proportional hazards model.³⁰ To examine whether the associations among physical activity, sedentary time, and HF risk would vary by race/ethnicity, BMI category, hypertension, and prevalent CHD, additional Cox proportional hazard models stratifying by these variables were completed including the same covariates as for the main models.

All analyses were performed using SAS version 9.2 (SAS Institute, Inc, Cary, NC). Significance level was set at 0.05 for a 2-sided test.

**Results**

A total of 84,170 men were enrolled in the cohort. Prevalent HF cases (n=1201) were excluded, as were men without follow-up information (n=274), leaving 82,695 participants.

At baseline, the mean age was 58±7 years. Mean BMI was 27.9±4.7 kg/m². Median moderate-to-vigorous physical activity was 1102 MET-minutes per week (75% interquartile range, 310–2122). The racial/ethnic distribution was 63% non-Hispanic white, 14% Hispanic, 11% Asian, 7% black, and 5% other. Almost half the sample had at least a college degree. Baseline characteristics across physical activity and sedentary time categories are displayed in Table 1. High physical activity was associated with low sedentary category, older age, non-Hispanic white race/ethnicity, college completion, higher income, lower BMI, favorable cardiovascular risk factors, and favorable dietary intake. Low sedentary time was associated with younger age, Asian or Hispanic race/ethnicity, higher education and income, lower BMI, and favorable cardiovascular risk factors and dietary intake. Prevalent CHD was found in 13.2% of the participants before an HF diagnosis.
<table>
<thead>
<tr>
<th>Baseline Variable*</th>
<th>Physical Activity</th>
<th>Sedentary Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low (n=25601)</td>
<td>Medium (n=27448)</td>
</tr>
<tr>
<td></td>
<td>Low (n=34899)</td>
<td>Medium (n=33682)</td>
</tr>
</tbody>
</table>

**Sedentary time**
- Low: 9732 (39.3), 11631 (43.0), 13437 (46.3), 34800
- Medium: 10197 (41.2), 11439 (42.3), 11987 (41.3), 33623
- High: 4838 (19.5), 3981 (14.7), 3608 (12.4), 12427

**Age**
- 44–54 y: 9183 (35.9), 9526 (34.7), 9923 (33.8), 28632
- 55–61 y: 8049 (31.4), 8472 (30.9), 8745 (29.8), 25266
- ≥62 y: 8369 (32.7), 9450 (34.4), 10670 (36.4), 28489

**Race/ethnicity**
- Non-Hispanic white: 13740 (54.5), 17499 (64.5), 19797 (68.2), 51036
- Hispanic: 4407 (17.5), 5225 (19.2), 5974 (20.8), 15606
- Asian: 3230 (12.8), 3221 (11.9), 2631 (9.1), 9082
- Black: 2585 (10.3), 1716 (6.3), 1751 (6.0), 6052
- Other: 1255 (5.0), 1326 (4.9), 1468 (5.1), 4049

**Education**
- ≤High school: 6610 (26.1), 4455 (16.4), 3877 (13.3), 14942
- Vocational or some college: 9496 (37.5), 9308 (34.2), 9507 (32.6), 28311
- ≥College: 9192 (36.3), 13594 (49.5), 15779 (54.1), 38363

**Annual income**
- <$20000: 1745 (7.1), 1098 (4.2), 993 (3.4), 3838
- $20000–$79999: 14493 (59.1), 10729 (39.4), 14013 (46.8), 38235
- ≥$80000: 8267 (33.8), 11409 (43.2), 13087 (46.4), 32763

**Body mass index**
- Normal weight (18.5–24.9 kg/m²): 4893 (20.1), 6748 (25.4), 8723 (30.6), 20464
- Overweight (25–29.9 kg/m²): 10957 (43.4), 12823 (48.2), 14073 (49.4), 36853
- Obese (≥30 kg/m²): 8743 (35.9), 6860 (25.8), 5586 (19.6), 21189

**Smoking status**
- Current: 4369 (17.1), 2892 (10.6), 2388 (8.2), 9649
- Quit <6 y: 1701 (6.7), 1553 (5.7), 1347 (4.6), 4600
- Quit ≥6 y: 9604 (37.6), 12163 (41.6), 32724 (10.9), 36190
- Never: 9859 (38.6), 11497 (43.6), 13418 (45.8), 35224

**Hypertension**
- 11930 (46.6), 11742 (42.8), 12004 (40.9), 35676

**Low HDL†**
- 11930 (46.6), 11742 (42.8), 12004 (40.9), 35676

**High glucose‡**
- 11930 (46.6), 11742 (42.8), 12004 (40.9), 35676

**High triglycerides§**
- 11930 (46.6), 11742 (42.8), 12004 (40.9), 35676

**Diabetes mellitus**
- 11930 (46.6), 11742 (42.8), 12004 (40.9), 35676

**Coronary heart disease**
- 11930 (46.6), 11742 (42.8), 12004 (40.9), 35676

**Daily fruit servings**
- <1: 10366 (40.8), 7854 (28.8), 6104 (20.9), 24324
- 1–2: 10918 (43.0), 13540 (49.6), 14030 (48.0), 38497
- ≥3: 4124 (16.2), 5902 (21.6), 9121 (31.2), 19147

**Daily vegetable servings**
- <1: 9247 (36.4), 6837 (25.0), 5264 (18.0), 21348
- 1–2: 12463 (49.1), 15378 (56.3), 16321 (55.8), 44162
- ≥3: 3681 (14.5), 5086 (18.6), 7663 (26.2), 16430

**Alcohol intake**
- None: 9022 (35.2), 7703 (28.1), 7323 (25.0), 24048

(Continued)
During a mean follow-up of 7.8 years (646989 person-years), there were 3473 incident HF diagnoses. HF incidence decreased across physical activity level: 7.8, 4.9, and 3.8 per 1000 person-years for low, medium, and high categories, respectively. Compared with the high physical activity category, adjusted hazard ratios (HR) were 1.52 (95% confidence interval [CI], 1.39–1.68) for the low and 1.17 (95% CI, 1.06–1.29) for the medium category (Table 2). HF risk was higher in the low physical activity category compared with the medium category (HR, 1.30 [95% CI, 1.20–1.42]). The test for trend was significant (P<0.0001). Including CHD in the model only slightly attenuated results.

There were 3.8 cases per 1000 person-years for the low sedentary time category, 5.6 for medium sedentary time, and 8.8 for high sedentary time (Table 2). Compared with low sedentary time, adjusted HRs were 1.13 (95% CI, 1.04–1.24) and 1.34 (95% CI, 1.21–1.48) for the medium and high sedentary time categories, respectively. The test for trend was significant (P<0.0001). The model including CHD produced similar HRs.

We evaluated the extent to which the physical activity and sedentary time constructs overlapped using the Gamma statistic. The value was −0.10, a small correlation. The Figure illustrates the adjusted HRs across joint physical activity and sedentary time categories. Men in the low physical activity and high sedentary time category had 2.2× (95% CI, 1.84–2.53) the risk of HF compared with men in the high physical activity and low sedentary time category. There was a slight additive interaction (relative excess risk due to interaction=0.08; 95% CI, 0.03–0.14), evidenced by examining the absolute unadjusted and adjusted event rates in the Figure footnote. Sensitivity analyses were performed excluding men with <3 months of follow-up (n=1161) and excluding HF cases diagnosed within the first year of follow-up (n=408). Results indicated that the HRs for HF only slightly changed.

### Table 1. Continued

<table>
<thead>
<tr>
<th>Baseline Variable*</th>
<th>Physical Activity</th>
<th>Sedentary Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low (n=25601)</td>
<td>Low (n=34899)</td>
</tr>
<tr>
<td></td>
<td>Medium (n=27448)</td>
<td>Medium (n=33682)</td>
</tr>
<tr>
<td></td>
<td>High (n=29338)</td>
<td>High (n=12453)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Total</td>
</tr>
<tr>
<td>&lt;1 drink/wk</td>
<td>5360 (20.9)</td>
<td>6587 (18.9)</td>
</tr>
<tr>
<td>≥1 drink/wk, &lt;1 drink/d</td>
<td>6106 (23.9)</td>
<td>10079 (28.9)</td>
</tr>
<tr>
<td>≥1+ drink/d</td>
<td>5113 (20.0)</td>
<td>8120 (23.3)</td>
</tr>
</tbody>
</table>

Percent daily calories from fat

>30%

Table 2. Number of Heart Failure Cases, Person-Years, Cases Per 1000 Person-Years, and Hazard Ratios by Physical Activity and Sedentary Time Categories

<table>
<thead>
<tr>
<th>Physical Activity</th>
<th>No. of Cases</th>
<th>Person-Years</th>
<th>Cases Per 1000 Person-Years</th>
<th>Hazard Ratio* (95% CI)</th>
<th>Hazard Ratio† (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>1505</td>
<td>193501</td>
<td>7.8</td>
<td>1.52 (1.39–1.68)</td>
<td>1.52 (1.38–1.67)</td>
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<tr>
<td>Medium</td>
<td>1051</td>
<td>216513</td>
<td>4.9</td>
<td>1.17 (1.06–1.29)</td>
<td>1.15 (1.04–1.26)</td>
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<tr>
<td>High</td>
<td>892</td>
<td>234773</td>
<td>3.8</td>
<td>1 (reference)</td>
<td>1</td>
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<tr>
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<td>25</td>
<td>2204</td>
<td>11.3</td>
<td>...</td>
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<table>
<thead>
<tr>
<th>Sedentary Time</th>
<th>No. of Cases</th>
<th>Person-Years</th>
<th>Cases Per 1000 Person-Years</th>
<th>Hazard Ratio* (95% CI)</th>
<th>Hazard Ratio† (95% CI)</th>
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<tr>
<td>Low</td>
<td>1041</td>
<td>276384</td>
<td>3.8</td>
<td>1 (reference)</td>
<td>1</td>
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<tr>
<td>Medium</td>
<td>1488</td>
<td>263543</td>
<td>5.6</td>
<td>1.13 (1.04–1.24)</td>
<td>1.09 (1.00–1.19)</td>
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<tr>
<td>High</td>
<td>828</td>
<td>94574</td>
<td>8.8</td>
<td>1.34 (1.21–1.48)</td>
<td>1.27 (1.15–1.41)</td>
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<tr>
<td>Missing</td>
<td>116</td>
<td>12489</td>
<td>9.3</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

CI indicates confidence interval.

*Adjusted for baseline age, race/ethnicity, education, income, body mass index, smoking status, hypertension and diabetes mellitus status, antihypertensive medications, high-density lipoprotein cholesterol, fasting glucose, triglycerides, daily percent calories from fat, daily fruit servings, daily vegetable servings, and alcohol intake. Physical activity hazard ratios adjusted for sedimentary time category. Sedentary time hazard ratios adjusted for physical activity category.

†Adjusted for baseline age, race/ethnicity, education, income, body mass index, smoking status, hypertension and diabetes mellitus status, antihypertensive medications, high density lipoprotein cholesterol, fasting glucose, triglycerides, daily percent calories from fat, daily fruit servings, daily vegetable servings, alcohol intake, and prevalent coronary heart disease.
The adjusted HRs for HF by physical activity and sedentary time categories across racial/ethnicity groups are presented in Table 3. For the Asian, Hispanic, white non-Hispanic, and other subgroups, the HRs were higher for the low compared with the high physical activity category. High sedentary time conferred increased HF risk for the Hispanic (HR, 1.78 [95% CI, 1.35–2.36]) and white non-Hispanic men (HR, 1.29 [95% CI, 1.13–1.47]).

Compared with those with high physical activity, the low physical activity category conferred higher HF risk among normal weight, overweight, and obese men (Table 3). Obese men with high sedentary time and normal weight and overweight men with both medium and high sedentary time had increased risk compared with men with low sedentary time. Low physical activity had a 53% greater risk among men with and without hypertension (Table 3). HF risk increased for the medium and high sedentary time categories for men without hypertension and for the high sedentary time with hypertension. Low physical activity increased HF risk for those with and without CHD, with the risk twice as great for men without CHD (32% versus 70%, respectively; Table 3). High sedentary time had an increased HF risk only for those without CHD.

### Discussion

In this diverse cohort of middle-aged and older men, low physical activity and high sedentary time each contributed to increased HR risk. These associations had independent contributions beyond each other and known sociodemographic, clinical, and lifestyle risk factors. The trends were consistent across most race/ethnicities, BMI categories, and hypertension status.

Others have found that prolonged sedentary behavior increases risk for cardiovascular disease incidence and mortality after controlling for physical activity. Some studies included HF in their definition of cardiovascular events, but none specifically examined HF. With our large sample size and during 10 years of follow-up, we had >600,000 person-years to examine this cardiovascular event. Our results strengthen the developing position that too much sitting is detrimental to cardiovascular health, independent of regular physical activity.

We found increased risk across BMI categories for low and medium physical activity compared with the high-activity group. These results are consistent with others who found that higher physical activity lowered HF risk within BMI levels, with the greatest HF risk for the obese with low physical activity.

Low physical activity conferred increased HF risk for men with and without CHD. However, high sedentary time increased risk only for those without CHD. With the relatively few men with CHD in this sample, it may be premature to conclude that high sedentary time increases HF risk only for those without CHD. Future studies with greater power are needed to examine sedentary time on HF risk for those with CHD.

It was notable that the combinations of low physical activity with high sedentary time and high physical activity with low sedentary time, respectively, yielded similar HRs when the analyses were stratified by baseline hypertensive status. In contrast, Djoussé et al. found that the lifetime HF risk for normal weight, nonsmoking, regularly exercising men was greater for those with hypertension than those without hypertension. Rather than creating a lifestyle risk score as Djoussé et al. controlled for other lifestyle factors that may explain the differing results.

We conducted stratified analyses by race/ethnicity and found that the associations were generally consistent. However, we had limited power to detect significant associations among the black and Asian men. Bell et al. examined physical activity and cardiovascular disease among blacks in the Atherosclerotic Risk In Communities (ARIC) study, reported similar HRs for HF incidence among blacks and whites after 21 years of follow-up. There are several key differences between ARIC and CMHS cohorts. During follow-up, 9.4% of the blacks in their cohort developed HF as opposed to 6.3% in our cohort, possibly increasing their power to detect associations. Also, most of the blacks in ARIC were recruited from Jackson, MS, a region vastly different from our predominantly urban regions.

The possible biological mechanisms through which either low physical activity or prolonged sedentary time may cause HF are not well established, but scant evidence suggests that the pathways may be different. Low physical activity is associated with higher blood pressure and unfavorable lipoprotein profile, glucose metabolism, and weight status. These increase the risk of CHD, thereby increasing the risk of HF. In addition, regular physical activity improves myocardial structure and function. Physical activity may prevent cardiac injury and neurohormonal activation and thereby decrease the risk of HF. Excessive sedentary behavior is also associated with unfavorable cardiovascular risk factors. Animal and prolonged human bed rest studies suggest that inadequate muscle contraction may suppress skeletal muscle lipoprotein lipase. This may elevate triglycerides and blood glucose and lower high-density lipoprotein cholesterol production, which can accelerate the development of CHD and eventual HF. This mechanism seems to be specific to prolonged sedentary time and not lack of regular physical activity.
Table 3. Hazard Ratios for Heart Failure by Physical Activity and Sedentary Time Categories Across Baseline Race/Ethnicity, Body Mass Index Categories, Hypertension, and Coronary Heart Disease Status

<table>
<thead>
<tr>
<th>Race/ethnicity</th>
<th>Low (n=25 601)</th>
<th>Medium (n=27 448)</th>
<th>High (n=29 338)</th>
<th>HR</th>
<th>Low (n=34 899)</th>
<th>Medium (n=33 682)</th>
<th>High (n=12 453)</th>
<th>HR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Hispanic white</td>
<td>1.56 (1.39–1.76)</td>
<td>1.13 (1.00–1.27)</td>
<td>1 (reference)</td>
<td>1.12 (1.00–1.25)</td>
<td>1.29 (1.13–1.47)</td>
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</tr>
<tr>
<td>Hispanic</td>
<td>1.61 (1.23–2.13)</td>
<td>1.45 (1.09–1.93)</td>
<td>1 (reference)</td>
<td>1.19 (0.94–1.51)</td>
<td>1.78 (1.35–2.36)</td>
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<td>Asian</td>
<td>1.45 (1.06–1.98)</td>
<td>1.22 (0.89–1.67)</td>
<td>1 (reference)</td>
<td>1.22 (0.94–1.58)</td>
<td>1.10 (0.76–1.58)</td>
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<td></td>
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<tr>
<td>Black</td>
<td>1.29 (0.97–1.72)</td>
<td>1.12 (0.82–1.53)</td>
<td>1 (reference)</td>
<td>1.01 (0.78–1.30)</td>
<td>1.23 (0.92–1.63)</td>
<td></td>
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<td></td>
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<tr>
<td>Other</td>
<td>1.56 (1.06–2.30)</td>
<td>1.10 (0.73–1.66)</td>
<td>1 (reference)</td>
<td>1.16 (0.81–1.66)</td>
<td>1.27 (0.84–1.90)</td>
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<tr>
<td>Body mass index</td>
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<tr>
<td>Normal weight (18.5–24.9 kg/m²)</td>
<td>1.40 (1.12–1.77)</td>
<td>1.10 (0.88–1.38)</td>
<td>1 (reference)</td>
<td>1.25 (1.02–1.53)</td>
<td>1.39 (1.07–1.80)</td>
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</tr>
<tr>
<td>Overweight (25–29.9 kg/m²)</td>
<td>1.51 (1.30–1.75)</td>
<td>1.15 (0.99–1.33)</td>
<td>1 (reference)</td>
<td>1.21 (1.06–1.38)</td>
<td>1.35 (1.15–1.59)</td>
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</tr>
<tr>
<td>Obese (≥30 kg/m²)</td>
<td>1.57 (1.36–1.83)</td>
<td>1.20 (1.02–1.40)</td>
<td>1 (reference)</td>
<td>1.01 (0.88–1.16)</td>
<td>1.26 (1.09–1.47)</td>
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<tr>
<td>Hypertension status</td>
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<tr>
<td>No</td>
<td>1.53 (1.30–1.81)</td>
<td>1.15 (0.98–1.36)</td>
<td>1 (reference)</td>
<td>1.25 (1.08–1.45)</td>
<td>1.32 (1.01–1.59)</td>
<td></td>
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</tr>
<tr>
<td>Yes</td>
<td>1.53 (1.36–1.71)</td>
<td>1.18 (1.05–1.32)</td>
<td>1 (reference)</td>
<td>1.08 (0.97–1.20)</td>
<td>1.33 (1.18–1.51)</td>
<td></td>
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<tr>
<td>Coronary heart disease status</td>
<td></td>
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<tr>
<td>No</td>
<td>1.70 (1.49–1.93)</td>
<td>1.23 (1.08–1.40)</td>
<td>1 (reference)</td>
<td>1.11 (0.99–1.24)</td>
<td>1.43 (1.25–1.63)</td>
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</tr>
<tr>
<td>Yes</td>
<td>1.32 (1.15–1.52)</td>
<td>1.06 (0.92–1.21)</td>
<td>1 (reference)</td>
<td>1.05 (0.93–1.19)</td>
<td>1.11 (0.95–1.29)</td>
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</tr>
</tbody>
</table>

CI indicates confidence interval; and HR, hazard ratio.

*HR adjusted for baseline age, race/ethnicity, education, income, body mass index, smoking status, hypertension and diabetes mellitus status, antihypertensive medications, high-density lipoprotein cholesterol, fasting glucose, triglycerides, daily percent calories from fat, daily fruit servings, daily vegetable servings, and alcohol intake. Physical activity model adjusted for sedentary time category. Sedentary time model adjusted for physical activity category.

There are study limitations. Our cohort consisted of only men. However, an NHANES (National Health and Nutrition Examination Survey) I follow-up study on HF risk factors found relative risks of low physical activity at 1.14 for men and 1.31 for women, suggesting that similar biological mechanisms may apply. Our exposures were determined by self-report. The physical activity instrument may have resulted in over-reporting in absolute terms, although we used it to determine relative ranking. The sedentary behavior questions only included the nonwork domain, and thus, our data cannot be applied to overall sedentary time. The condition of HF was identified from diagnosis codes, which can result in misclassification, although any misclassification was likely nondifferential and would attenuate toward the null. Men who are unhealthy, have underlying symptoms, or a newly diagnosed disease may have decreased their physical activity or increased their sedentary time before obtaining an HF diagnosis. We attempted to reduce this bias by adjusting for prevalent hypertension, diabetes mellitus, CHD, BMI, and lipids. We conducted stratified analyses by BMI category and hypertension and CHD status and performed sensitivity analyses to examine this potential bias. Finally, participants were members of health plans that provide comprehensive care; results may not generalize to men lacking health insurance.

In conclusion, the results from this large, prospective study on HF risk factors for sedentary time across baseline race/ethnicity, body mass index categories, hypertension, and CHD status and performed sensitivity analyses to examine this potential bias. Finally, participants were members of health plans that provide comprehensive care; results may not generalize to men lacking health insurance.

We thank CMHS men for their participation and acknowledge the contributions of study staff.

Acknowledgments

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The California Cancer Research Program, grant 99-86883, and the Kaiser Permanente Northern California Community Benefit Program established the cohort. Analyses were supported by the Kaiser Permanente Southern California Community Benefit Program.

Disclosures

None.

References


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Sternfeld, Steven J. Jacobsen, Jeffrey M. Slezak, Bette Caan and Virginia P. Quinn

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