Background—Vigorous exertion and endurance training have been reported to increase atrial fibrillation (AF). Associations of habitual light or moderate activity with AF incidence have not been evaluated.

Methods and Results—We prospectively investigated associations of leisure-time activity, exercise intensity, and walking habits, assessed at baseline and updated during follow-up visits, with incident AF, diagnosed by annual 12-lead ECGs and hospital discharge records, from 1989 to 2001 among 5446 adults ≥65 years of age in the Cardiovascular Health Study. During 47 280 person-years of follow-up, 1061 new AF cases occurred (incidence 22.4/1000 person-years). In multivariable-adjusted analyses, leisure-time activity was associated with lower AF incidence in a graded manner, with 25% (hazard ratio [HR] 0.75, 95% confidence interval [CI] 0.61 to 0.90), 22% (HR 0.78, 95% CI 0.65 to 0.95), and 36% (HR 0.64, 95% CI 0.52 to 0.79) lower risk in quintiles 3, 4, and 5 versus quintile 1 (P for trend <0.001). Exercise intensity had a U-shaped relationship with AF (quadratic P=0.02): Versus no exercise, AF incidence was lower with moderate-intensity exercise (HR 0.72, 95% CI 0.58 to 0.89) but not with high-intensity exercise (HR 0.87, 95% CI 0.64 to 1.19). Walking distance and pace were each associated with lower AF risk in a graded manner (P for trend <0.001); when we assessed the combined effects of distance and pace, individuals in quartiles 2, 3, and 4 had 25% (HR 0.75, 95% CI 0.56 to 0.99), 32% (HR 0.68, 95% CI 0.50 to 0.92), and 44% (HR 0.56, 95% CI 0.38 to 0.82) lower AF incidence than individuals in quartile 1. Findings appeared unrelated to confounding by comorbidity or indication. After evaluation of cut points of moderate leisure-time activity (≥600 kcal/week), walking distance (12 blocks per week), and pace (2 mph), 26% of all new AF cases (95% CI 7% to 43%) appeared attributable to absence of these activities.

Conclusions—Light to moderate physical activities, particularly leisure-time activity and walking, are associated with significantly lower AF incidence in older adults. (Circulation. 2008;118:800-807.)

Key Words: arrhythmia ■ exercise ■ prevention ■ atrial fibrillation

Atrial fibrillation (AF) is a common chronic arrhythmia and results in significant morbidity and increased healthcare utilization due to elevated stroke risk, reduced exercise tolerance, and potential bleeding complications from anticoagulant therapy.1–3 AF is particularly problematic in older adults (≥65 years of age), in whom the risk of new-onset AF is ≈2% per year1,2,4; both the incidence and prevalence of AF will likely grow as the population continues to age. Physical activity has been reported to increase the risk of AF5–11; however, only vigorous exertion and endurance training have been evaluated, and largely only in retrospective case-control studies and case series of younger athletes and middle-aged adults.5–11 Hypothesized mechanisms for such potentially higher risk include transient influences (ie, during or immediately after exercise) on autonomic tone and long-term changes in cardiac dimensions due to chronic effects of high-intensity training (eg, left ventricular hypertrophy among distance runners). No prior studies have prospectively evaluated the relationship between habitual light to moderate physical activity and incidence of AF.

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Among older adults, the pathophysiology of AF may often be related to increased vascular stiffness and reduced left ventricular compliance, as reflected by risk factors for AF such as higher systolic blood pressure, treated hypertension, prior myocardial infarction (MI), congestive heart failure (CHF), valvular heart disease, and left atrial enlargement.2,4
On the basis of these risk factors, in older adults, habitual physical activity might be expected to reduce the incidence of AF (for example, by reducing blood pressure, improving vascular compliance, or reducing risk of MI or CHF); however, the relationship between habitual physical activity and incidence of AF among older adults is unknown. The significant morbidity associated with AF, including stroke risk and potential bleeding due to anticoagulation therapy, makes prevention of paramount importance. A relationship between physical activity and risk of AF later in life would suggest that simple lifestyle behaviors could potentially affect this serious condition. Given the prospectively collected information on physical activity measures; the medical, ECG, hospital, and Holter information on AF; and the focus on older adults, we examined the association of physical activity with incidence of new-onset AF among 5446 men and women ≥65 years of age in the Cardiovascular Health Study (CHS), a National Heart, Lung, and Blood Institute–sponsored prospective cohort study of determinants of cardiovascular risk among older adults. We hypothesized that greater habitual physical activity would be associated with lower incidence of AF.

Methods

Design and Population

The CHS design and recruitment experiences have been described previously.12–15 Briefly, 5201 men and women ≥65 years of age were randomly selected and enrolled from Medicare eligibility lists in 4 US communities in 1989 to 1990; an additional 687 black participants were recruited and enrolled in 1992. Each center’s institutional review committee approved the study, and all participants gave informed consent. Participants were only enrolled if they were ambulatory and noninstitutionalized. Baseline evaluation included standardized physical examination, diagnostic testing, laboratory evaluation, and questionnaires on health status, medical history, lifestyle habits, and cardiovascular risk factors.12–13 After the exclusion of 166 individuals with incomplete information on leisure-time activity, exercise intensity, or walking habits and 276 individuals with AF at baseline, 5446 participants were included in the study. We assessed these measures in prespecified walking score that combined blocks walked (ordinal score for quintiles) and pace walked (ordinal score for 3 categories), evaluated in quartiles, to account for both distance and pace of usual walking.

Identification of AF

Participants were followed up by means of annual examinations that included annual resting 12-lead ECGs through year 10 and interim 6-month telephone contacts.14 Hospital records were obtained for all hospitalizations with adjudication of cardiovascular events by centralized events committees.18 Cases of AF were identified by (1) annual 12-lead ECGs, centrally reviewed at the CHS ECG Reading Center,19 or (2) hospital discharge diagnoses (International Classification of Diseases, 9th Revision, codes 427.3, 427.31, or 427.32). Review of medical records that included hospital ECGs in a subset of cases demonstrated that hospital discharge diagnoses provided an accuracy (positive predictive value) of 98.6% for diagnosing AF in CHS.20 To evaluate the potential for missed outcomes, results of 24-hour Holter monitoring performed at year 5 were evaluated in a subset of 819 participants.21 Fifteen individuals demonstrated sustained AF, all of whom were identified by the above criteria, and 4 individuals demonstrated intermittent AF, 3 of whom were identified by the above criteria. Thus, as determined by 24-hour Holter monitoring, only 1 in 819 individuals (0.1%) had sustained or intermittent AF not identified by the above criteria.

Statistical Analysis

Physical activity categories were assessed as ordinal variables for evaluation of differences in baseline characteristics with linear (continuous variables) or logistic (dichotomous variables) regression, as well as for evaluation of tests for trend. Physical activity habits were updated over time with cumulative averaging to minimize misclassification (measurement error) and assess long-term effects of habitual activity. For example, walking habits at baseline were related to incidence of AF in the first year of follow-up; the average of walking habits at the baseline and first follow-up visits was related to incidence of AF in the second year; the average of walking habits at the baseline and first and second follow-up visits was related to incidence of AF in the third year; etc. Findings with baseline data only were generally similar; we present the cumulative updated results. Cox proportional hazards models were used to estimate relative risk (hazard ratio) of incident AF, censored at death or last day of follow-up through June 30, 2001. Follow-up after 2001 was censored because the last physical activity assessment, clinic examination, and annual ECG occurred at year 10 (1999–2000). To minimize potential confounding, covariates were selected on the basis of clinical interest, previously established risk factors for incident AF in older adults,4 or associations with exposures or outcomes in the present study cohort. Care was taken to evaluate separately factors that might be potential confounders (such as age, gender, race, and education) versus factors that might be potential confounders or mediators of the effect of physical activity on incidence of AF (such as body mass index, blood pressure, antihypertensive medication use, cholesterol levels, glucose levels, and left ventricular mass).

We also evaluated potential mediation by intermediary nonfatal MI or CHF using time-varying adjustment. Other covariates that did not materially alter the relations between physical activity and AF risk were excluded from the final models, including month of visit, income, preexisting stroke or transient ischemic attack, use of angiotensin-converting enzyme inhibitors and lipid-lowering medication (and among those with dietary data) fish consumption, as well as (in mediator models) heart rate, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol, and triglycerides. Missing covariates (all ≤6% missing) were imputed by best-subset regression with age, gender, race, education, preexisting CHD (nonfatal MI, coronary revascularization, or angina), stroke, diabetes mellitus, and chronic pulmonary disease. Potential effect modification was evaluated by subgroups of age, gender, hypertension, preexisting CHD, and preexisting cardiovascular disease (CHD, CHF, or stroke) by evaluation of the significance of multiplicative interaction terms with likelihood ratio tests. Population attributable risk percentage was
At baseline, average participant age was 73 years (mean ± SD 72.8 ± 5.6 years; range 65 to 100 years); 58% were women, and 17% were nonwhite. Participant characteristics according to leisure-time activity and exercise intensity at baseline are shown in Table 1. Greater leisure-time activity was associated with slightly younger age, male gender, white race, greater education, greater alcohol use, and generally fewer cardiovascular risk factors, including slightly less current smoking and lower prevalence of diabetes mellitus, CHD, treated hypertension, and pulmonary disease. As would be expected on the basis of physiological effects, greater activity was also associated with lower blood pressure, heart rate, low-density lipoprotein cholesterol, triglyceride, and C-reactive protein levels. In these unadjusted analyses, exercise intensity was associated with higher high-density lipoprotein cholesterol, whereas leisure-time activity was associated with lower high-density lipoprotein cholesterol. Leisure-time activity was not associated with preexisting CHD or β-blocker use. These relationships were generally similar, or even more pronounced, for exercise intensity (Table 1). Findings were also generally similar for measures of walking distance and pace (data not shown). Leisure-time activity, exercise intensity, and distance and pace of walking were only modestly positively intercorrelated (Spearman ρ = 0.23 to 0.57). Associations of physical activity with incident AF were assessed with and without adjustment for each of the factors in Table 1.

### Results

At baseline, average participant age was 73 years (mean ± SD 72.8 ± 5.6 years; range 65 to 100 years); 58% were women, and 17% were nonwhite. Participant characteristics according to leisure-time activity and exercise intensity at baseline are shown in Table 1. Greater leisure-time activity was associated with slightly younger age, male gender, white race, greater education, greater alcohol use, and generally fewer cardiovascular risk factors, including slightly less current smoking and lower prevalence of diabetes mellitus, CHD, treated hypertension, and pulmonary disease. As would be expected on the basis of physiological effects, greater activity was also associated with lower blood pressure, heart rate, low-density lipoprotein cholesterol, triglyceride, and C-reactive protein levels. In these unadjusted analyses, exercise intensity was associated with higher high-density lipoprotein cholesterol, whereas leisure-time activity was associated with lower high-density lipoprotein cholesterol. Leisure-time activity was not associated with preexisting CHD or β-blocker use. These relationships were generally similar, or even more pronounced, for exercise intensity (Table 1). Findings were also generally similar for measures of walking distance and pace (data not shown). Leisure-time activity, exercise intensity, and distance and pace of walking were only modestly positively intercorrelated (Spearman ρ = 0.23 to 0.57). Associations of physical activity with incident AF were assessed with and without adjustment for each of the factors in Table 1.

### Leisure-Time Activity and Exercise Intensity

During 12 years of follow-up (47 280 total person-years), 1061 new cases of AF were documented (incidence rate 22.4 cases per 1000 person-years). After adjustment for age and gender, both leisure-time activity and exercise intensity were associated with lower AF incidence (P < 0.001; Table 2). After multivariable adjustment, graded lower risk was evident across quintiles of leisure-time activity: Compared with the lowest quintile, individuals in quintiles 3, 4, and 5 had 25%, 22%, and 36% lower risk, respectively (P for trend < 0.001). Conversely, after multivariable adjustment, a nonlinear U-shaped relationship was seen between exercise intensity and incident AF: Compared with no regular exercise, individuals with moderate-intensity exercise had 28% lower risk of AF, but individuals with high-intensity exercise did not have significantly lower risk than those with no regular exercise (Table 2). In a post hoc test, the addition of a U-shaped (quadratic) term to the ordinal model for exercise intensity was statistically significant (P = 0.02), which confirms the nonlinearity of this relationship. Further adjust-
ments for factors that might be potential confounders or mediators of effects of physical activity on AF, including body mass index (kg/m²), treated hypertension (yes/no), systolic blood pressure (quintiles), fasting cholesterol (quintiles), fasting glucose (quintiles), C-reactive protein (quintiles), and estimated left ventricular mass from ECG (quintiles), modestly affected these associations: The extreme quintile relative risk for leisure-time activity increased from 0.64 to 0.67 (95% confidence interval [CI] 0.54 to 0.83), and the relative risks for moderate and for high exercise intensity increased from 0.72 to 0.73 (95% CI 0.59 to 0.91) and from 0.87 to 0.93 (95% CI 0.66 to 1.28), respectively.

**Table 2. Risk of New-Onset AF in 5446 Older Adults According to Leisure-Time Activity and Exercise Intensity**

<table>
<thead>
<tr>
<th>Leisure-time activity, quintiles (n*)</th>
<th>No. of Events</th>
<th>Person-Years</th>
<th>Age- and Gender-Adjusted</th>
<th>Adjusted for Multiple Variables†</th>
</tr>
</thead>
<tbody>
<tr>
<td>I (n=1098)</td>
<td>247</td>
<td>9131</td>
<td>1.0 (Reference)</td>
<td>1.0 (Reference)</td>
</tr>
<tr>
<td>II (n=1081)</td>
<td>208</td>
<td>9390</td>
<td>0.81 (0.67–0.97)</td>
<td>0.86 (0.71–1.03)</td>
</tr>
<tr>
<td>III (n=1092)</td>
<td>192</td>
<td>9432</td>
<td>0.70 (0.58–0.85)</td>
<td>0.75 (0.61–0.90)</td>
</tr>
<tr>
<td>IV (n=1090)</td>
<td>222</td>
<td>9567</td>
<td>0.76 (0.63–0.92)</td>
<td>0.78 (0.65–0.95)</td>
</tr>
<tr>
<td>V (n=1085)</td>
<td>192</td>
<td>9762</td>
<td>0.60 (0.49–0.73)</td>
<td>0.64 (0.52–0.79)</td>
</tr>
<tr>
<td>P for trend</td>
<td>...</td>
<td>...</td>
<td>&lt;0.001</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Exercise intensity (n*)

<table>
<thead>
<tr>
<th>Exercise intensity (n*)</th>
<th>No. of Events</th>
<th>Person-Years</th>
<th>Age- and Gender-Adjusted</th>
<th>Adjusted for Multiple Variables†</th>
</tr>
</thead>
<tbody>
<tr>
<td>None (n=477)</td>
<td>127</td>
<td>3933</td>
<td>1.0 (Reference)</td>
<td>1.0 (Reference)</td>
</tr>
<tr>
<td>Low (n=2587)</td>
<td>545</td>
<td>23216</td>
<td>0.76 (0.63–0.93)</td>
<td>0.85 (0.69–1.03)</td>
</tr>
<tr>
<td>Moderate (n=1877)</td>
<td>324</td>
<td>16848</td>
<td>0.61 (0.49–0.75)</td>
<td>0.72 (0.58–0.89)</td>
</tr>
<tr>
<td>High (n=505)</td>
<td>65</td>
<td>3283</td>
<td>0.71 (0.52–0.96)</td>
<td>0.87 (0.64–1.19)</td>
</tr>
<tr>
<td>P for trend</td>
<td>...</td>
<td>...</td>
<td>&lt;0.001</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Values are RR (95% CI) where appropriate. RR indicates relative risk (hazard ratio).
*No. of individuals in each category at baseline.
†Adjusted for age (years), gender (male/female), race (white/nonwhite), enrollment site (4 sites), education (< high school, high school, > high school), smoking status (never, former, current), pack-years of smoking (4 categories), CHD (yes/no), chronic pulmonary disease (yes/no), diabetes mellitus (yes/no), alcohol use (6 categories), and β-blocker use (yes/no).

**Table 3. Risk of New-Onset AF in 5446 Older Adults According to Walking Habits**

<table>
<thead>
<tr>
<th>Walking distance, blocks/wk (n*)</th>
<th>No. of Events</th>
<th>Person-Years</th>
<th>Age- and Gender-Adjusted</th>
<th>Adjusted for Multiple Variables†</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–4 (n=1145)</td>
<td>272</td>
<td>8867</td>
<td>1.0 (Reference)</td>
<td>1.0 (Reference)</td>
</tr>
<tr>
<td>5–11 (n=855)</td>
<td>218</td>
<td>9188</td>
<td>0.78 (0.65–0.93)</td>
<td>0.78 (0.65–0.94)</td>
</tr>
<tr>
<td>12–23 (n=981)</td>
<td>212</td>
<td>9452</td>
<td>0.71 (0.59–0.86)</td>
<td>0.76 (0.63–0.91)</td>
</tr>
<tr>
<td>24–59 (n=1205)</td>
<td>191</td>
<td>9789</td>
<td>0.62 (0.51–0.75)</td>
<td>0.67 (0.55–0.81)</td>
</tr>
<tr>
<td>≥60 (n=1260)</td>
<td>168</td>
<td>9984</td>
<td>0.51 (0.42–0.63)</td>
<td>0.56 (0.45–0.69)</td>
</tr>
<tr>
<td>P for trend</td>
<td>...</td>
<td>...</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Walking pace (n*)

<table>
<thead>
<tr>
<th>Walking pace (n*)</th>
<th>No. of Events</th>
<th>Person-Years</th>
<th>Age- and Gender-Adjusted</th>
<th>Adjusted for Multiple Variables†</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2 mph (n=1656)</td>
<td>527</td>
<td>16805</td>
<td>1.0 (Reference)</td>
<td>1.0 (Reference)</td>
</tr>
<tr>
<td>2–3 mph (n=2314)</td>
<td>427</td>
<td>22494</td>
<td>0.62 (0.55–0.71)</td>
<td>0.68 (0.59–0.77)</td>
</tr>
<tr>
<td>&gt;3 mph (n=1476)</td>
<td>107</td>
<td>7982</td>
<td>0.51 (0.41–0.63)</td>
<td>0.59 (0.48–0.74)</td>
</tr>
<tr>
<td>P for trend</td>
<td>...</td>
<td>...</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Values are RR (95% CI) where appropriate. RR indicates relative risk (hazard ratio).
*No. of individuals in each category at baseline.
†Adjusted for age (years), gender (male/female), race (white/nonwhite), enrollment site (4 sites), education (< high school, high school, > high school), smoking status (never, former, current), pack-years of smoking (4 categories), CHD (yes/no), chronic pulmonary disease (yes/no), diabetes mellitus (yes/no), alcohol use (6 categories), and β-blocker use (yes/no).

**Distance and Pace of Walking**

Walking habits were also associated with risk of AF (Table 3). In multivariable-adjusted analyses, compared with walking 0 to 4 blocks per week, individuals walking 5 to 11, 12 to 23, 24 to 59, and ≥60 blocks per week had 22%, 24%, 33%, and 44% lower risk, respectively (P for trend <0.001). Compared with pace <2 mph, individuals with pace of 2 to 3

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between physical activity and AF might be mediated by
Mediation by Preceding MI and CHF
We evaluated the extent to which observed relationships
among 5446 older adults according to usual
walking habits (evaluated in quartiles, Q1 through Q4), combining
distance and pace of walking, adjusted for age, gender,
race, enrollment site, education, smoking status, pack-years of
smoking, CHD, chronic pulmonary disease, diabetes mellitus,
alcohol use, and β-blocker use. Diamonds represent risk esti-
mates, and bars represent 95% CIs, with the lowest category
of walking habits as the reference group.
mph and >3 mph had 32% and 41% lower risk, respectively
(P for trend <0.001). We also assessed the combined effects
of walking distance and pace by means of a prespecified
walking score (ordinal score for the sum of the categories of
distance [0–4] and pace [0–2] of walking), evaluated in
quartiles. A graded inverse relationship was evident between
walking distance/pace and incidence of AF (Figure); indi-
viduals in the highest quartile had 48% lower risk (95% CI
35% to 58%; P for trend <0.001). Further adjustments for
other factors that might be either confounders or mediators
(as above) modestly mitigated these associations: Compared
with the lowest quartile of distance/pace walked, the relative
risk for individuals in the highest quartile increased from 0.52
to 0.56 (95% CI 0.45 to 0.69).

Assessment of Confounding by Comorbidity
To assess confounding by physical activity limitation, we
excluded individuals with comorbidities that could signifi-
cantly limit activity, including claudication, angina, signifi-
antly limited vision, abnormal FEV1, or any reported limi-
tation of 1 or more activities of daily living at baseline
(n=1150). Results were not greatly altered, with lower AF
risk in multivariable-adjusted analyses with greater leisure-
time activity (for comparison of extreme quintiles, hazard
ratio 0.68, 95% CI 0.54 to 0.86, P for trend 0.003), moderate
exercise intensity (for comparison of moderate to none, hazard
ratio 0.70, 95% CI 0.54 to 0.90), and greater distance/
pace walked (for comparison of extreme quartiles, hazard
ratio 0.54, 95% CI 0.42 to 0.69, P for trend <0.001). In
stratified analyses, little evidence was found that associations
of physical activity with incident AF varied more than would
be expected by chance alone according to age, gender,
hypertension, preexisting CHD (P for interaction >0.10 for
each), or presence or absence of preexisting cardiovascular
disease (Table 4).

Mediation by Preceding MI and CHF
We evaluated the extent to which observed relationships
between physical activity and AF might be mediated by

![Figure](http://circ.ahajournals.org/)

**Figure.** Relative risk (RR; hazard ratio) of incident AF during 12
years of follow-up among 5446 older adults according to usual
walking habits (evaluated in quartiles, Q1 through Q4), combing
distance and pace of walking, adjusted for age, gender,
race, enrollment site, education, smoking status, pack-years of
smoking, CHD, chronic pulmonary disease, diabetes mellitus,
alcohol use, and β-blocker use. Diamonds represent risk esti-
mates, and bars represent 95% CIs, with the lowest category
of walking habits as the reference group.

lower risk of preceding MI or CHF by adjusting for both
preexisting and incident MI and CHF as time-varying
covariates. In multivariable-adjusted analyses (covariates as
in Table 4), preceding MI or CHF was a strong risk
factor for incident AF (hazard ratio 4.64, 95% CI 4.08 to
5.26). After adjustment for preceding MI or CHF, relation-
ships of physical activity with incident AF were slightly
attenuated: The extreme quintile relative risk for leisure-
time activity increased from 0.64 to 0.67 (95% CI 0.55 to
0.83), the relative risk for moderate compared with no
exercise intensity increased from 0.72 to 0.76 (95% CI

<table>
<thead>
<tr>
<th>Categories of Physical Activity</th>
<th>No History of CVD (n=4193)</th>
<th>History of CVD (n=1253)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leisure-time activity, quintiles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>1.0 (Reference)</td>
<td>1.0 (Reference)</td>
</tr>
<tr>
<td>II</td>
<td>0.86 (0.69–1.09)</td>
<td>0.87 (0.63–1.20)</td>
</tr>
<tr>
<td>III</td>
<td>0.73 (0.58–0.93)</td>
<td>0.82 (0.58–1.15)</td>
</tr>
<tr>
<td>IV</td>
<td>0.74 (0.58–0.94)</td>
<td>0.91 (0.66–1.25)</td>
</tr>
<tr>
<td>V</td>
<td>0.66 (0.51–0.85)</td>
<td>0.63 (0.44–0.91)</td>
</tr>
<tr>
<td>P for trend</td>
<td>0.001</td>
<td>0.04</td>
</tr>
<tr>
<td>P for interaction: ordinal†</td>
<td>0.83</td>
<td>...</td>
</tr>
<tr>
<td>P for interaction: categorical†</td>
<td>0.86</td>
<td>...</td>
</tr>
<tr>
<td>Exercise intensity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>1.0 (Reference)</td>
<td>1.0 (Reference)</td>
</tr>
<tr>
<td>Low</td>
<td>0.84 (0.65–1.09)</td>
<td>0.90 (0.66–1.23)</td>
</tr>
<tr>
<td>Moderate</td>
<td>0.70 (0.53–0.93)</td>
<td>0.77 (0.54–1.10)</td>
</tr>
<tr>
<td>High</td>
<td>0.95 (0.65–1.38)</td>
<td>0.74 (0.41–1.31)</td>
</tr>
<tr>
<td>P for trend</td>
<td>0.11</td>
<td>0.11</td>
</tr>
<tr>
<td>P for interaction: ordinal†</td>
<td>0.87</td>
<td>...</td>
</tr>
<tr>
<td>P for interaction: categorical†</td>
<td>0.30</td>
<td>...</td>
</tr>
<tr>
<td>Distance/pace walked, quartiles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>1.0 (Reference)</td>
<td>1.0 (Reference)</td>
</tr>
<tr>
<td>II</td>
<td>0.73 (0.59–0.90)</td>
<td>0.75 (0.56–0.99)</td>
</tr>
<tr>
<td>III</td>
<td>0.58 (0.46–0.73)</td>
<td>0.68 (0.50–0.92)</td>
</tr>
<tr>
<td>IV</td>
<td>0.51 (0.39–0.67)</td>
<td>0.56 (0.38–0.82)</td>
</tr>
<tr>
<td>P for trend</td>
<td>&lt;0.001</td>
<td>0.002</td>
</tr>
<tr>
<td>P for interaction: ordinal†</td>
<td>0.39</td>
<td>...</td>
</tr>
<tr>
<td>P for interaction: categorical†</td>
<td>0.70</td>
<td>...</td>
</tr>
</tbody>
</table>

CVD indicates cardiovascular disease.

*Preexisting CHD (nonfatal MI, coronary revascularization, or angina), CHF, or
stroke. In 4193 individuals without preexisting CVD, 709 AF cases occurred; in
1253 individuals with preexisting CVD, 352 AF cases occurred. Values
represent hazard ratios (95% CI), adjusted for age (years), gender (male/female),
race (white/nonwhite), enrollment site (4 sites), education (<high school,
high school, >high school), smoking status (never, former, current),
pack-years of smoking (4 categories), chronic pulmonary disease (yes/no),
diabetes mellitus (yes/no), alcohol use (6 categories), and β-blocker use
(yes/no).
†Evaluated with likelihood ratio testing comparing nested models with vs
without interaction terms for preexisting cardiovascular disease multiplied by
the measure of physical activity, with the potential interaction modeled both
ordinarily and categorically.
0.61 to 0.95), and the extreme quartile relative risk for distance/pace of walking increased from 0.52 to 0.56 (95% CI 0.45 to 0.70).

**Population Attributable Risk**

We calculated the proportion of cases of new-onset AF in the population attributable to lack of moderate activities, defined as leisure-time activity below the median (<616 kcal/week), walking fewer than 12 blocks per week, or walking at a pace less than 2 mph, adjusting for these habits simultaneously in the multivariable model (other covariates as in Table 2). In sum, the proportion of all new cases of AF attributable to the absence of these moderate activities was 26% (95% CI 7% to 43%).

**Discussion**

Incidence of AF rises sharply with age, and most cases in the population occur after age 65 years. Although vigorous exertion and endurance training have been reported as risk factors for AF in younger and middle-aged populations, this is the first study to focus on older adults and to evaluate prospectively the relationships of light to moderate habitual physical activity with incidence of AF. Greater leisure-time activity and walking were associated with graded lower incidence of AF, with progressively lower risk as both leisure-time activity and distances and paces of walking increased. Conversely, intensity of exercise had a U-shaped relationship with AF, with lower risk among individuals exercising with moderate, but not high, intensity.

Physical activity and exercise may have both acute (during a bout) and chronic (related to habitual activity) physiological effects. For example, whereas the risk of sudden cardiac death may be increased transiently during vigorous exercise, habitual physical activity is associated with an overall decreased risk of sudden cardiac death.21–23 Higher risk of AF has been reported in case series and retrospective studies of younger athletes and middle-aged adults with high-intensity endurance exercise.24,25 In a retrospective study, 262 military veterans likely to report current sports practice (31%) than population controls (14%).10 Thus, case series and retrospective studies suggest that part of the observed lower risk may be mediated in part by a lower risk of preceding MI and/or CHF.

In considering relationships between physical activity and incident AF, potential confounding by underlying comorbidity must be assessed carefully. Some individuals may have comorbidities that both limit their physical activity and increase their risk of AF, which would cause physical activity to appear more protective than the true effect. Conversely, other individuals may increase their physical activity in response to diagnosis of a condition that also increases risk of AF (confounding by indication), which would cause physical activity to appear less protective than the true effect. Multivariable adjustments are 1 method to decrease such confounding. We also used restriction and stratification to assess such potential confounding. The findings did not appear to be
attributable to confounding by presence of comorbid conditions, such as chronic pulmonary disease, preexisting CHD, or preexisting cardiovascular disease. Notably, the relationships of most potential confounders were similar or even more prominent for exercise intensity than for leisure-time activity (Table 1), but multivariable-adjusted analyses revealed different relationships of exercise intensity (U-shaped risk) versus leisure-time activity (graded lower risk) with incident AF, which suggests that confounding alone would not fully account for the observed relationships.

The present analysis has several strengths. The prospective assessment of physical activity and other covariates reduces potential bias from recall differences. The cohort design minimizes selection bias (ie, the noncases represent the true population from which the cases arose). Standardized assessment of a wide variety of participant characteristics increases the capacity to adjust for confounding. Close follow-up, annual ECGs, and review of all hospitalizations reduce the potential for missed or misclassified outcomes. The use of repeated assessments of physical activity and other risk factors over time reduces misclassification due to changes in activity and assesses long-term effects. The large number of events provides ample statistical power. The population-based recruitment strategy enhances generalizability.

Potential limitations are also evident. Physical activity was self-reported and assessed average activity in the prior 2 weeks at each visit, and some misclassification of the true activity of each individual is likely (although cumulative averaging over time reduces such error). Cases of asymptomatic paroxysmal AF may have been missed, which would reduce the power to detect associations. The possibility of residual confounding due to unmeasured or imprecisely measured factors cannot be excluded. On the other hand, these findings are consistent with observational studies showing lower incidence of CHD and diabetes with greater physical activity; the latter relationship has been confirmed in randomized, controlled trials.31,32 Another limitation is that the associations were observed in older adults participating in a cohort study and may not be generalizable to younger individuals.

Overall, in 5 of these older US adults developed AF during 12 years of follow-up. Our findings suggest that moderate physical activity may meaningfully reduce this risk and that up to one fourth of new cases of AF in older adults may be attributable to absence of moderate leisure-time activity and regular walking at a moderate distance and pace. These results suggest that these easily achievable lifestyle habits should be further evaluated as potential preventive measures to reduce the incidence of AF in the particularly high-risk and growing population of older adults.

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Disclosures
None.

References
Physical activity is often considered to increase the risk of atrial fibrillation (AF), on the basis of anecdotal reports, case series, and retrospective studies evaluating vigorous exertion and endurance training in younger and middle-aged athletes; however, most AF cases do not occur in athletes but in the general population of older adults (≥65 years old), in whom 10-year risk of AF approaches 20%. At these ages, AF risk factors include long-standing hypertension, reduced ventricular compliance, and structural heart disease, all of which are risk factors that might be improved or prevented by habitual light to moderate activity. However, relationships of physical activity with incidence of AF in older adults had not been evaluated. We prospectively investigated associations of habitual light to moderate activity, including leisure-time activities and walking, with AF incidence among 5446 adults ≥65 years of age over a 12-year period. After adjustment for other risk factors, both leisure-time activity and walking were associated with significantly lower AF incidence, including a 36% lower risk for the highest versus lowest quintile of leisure-time activity and a 50% lower risk for the highest versus lowest category of walking distance/pace. Strenuous exertion was not required: Lower risk was seen with regularly walking 5 to 10 blocks per week and at 2- to 3- mph paces (greater distances and paces were associated with even lower risk). Although these observational findings do not prove causality, the strength and consistency of associations, including among individuals with and without preexisting cardiovascular disease, and the known biological effects of exercise suggest that regular light to moderate activity may reduce AF incidence in older adults. This provides additional strong impetus for clinicians and policy makers to focus on regular physical activity, including leisure-time activities and walking, to maintain cardiovascular health in older adults.
Physical Activity and Incidence of Atrial Fibrillation in Older Adults: The Cardiovascular Health Study
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