Healthy Lifestyle Factors in the Primary Prevention of Coronary Heart Disease Among Men
Benefits Among Users and Nonusers of Lipid-Lowering and Antihypertensive Medications

Stephanie E. Chiuve, ScD; Marjorie L. McCullough, RD, ScD; Frank M. Sacks, MD; Eric B. Rimm, ScD

Background—Healthy lifestyle choices such as eating a prudent diet, exercising regularly, managing weight, and not smoking may substantially reduce coronary heart disease (CHD) risk by improving lipids, blood pressure, and other risk factors. The burden of CHD that could be avoided through adherence to these modifiable lifestyle factors has not been assessed among middle-aged and older US men, specifically men taking medications for hypertension or hypercholesterolemia.

Methods and Results—We prospectively monitored 42,847 men in the Health Professionals Follow-up Study, 40 to 75 years of age and free of disease in 1986. Lifestyle factors were updated through self-reported questionnaires. Low risk was defined as (1) absence of smoking, (2) body mass index $< 25 \text{ kg/m}^2$, (3) moderate-to-vigorous activity $\geq 30 \text{ min/d}$, (4) moderate alcohol consumption (5 to 30 g/d), and (5) the top 40% of the distribution for a healthy diet score. Over 16 years, we documented 2183 incident cases of CHD (nonfatal myocardial infarction and fatal CHD). In multivariate-adjusted Cox proportional hazards models, men who were at low risk for 5 lifestyle factors had a lower risk of CHD (relative risk: 0.13; 95% confidence interval [CI]: 0.09, 0.19) compared with men who were at low risk for no lifestyle factors. Sixty-two percent (95% CI: 49%, 74%) of coronary events in this cohort may have been prevented with better adherence to these 5 healthy lifestyle practices. Among men taking medication for hypertension or hypercholesterolemia, 57% (95% CI: 32%, 79%) of all coronary events may have been prevented with a low-risk lifestyle. Compared with men who did not make lifestyle changes during follow-up, those who adopted 2 additional low-risk lifestyle factors had a 27% (95% CI: 7%, 43%) lower risk of CHD.

Conclusions—A majority of CHD events among US men may be preventable through adherence to healthy lifestyle practices, even among those taking medications for hypertension or hypercholesterolemia. (Circulation. 2006;114:160-167.)

Key Words: diet ■ lifestyle ■ risk factors ■ coronary disease ■ epidemiology

Major risk factors for coronary heart disease (CHD), such as hypercholesterolemia, hypertension, and smoking, are modifiable.1 Pharmacological therapies, including lipid-lowering and antihypertensive medications, are efficacious in lowering some of these risk factors,2,3 typically reducing cardiovascular disease risk by 20% to 30%.2,4 Although pharmacological agents successfully reduce coronary events, the overall reduction in risk is relatively modest and could be greatly improved by the addition of lifestyle modifications.

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Healthy diet and other lifestyle practices, including not smoking, maintaining a healthy weight, and exercising daily, also improve these clinical risk factors as well as reduce inflammation, homocysteine, glucose intolerance, and arrhythmias.5-11 Individually, these modifiable lifestyle factors are associated with lower risk of CHD,12 but a combination of healthy lifestyle choices has a greater impact than any single lifestyle factor. A healthy lifestyle has been associated with lower risk of incident coronary events among middle-aged women13 and lower risk of CHD mortality in a population of elderly men and women.14 Little is known about the relation between combined healthy lifestyle choices and incident CHD among middle-aged and older men, especially those who are reducing their risk by using drugs for hypertension or hypercholesterolemia.
We estimated the burden of CHD that could potentially be avoided through a healthy lifestyle among highly educated middle-aged and older US men. We hypothesized that among men taking medication for hypertension or hypercholesterolemia, these healthy lifestyle characteristics would still remain associated with lower CHD risk. Finally, we examined the association between changes in lifestyle during middle and older ages and risk of CHD among these men.

### Methods

#### Study Population

The Health Professionals Follow-up Study (HPFS) is a cohort of 51,529 US male health professionals, ages 40 to 75 years (mean age, 53) at baseline in 1986. Participants have provided information on current medical conditions and lifestyle factors biennially starting in 1986 through the use of self-administered questionnaires. We excluded men with missing or implausible nutrient intakes at baseline (≥70 items left blank or estimated total energy intake ≤800 or

### TABLE 1. Multivariate Relative Risk of CHD Associated With Modifiable Lifestyle Factors

<table>
<thead>
<tr>
<th>Lifestyle Factors</th>
<th>No. of Cases</th>
<th>Frequency,* %</th>
<th>RR (95% CI)</th>
<th>Model 1†</th>
<th>Model 2‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoking (cigarettes/d)</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>≥25</td>
<td>92</td>
<td>2</td>
<td>3.21 (2.57–4.01)</td>
<td>3.10 (2.46–3.89)</td>
<td></td>
</tr>
<tr>
<td>15–24</td>
<td>80</td>
<td>2</td>
<td>2.17 (1.72–2.75)</td>
<td>2.16 (1.70–2.74)</td>
<td></td>
</tr>
<tr>
<td>1–14</td>
<td>82</td>
<td>2</td>
<td>2.03 (1.61–2.57)</td>
<td>2.14 (1.69–2.71)</td>
<td></td>
</tr>
<tr>
<td>Past</td>
<td>1070</td>
<td>47</td>
<td>1.06 (0.97–1.17)</td>
<td>1.09 (0.99–1.20)</td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>791</td>
<td>44</td>
<td>1.00 (ref)</td>
<td>1.00 (ref)</td>
<td></td>
</tr>
<tr>
<td>Low risk (not current vs current)</td>
<td>1861</td>
<td>91</td>
<td>0.45 (0.40–0.51)</td>
<td>0.47 (0.42–0.54)</td>
<td></td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥29.0</td>
<td>429</td>
<td>15</td>
<td>1.68 (1.45–1.96)</td>
<td>1.57 (1.34–1.83)</td>
<td></td>
</tr>
<tr>
<td>25.0–28.9</td>
<td>998</td>
<td>42</td>
<td>1.36 (1.19–1.55)</td>
<td>1.33 (1.17–1.52)</td>
<td></td>
</tr>
<tr>
<td>23.0–24.9</td>
<td>434</td>
<td>26</td>
<td>0.96 (0.85–1.12)</td>
<td>0.98 (0.84–1.14)</td>
<td></td>
</tr>
<tr>
<td>&lt;23.0</td>
<td>306</td>
<td>17</td>
<td>1.00 (ref)</td>
<td>1.00 (ref)</td>
<td></td>
</tr>
<tr>
<td>Low risk (&lt;25 vs ≥25 kg/m²)</td>
<td>740</td>
<td>43</td>
<td>0.68 (0.62–0.75)</td>
<td>0.70 (0.64–0.77)</td>
<td></td>
</tr>
<tr>
<td>Exercise (h/wk)§</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1038</td>
<td>38</td>
<td>1.52 (1.32–1.73)</td>
<td>1.22 (1.06–1.40)</td>
<td></td>
</tr>
<tr>
<td>0.1–1.5</td>
<td>349</td>
<td>17</td>
<td>1.22 (1.04–1.43)</td>
<td>1.05 (0.90–1.24)</td>
<td></td>
</tr>
<tr>
<td>1.5–3.5</td>
<td>334</td>
<td>17</td>
<td>1.18 (1.00–1.38)</td>
<td>1.08 (0.92–1.27)</td>
<td></td>
</tr>
<tr>
<td>3.5–6.0</td>
<td>183</td>
<td>12</td>
<td>0.96 (0.79–1.16)</td>
<td>0.92 (0.76–1.11)</td>
<td></td>
</tr>
<tr>
<td>≥6.0</td>
<td>279</td>
<td>17</td>
<td>1.00 (ref)</td>
<td>1.00 (ref)</td>
<td></td>
</tr>
<tr>
<td>Low risk (≥3.5 vs &lt;3.5 h/wk)</td>
<td>462</td>
<td>29</td>
<td>0.72 (0.65–0.80)</td>
<td>0.83 (0.74–0.92)</td>
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</tr>
<tr>
<td>Diet score¶</td>
<td></td>
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</tr>
<tr>
<td>≤31.6</td>
<td>491</td>
<td>20</td>
<td>1.58 (1.38–1.81)</td>
<td>1.28 (1.11–1.47)</td>
<td></td>
</tr>
<tr>
<td>31.6–37.2</td>
<td>435</td>
<td>20</td>
<td>1.30 (1.13–1.50)</td>
<td>1.14 (0.99–1.32)</td>
<td></td>
</tr>
<tr>
<td>37.2–42.4</td>
<td>462</td>
<td>20</td>
<td>1.30 (1.13–1.49)</td>
<td>1.18 (1.03–1.36)</td>
<td></td>
</tr>
<tr>
<td>42.4–48.9</td>
<td>403</td>
<td>20</td>
<td>1.09 (0.94–1.25)</td>
<td>1.02 (0.89–1.18)</td>
<td></td>
</tr>
<tr>
<td>≥48.9</td>
<td>392</td>
<td>20</td>
<td>1.00 (ref)</td>
<td>1.00 (ref)</td>
<td></td>
</tr>
<tr>
<td>Low risk (score ≥42.4 vs &lt;42.4)</td>
<td>795</td>
<td>40</td>
<td>0.75 (0.69–0.82)</td>
<td>0.84 (0.77–0.92)</td>
<td></td>
</tr>
<tr>
<td>Alcohol (g/d)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>639</td>
<td>24</td>
<td>1.40 (1.25–1.55)</td>
<td>1.37 (1.23–1.53)</td>
<td></td>
</tr>
<tr>
<td>0.1–4.9</td>
<td>579</td>
<td>24</td>
<td>1.34 (1.20–1.50)</td>
<td>1.34 (1.20–1.49)</td>
<td></td>
</tr>
<tr>
<td>5–29.9</td>
<td>739</td>
<td>40</td>
<td>1.00 (ref)</td>
<td>1.00 (ref)</td>
<td></td>
</tr>
<tr>
<td>≥30</td>
<td>226</td>
<td>11</td>
<td>1.03 (0.88–1.19)</td>
<td>0.88 (0.75–1.02)</td>
<td></td>
</tr>
<tr>
<td>Low risk (5–30 g/d vs others)</td>
<td>738</td>
<td>40</td>
<td>0.77 (0.70–0.84)</td>
<td>0.79 (0.73–0.87)</td>
<td></td>
</tr>
</tbody>
</table>

*Numbers may not add up to 100% because of missing values and rounding.
†RRs were estimated from a multivariate Cox proportional hazards model, adjusted for age, family history of MI before age of 60, aspirin use, use of antihypertensive medication, baseline hypercholesterolemia, and baseline hypertension. CI signifies confidence intervals.
‡Controlling for covariates in model 1 + other lifestyle factors simultaneously.
§Exercise at moderate to vigorous intensity (≥4 METs).
¶The AHEI-based diet score is based on intake of trans fatty acid, ratio of polyunsaturated:saturated fat, ratio of chicken and fish: red meat (in grams), fruits, vegetables, vegetable protein, cereal fiber, and multivitamin use.
≥4200 kcal) and those with a history of chronic disease. The final population for this analysis was 42,847. The Institutional Review Board of the Harvard School of Public Health approved the study protocol.

### Exposure and Covariate Ascertainment

Self-reported height and family history of myocardial infarction (MI) before 60 years of age were ascertained on the baseline questionnaire. Participants reported the average time engaged in specific activities biennially, using an activity questionnaire previously validated within a subset of this cohort. We calculated hours per week of moderate-to-vigorous activity requiring at least 4 metabolic equivalents. We included walking at a brisk pace (>3 mph), jogging, running, bicycling, swimming, tennis, squash, racquetball, rowing, and calisthenics.

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We assessed dietary information by using a 151-item, semiquantitative food frequency questionnaire (FFQ), administered every 4 years. The reproducibility and validity of these FFQs are high when compared with multiple 1-week diet records and biochemical markers. We calculated a summary dietary score based on the Alternate Healthy Eating Index (AHEI). The AHEI is a modification of the Healthy Eating Index (HEI), created by the US Department of Agriculture to assess how well the US population met dietary recommendations based on the Food Guide Pyramid and the Dietary Guidelines for Americans. The AHEI, which targets foods and nutrients associated with lower risk of chronic disease, better predicts chronic disease risk than do other measures of diet quality, including the HEI. Although alcohol was part of the original AHEI, for the present study we considered it a separate lifestyle factor. With the exception of multivitamin use, the AHEI components were given a score ranging from 0 to 10, where 10 signified optimal dietary behavior. The 7 specific components (criteria for minimum, maximum scores) were percent energy from trans fat (>4%, ≤0.5%), ratio of polyunsaturated:saturated fat (≤0.1, ≥1), and chicken plus fish:meat (0, 4; a small percentage of vegetarians were given a score of 10), daily servings of fruit (0, >4), vegetables (0, ≥5), vegetable proteins (legumes, tofu, and soy products) (0, ≥1), and grams of cereal fiber (0, ≥15). The eighth component, multivitamin use for >5 years, was dichotomous, to avoid overweighting this component (yes=7.5, no=2.5 points). Our diet score ranged from 2.5 (worst) to 77.5 (best).

For each lifestyle factor (smoking, BMI, exercise, diet score, and alcohol), we created a binary low-risk variable, where the men received a 1 if they met the criteria for low risk and a 0 if otherwise. The a priori definition of low risk was based on the current literature and recommended guidelines but also on levels realistically obtainable within the general population. For smoking, we defined low risk as not currently smoking. Because we wanted to consider only modifiable factors, we included former smokers in our low-risk category, as current smokers cannot attain the status of “never smoker.” The risk of CHD among former smokers declines after smoking cessation, approximating the risk of those who have never smoked after 10 to 14 years. For exercise, at least 30 min/week of moderate-to-vigorous intensity was considered low risk, on the basis of current guidelines. Optimal body weight was defined as a BMI of <25 kg/m², the standard World Health Organization cutoff for healthy weight. We considered average daily alcohol intake of 5 to 30 g as low risk. This is consistent with guidelines for moderate alcohol consumption, although higher amounts of alcohol intake are associated with lower risk of CHD. For diet, low risk was defined as a diet score in the top 40% of the cohort distribution, as there are no recommendations established for the AHEI. The average diet score among the men with low-risk diets was 50.3. An average low-risk diet of a long-term multivitamin user would consist of approximately 3 servings of vegetables, 2.5 servings of fruit, 0.5 servings of nuts, 9 g of cereal fiber, 1.8% of calories from trans fat, 2.5 servings of chicken and fish for 1 serving of red meat, and a polyunsaturated:saturated fat ratio of 0.6.

We calculated a healthy lifestyle score by summing the total number of lifestyle factors for which the men were at low risk. The men could obtain a healthy lifestyle score from 0 (least healthy) to 5 (most healthy).

### Outcome Ascertainment

The outcome for this analysis was incident CHD, defined as nonfatal MI or fatal CHD, occurring between the return of the baseline questionnaire in 1986 and January 31, 2002. Confirmed MIs were defined according to World Health Organization criteria and, when available, cardiac-specific troponin levels were used. If an individual was admitted to the hospital for an MI but medical records were unavailable, the infarction was considered probable. Confirmed deaths were those caused by MI, according to autopsy or hospital records, or if CHD was listed as the cause of death and previous evidence of CHD was obtained. Deaths were considered probable if the cause of death was CHD without confirmation of previous CHD or those listed as sudden deaths with no other potential cause. We used both confirmed and probable cases, as results were similar when we excluded probable cases (17% of cases).

### Statistical Analysis

We used the cumulative average of the AHEI-based diet score from repeated dietary assessments to represent long-term dietary information and minimize within-person variation. For example, the diet score from the 1986 FFQ was used to estimate CHD risk between 1986 and 1990, whereas an average of the 1986 and 1990 diet score was used to predict CHD risk occurring between 1990 and 1994. The average of the 1986, 1990, and 1994 diet scores was used to estimate disease risk between 1994 and 1998, and so on. Because diagnosis of diabetes, angina, hypertension, hypercholesterolemia, or revascularization surgery may lead to changes in diet, we stopped updating dietary information after new diagnoses of these outcomes during follow-up. Nondietary factors were updated every 2 years.

For individuals missing information on any lifestyle factor, we carried forward information from the previous questionnaire, when available. Men with residual missing values were placed in the high-risk category, to give the most conservative estimate. Less than 1% of values were missing for each lifestyle factor; among the current smokers, <2% of men were missing information on number of cigarettes.

Each individual contributed person-time from the return of the 1986 questionnaire until the date of first coronary event, date of diagnosis of cancer or stroke, death, or January 31, 2002, whichever came first. Relative risks (RRs) and 95% confidence intervals (CIs) were estimated by using Cox proportional hazards models adjusted for age, calendar year, parental history of MI, history of hypertension, history of hypercholesterolemia, aspirin use, and antihypertensive medication use. Further adjustment for lipid-lowering medications did not appreciably alter the results.

We calculated the population-attributable risk and 95% CI to estimate the proportion of cases within the population that could have been avoided had all the men adhered to the low-risk lifestyle practices, assuming a causal relation between the low-risk lifestyle practices and risk of CHD. To calculate the population-attributable risk, we used Cox proportional hazards models to calculate relative risks of CHD, comparing men at low risk in a specific combination of lifestyle factors with those in the high risk of the population.

To assess whether modifiable lifestyle factors were associated with lower risk among men already undergoing drug therapy, we examined the relation between healthy lifestyle score and risk of CHD separately among subgroups of users and nonusers of lipid-lowering or antihypertensive medications. We defined medication use as current use, which was updated every 2 years.

We estimated changes in lifestyle and risk of CHD by modeling the difference between the attained healthy lifestyle score at follow-up and the healthy lifestyle score at baseline, controlling for baseline score. For this analysis, we included only men who...
completed the baseline questionnaire and at least one questionnaire
during the follow-up period (n=33,759).

The authors had full access to the data and take responsibility for
its integrity. All authors have read and agreed to the manuscript as
written.

Results

After 16 years of follow-up, we documented 2183 incident
coronary events. The frequencies of each lifestyle factor
within this population are shown in Table 1. For each lifestyle
factor, we observed an inverse association with risk of CHD,
which remained significant when all 5 lifestyle factors were
included in the same model (Table 1). When categorized as a
dichotomous variable, being at low risk for each lifestyle
factor was still significantly and independently associated
with lower risk.

Overall, the healthy lifestyle score was significantly in-
versely associated with risk of CHD (P for trend, <0.001) (Figure 1). Men at low risk for \( \geq 1 \) lifestyle factor had a
significantly lower risk of CHD, compared with men at low
risk for none of the 5 factors. Men at low risk for all 5 factors
had the lowest risk.

Men in this population reported use of lipid-lowering or
antihypertensive medication use for 21% of the person-time
during follow-up. Among these medication users (and also
among nonusers), the healthy lifestyle score was significantly
inversely associated with risk of CHD (Figure 2). Results
were not appreciably different when we excluded men who
were diagnosed with hypertension or hypercholesterolemia
during follow-up but reported no medication use (data not
shown).

We calculated the population-attributable risk for men who
adhered to a combination of low-risk lifestyle practices
(Table 2). Men in the low-risk group for all 5 lifestyle
practices, only 4% of the population, had an RR of 0.37 (95%
CI: 0.26, 0.53), compared with the remaining men in the
population. This translates to a population-attributable risk of
62% (95% CI: 49%, 74%), suggesting that a majority of
coronary disease in this population may be attributed to poor
adherence to a healthy lifestyle.

Among medication users, the population-attributable risk
for adhering to all 5 low-risk lifestyle practices was 57% (95%
CI: 32%, 79%) (Table 3). We found similar associa-
tions among antihypertensive and lipid-lowering medications
users separately albeit with wider confidence intervals. The
population-attributable risk for adhering to all 5 low-risk
lifestyle practices was much higher among middle-aged men
(<65 years old) (population-attributable risk: 79%; 95% CI:
61%, 90%) than among men 65 years or older (population-
attributable risk: 47%; 95% CI: 27%, 68%) (Table 3).

Because of the long follow-up period and the repeated
assessment of lifestyle characteristics over time, we were able
to examine the CHD risk associated with changes in the healthy lifestyle score. Among the men included in the change in lifestyle analysis, there were 1583 incident coronary events. Men who adopted at least 2 new healthy characteristics during follow-up had a relative risk of 0.73 (95% CI: 0.57, 0.93) compared with men who did not change, controlling for the number at baseline (Table 4). On the other hand, men who reduced their healthy lifestyle score by 2 or more factors had a relative risk of 1.48 (95% CI: 1.15, 1.88), compared with men who did not change.

Discussion
In this population of male health professionals, 62% of all coronary events may have been avoided had all men adhered to a low-risk lifestyle of not smoking, exercising regularly, eating prudently, consuming alcohol in moderation, and maintaining a healthy weight. Equally important, we found that this combination of healthy lifestyle characteristics was strongly inversely associated with risk even among men taking medication for coronary risk factors. Further, we found that middle-aged and older men who adopted additional healthy lifestyle practices over time further lowered their risk of coronary disease.

The therapeutic benefits of antihypertensive and lipid-lowering drugs are well documented, but coronary disease remains elevated in this population. The addition of healthy behaviors, such as a prudent diet and regular exercise, to either antihypertensive or lipid-lowering drug therapy in other populations reduced risk factors, such as systolic and diastolic blood pressure and low-density lipoprotein cholesterol, as well as the inflammatory biomarker C-reactive protein, compared with drug therapy alone.

In our cohort, the population-attributable risk for men at low risk for all 5 lifestyle factors was 57% among the users of cardiovascular medications. This implies that more than half of the cases of CHD among the medication users in this population may have been avoided by adherence to low-risk lifestyle practices, in addition to the benefits seen from medication use. Cardiovascular medications should be used as an adjunct to, not just a replacement for, healthy lifestyle practices, especially in the setting of primary prevention.

This study shows the extent to which healthy lifestyle changes may lower the risk of CHD, even during middle age or later in life. We probably underestimated the true benefit of healthy changes, as the men who were the healthiest (those with 4 or 5 low-risk lifestyle factors) could not increase their score by 2 factors. Furthermore, we could not capture the benefit among men who met the threshold for low risk but continued to improve their lifestyle. This was an observational study, not a clinical trial; thus, these men made changes of their own free will. Only 4% of the men adopted all healthy

### Table 2: Risk of CHD According to Different Combinations of Low-Risk Lifestyle Factors

<table>
<thead>
<tr>
<th>Low-Risk Combination</th>
<th>Frequency</th>
<th>No. of Cases</th>
<th>RR (95% CI)*</th>
<th>% Population-Attributable Risk (95% CI)†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combination 1</td>
<td>14%</td>
<td>205</td>
<td>0.65 (0.57–0.76)</td>
<td>31 (23–41)</td>
</tr>
<tr>
<td>Not currently smoking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diet score top 40%‡</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exercise ≥30 min/d</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Combination 2</td>
<td>8%</td>
<td>84</td>
<td>0.46 (0.37–0.57)</td>
<td>52 (42–62)</td>
</tr>
<tr>
<td>Not currently smoking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diet score top 40%‡</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exercise ≥30 min/d</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Combination 3</td>
<td>4%</td>
<td>31</td>
<td>0.37 (0.26–0.53)</td>
<td>62 (49–74)</td>
</tr>
<tr>
<td>Not currently smoking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diet score top 40%‡</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exercise ≥30 min/d</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*R for men at low-risk for all listed lifestyle factors compared with the rest of the population, adjusted for age, family history of myocardial infarction before age of 60, aspirin use, use of antihypertensive medication, baseline hypercholesterolemia, baseline hypertension, and other lifestyle factors. CI signifies confidence intervals.

†Population-attributable risk is the proportion of cases within the population that may have been avoided had all men been at low risk for the lifestyle factors, adjusted for age, family history of myocardial infarction before age of 60, aspirin use, use of antihypertensive medication, baseline hypercholesterolemia, baseline hypertension, and other lifestyle factors. Men with missing values were considered to be at high risk.

‡A diet score of ≥42.4 represents the top 40%. The AHEI-based diet score is based on intake of trans fat, ratio of polyunsaturated:saturated fat, ratio of chicken and fish:red meat (in grams), fruits, vegetables, vegetable protein, cereal fiber, and multivitamin use.
practices on their own; however, whether a greater number of these men would follow a low-risk regimen if given as a direct intervention cannot be determined from our data. The population-attributable risk resulting from low-risk lifestyle practices within this population of men was lower than expected. However, when we excluded men >65 years of age, the results were similar to those seen among middle-aged women from the Nurses’ Health Study as well as from studies of CHD mortality conducted among younger and middle-aged men and women, using clinical definitions of low risk. Even among older men (>65 years), healthy lifestyle factors were associated with significantly lower risk. In an older Mediterranean population (70 to 90 years), risk of CHD mortality was 65% lower among participants who committed to 4 healthy lifestyle choices.

Overall, these health professionals were at lower risk of developing CHD than men in the general population. The rate of incident CHD in this population (2.86 events/1000 person-years) was almost half of the age-standardized rate seen in the Atherosclerosis Risk in Communities (ARIC) study population (5.53 events/1000 person-years), the participants of which were selected to be representative of adults in 4 communities across the United States. Summary results from the National Health Interview Survey indicate that fewer men in the United States ≥45 years of age met our low-risk criteria for exercise (16% versus 29% in our cohort), optimal BMI (37% versus 43%), absence of current smoking (84% versus 91%), and moderate alcohol consumption (19% versus 40%). Nationally representative data needed to calculate the AHEI-based diet score are not available. The average HEI score of 68.3, within this cohort, is slightly higher than the mean HEI score of 65.2 among US men 51 years or older. Even though the men in our cohort were healthier than men in the United States, only 4% of men met the low-risk criteria for all 5 characteristics. We still conclude that a majority of cases of CHD among this low-risk population of men may have been prevented through a healthy lifestyle.

Although the accuracy of self-reported data within this population of motivated and educated health professionals has been well documented, measurement error in self-reported variables is inevitable. Because of the prospective design of the study, this misclassification should be nondifferential with respect to disease status and would attenuate the true relative risk. A randomized clinical trial is ideal to establish causality of these lifestyle factors on risk of CHD. For some of these lifestyle factors, such as smoking and alcohol consumption, a clinical trial may not be ethical. Short-term trials on diet, physical activity, and weight loss

### TABLE 3. Relative Risks and Population-Attributable Risks of CHD Among Men With 5 Low-Risk Lifestyle Factors According to Medication Use and Age

<table>
<thead>
<tr>
<th>Subgroups (% Frequency)</th>
<th>No. of Cases</th>
<th>No. of All 5 Factors</th>
<th>% All 5 Factors</th>
<th>RR (95% CI)†</th>
<th>Population-Attributable Risk (95% CI)‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medication use§</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No (79%)</td>
<td>1404</td>
<td>20</td>
<td>4</td>
<td>0.34 (0.22–0.53)</td>
<td>66 (49–79)</td>
</tr>
<tr>
<td>Yes (21%)</td>
<td>779</td>
<td>11</td>
<td>4</td>
<td>0.42 (0.23–0.77)</td>
<td>57 (32–79)</td>
</tr>
<tr>
<td>Lipid-lowering medications (27%)¶</td>
<td>165</td>
<td>3</td>
<td>5</td>
<td>0.31 (0.07–1.30)</td>
<td>68 (21–94)</td>
</tr>
<tr>
<td>Antihypertensive medications (84%)¶</td>
<td>699</td>
<td>10</td>
<td>3</td>
<td>0.45 (0.24–0.85)</td>
<td>54 (27–79)</td>
</tr>
<tr>
<td>Age**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;65 years old (71%)</td>
<td>1023</td>
<td>8</td>
<td>4</td>
<td>0.20 (0.10–0.40)</td>
<td>79 (61–90)</td>
</tr>
<tr>
<td>≥65 years old (29%)</td>
<td>1160</td>
<td>23</td>
<td>4</td>
<td>0.52 (0.34–0.79)</td>
<td>47 (27–68)</td>
</tr>
</tbody>
</table>

*Low risk for each lifestyle factor was defined as not currently smoking, BMI <25 kg/m², exercise moderate/vigorous intensity for 30 min/d, diet in the top 40% of AHEI-based diet score distribution, and 5–30 g/d alcohol consumption.
†RRs adjusted for age, family history of myocardial infarction before age of 60, aspirin use, baseline hypercholesterolemia, and baseline hypertension. CI signifies confidence intervals.
‡Population-attributable risk is the proportion of cases within the population that may have been avoided had all men adhered to a low-risk lifestyle, adjusted for age, family history of myocardial infarction before age of 60, aspirin use, baseline hypercholesterolemia, and baseline hypertension. Men with missing values for lifestyle factors were considered to be at high risk.
¶Reported use of lipid-lowering or antihypertensive medication use.
†Percentage of the men reporting use of specific medications among those who reported lipid-lowering or antihypertensive medication use.
**Also adjusted for antihypertensive medication use.

### TABLE 4. Multivariate Relative Risk of CHD According to Changes in Healthy Lifestyle Score*

<table>
<thead>
<tr>
<th>Change in Lifestyle Score†</th>
<th>Frequency, %</th>
<th>No. of Cases</th>
<th>RR (95% CI)†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decrease by ≥2</td>
<td>5</td>
<td>81</td>
<td>1.48 (1.15–1.88)</td>
</tr>
<tr>
<td>Decrease by 1</td>
<td>21</td>
<td>327</td>
<td>1.01 (0.97–1.28)</td>
</tr>
<tr>
<td>No change</td>
<td>52</td>
<td>797</td>
<td>1.00 (ref)</td>
</tr>
<tr>
<td>Increase by 1</td>
<td>17</td>
<td>302</td>
<td>0.91 (0.79–1.05)</td>
</tr>
<tr>
<td>Increase by ≥2</td>
<td>4</td>
<td>76</td>
<td>0.73 (0.57–0.93)</td>
</tr>
</tbody>
</table>

P value for trend <0.0001

*Among men who completed the baseline questionnaire (1986) and at least one follow-up questionnaire (1988–1998); all models are adjusted for total No. of healthy lifestyle factors in 1986, age, family history of MI before age of 60, aspirin use, use of antihypertensive medication, baseline hypercholesterolemia, and baseline hypertension. CI denotes confidence interval.
†Low risk for each lifestyle factor was defined as not currently smoking, BMI <25 kg/m², exercise moderate/vigorous intensity for 30 min/d, diet in the top 40% of AHEI-based diet score distribution, and 5–30 g/d alcohol consumption.
have shown substantial reduction in coronary risk factors as well as coronary events.\textsuperscript{57,48} In our analysis, we estimated the impact of multiple lifestyle factors simultaneously, which would be difficult if not impossible to study in a trial with 16 years of follow-up. The observational design and repeated measures of diet and lifestyle allowed us to assess the consequences of changes in multiple lifestyle factors, which generally occur in free-living populations.

In conclusion, a healthy lifestyle plays an important role in the primary prevention of CHD in middle-aged and older men, even among men on antihypertensive or lipid-lowering medication. A healthy lifestyle can be an effective, nonpharmacological approach to reducing coronary heart disease among men.

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Disclosures

E. Rimm has received honoraria for several academic talks sponsored by the nonprofit arm of industry-related organizations (the Distilled Spirits Council and the National Beer Wholesalers Association). M. McCulloh has received honoraria for articles on diet and cancer in Oncogene and for a lecture on flavonoids and cardiovascular disease given at a cardiovascular conference in Switzerland. The remaining authors report no disclosures.

References

Many healthy lifestyle choices, including eating well, exercising regularly, managing weight, and not smoking, may individually lower the risk of coronary heart disease, but the impact of a combination of healthy choices may provide even greater benefit. We monitored a population of middle-aged and older male health professionals for 16 years to assess the effect of following a low-risk lifestyle (defined as not smoking, exercising daily, eating prudently, consuming alcohol in moderation, and maintaining a healthy weight) on the risk of coronary heart disease. A majority of coronary events in this population of men may have been prevented through better adherence to a low-risk lifestyle. This low-risk lifestyle was also associated with lower risk of coronary heart disease among men taking antihypertensive and lipid-lowering medications. Finally, we found that adopting additional low-risk lifestyle practices over time was associated with lower risk of coronary heart disease. Our results suggest that a low-risk lifestyle may be an effective strategy to lower the risk of coronary heart disease among middle-aged and older men, and even among men already reducing cardiovascular risk by taking antihypertensive and lipid-lowering medications. Furthermore, beneficial changes in lifestyle habits even during middle age or later in life may also lower the risk of coronary disease.
Healthy Lifestyle Factors in the Primary Prevention of Coronary Heart Disease Among Men. Benefits Among Users and Nonusers of Lipid-Lowering and Antihypertensive Medications

Stephanie E. Chiuve, Marjorie L. McCullough, Frank M. Sacks and Eric B. Rimm

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