Association Between a Healthy Heart Score and the Development of Clinical Cardiovascular Risk Factors Among Women

Potential Role for Primordial Prevention

Mercedes Sotos-Prieto, PhD; Josiemer Mattei, PhD, MPH; Frank B. Hu, MD, PhD; Andrea K. Chomistek, ScD, MPH; Eric B. Rimm, ScD; Walter C. Willett, MD, DrPH; A. Heather Eliassen, ScD; Stephanie E. Chiuve, ScD

Background—The prevailing efforts for cardiovascular disease (CVD) prevention focused on treatment of common CVD risk factors rather than primordial prevention of risk factors through health behaviors. The previously validated Healthy Heart Score effectively predicted the 20-year risk of CVD in midadulthood; however, it is unknown whether this risk score is associated with clinically relevant CVD risk factors.

Methods and Results—We analyzed the association between the Healthy Heart Score and the incidence of clinical CVD risk factors, including diabetes mellitus, hypertension, and hypercholesterolemia among 69,505 US women in the Nurses’ Health Study II (NHSII; 1991–2011). The Healthy Heart Score estimates the 20-year CVD risk based on 9 lifestyle factors; thus, a higher score reflected a higher predictive CVD risk. During 20 years, we documented 3275 incident cases of diabetes mellitus, 17,420 of hypertension, and 24,385 of hypercholesterolemia. Women with higher predicted CVD risk based on the Healthy Heart Score (highest quintile versus lowest quintile) had significantly greater risk of each clinical risk factor individually (hazard ratios: 18.1 [95% confidence interval, 14.4–22.7] for diabetes mellitus, 5.10 [4.66–5.57] for hypertension, and 2.57 [2.40–2.75] for hypercholesterolemia). The hazard ratio for developing the high-CVD profile was 52.5 (33.6–82.1). These associations were most pronounced among women who were younger, were nonsmokers, or had optimal weight.

Conclusions—An absolute 20-year risk of CVD, estimated by the Healthy Heart Score, was strongly associated with the development of CVD clinically relevant risk factors. This risk score may serve as the first step for CVD risk assessment in primordial prevention. (Circ Cardiovasc Qual Outcomes. 2016;9:S77-S85. DOI: 10.1161/CIRCOUTCOMES.115.002372.)

Key Words: cardiovascular diseases ■ epidemiology ■ lifestyle ■ prevention and control ■ women

Despite significant reductions in mortality, cardiovascular disease (CVD) remains the leading cause of death in the United States. Clinical risk factors, such as diabetes mellitus, hypertension, and dyslipidemia, are associated with substantial long-term risk of CVD. Current prevention strategies focus on the primary prevention of CVD through the reduction in levels of clinical risk factors, primarily through drug therapy. However, successful pharmacological treatment of clinical risk factors does not eliminate the harmful effects of having developed risk factors entirely and is associated with substantial costs and side effects. Alternatively, primordial prevention of CVD focuses on the prevention of the development of clinical risk factors through healthy lifestyle factors. Nonetheless, the prevalence of these healthy behaviors among US adults remains low.

We recently derived and validated the Healthy Heart Score, a 20-year CVD risk prediction model based on modifiable lifestyle factors in middle-aged adults. Such a tool may help prioritize primordial prevention strategies in clinical and community-based settings; however, whether the Healthy Heart Score is associated with intermediate clinical CVD risk factors is not known. We aimed to quantify the association between the previously derived Healthy Heart Score and incidence of clinical risk factors, including diabetes mellitus, hypertension, and hypercholesterolemia, among women in the Nurses’ Health Study II (NHSII).
WHAT IS KNOWN

• The prevention of risk factor development through healthy lifestyle factors or primordial prevention is of paramount importance to minimize the long-term risk of cardiovascular disease (CVD). However, the prevalence of these healthy behaviors among US adults remains low.

• The Healthy Heart Score, a 20-year CVD risk prediction model based on modifiable lifestyle factors, effectively predicted the 20-year risk of CVD in midadulthood, but whether this risk score is associated with clinically relevant CVD risk factors is unknown.

WHAT THE STUDY ADDS

• A higher predicted CVD risk, estimated by the Healthy Heart Score, was associated with a greater risk of developing clinical risk factors.

• The Healthy Heart Score is a patient-oriented, scientifically derived lifestyle-based prediction model that may eventually serve as the first step for risk assessment and a catalyst for communication between patients and clinicians in the primordial prevention setting.

Methods

Study Population

The NHSII was established in 1989 when 116,430 registered nurses aged 25 to 42 years responded to a self-administered questionnaire about detailed medical history, lifestyle, and other health information. Participants first completed a validated semiquantitative food frequency questionnaire to assess dietary intake in 1991, which served as the baseline for the current investigation. We send follow-up questionnaires biennially to update participant information on potential risk factors and to identify newly diagnosed diseases.

We excluded women who had invalid dietary data (>70 food items blank or reported energy intake <600 kcal per day or >3,500 kcal per day) or who were missing information on alcohol, physical activity, body mass index (BMI), or smoking in 1991. In addition, we excluded women who had CVD, cancer, diabetes mellitus, hypertension, or hypercholesterolemia at baseline, leaving 69,505 women available for the current analysis. The Institutional Review Board at Brigham and Women’s Hospital approved the study protocol and return of the questionnaire implied informed consent.

Assessment of Healthy Lifestyle

The Healthy Heart Score is a CVD risk prediction model that estimates the 20-year risk of CVD based on lifestyle factors and was developed separately within 2 cohorts of men (the Health Professional Follow-Up Study [HPFS]) and women (the Nurses’ Health Study [NHS]) free of CVD, diabetes mellitus, and cancer at baseline. The score demonstrated good discrimination, fit, and calibration. We applied the Healthy Heart Score derived in the NHS to this new cohort of younger female nurses. Although numerous lifestyle predictors of CVD were considered, the final parsimonious model included the 9 most critical factors that best estimated CVD risk: current smoking, higher BMI, low physical activity, lack of moderate alcohol consumption, low intakes of fruits, vegetables, cereal fiber, and nuts, and high intakes of sugar-sweetened beverages and red and processed meats (Figure 1). Higher Healthy Heart Scores reflected a higher risk of CVD.

Smoking status was self-reported and categorized as never, past, or current. BMI (kg/m²) was calculated from self-reported height and weight, which was highly correlated with directly measured weight previously (r=0.96). For physical activity, we used a previously validated physical activity questionnaire to estimate the average hours per week spent in moderate or vigorous intensity activity (2.3 metabolic equivalent tasks). For each food item, participants were asked how often, on average, a specified portion was consumed during the past year. Cereal fiber and alcohol intake were calculated by multiplying the nutrient content of each food item (from the Harvard University Food Composition Database) by the frequency of intake and summed across all food items. We used the residual method to adjust cereal fiber for total energy. We calculated the average of alcohol intake (gram per day), assuming 12.8 g of alcohol in 12 oz of beer, 11.0 g of alcohol in 4 oz of wine, and 14.0 g of alcohol in 1.5 oz of liquor. Every two years, we updated information on smoking status, weight, and physical activity. Diet was updated every 4 years. Data on parental history of myocardial infarction, aspirin use, menopausal status, postmenopausal hormone use, parity, and oral contraceptive use were assessed on biennial self-reported questionnaires.

Assessment of Clinical Risk Factors

The outcomes for this study included 3 health factors included in the American Heart Association’s definition of cardiovascular health: type 2 diabetes mellitus, hypertension, and hypercholesterolemia. Self-reported type 2 diabetes mellitus was confirmed by a validated supplemental questionnaire using the National Diabetes Data Group criteria for cases identified before 1998 and the American Diabetes Association criteria for cases identified after 1998. In a previous validation study, 98% of self-reported cases were confirmed by medical records. Participants self-reported physician-diagnosed hypertension and hypercholesterolemia. We defined incident hypertension and hypercholesterolemia as the first report of either the physician diagnosis of the risk factor or the reported use of medication for lowering blood pressure or cholesterol, respectively. In validation studies, 94% of self-reported cases of hypertension and 86% of self-reported cases of hypercholesterolemia were confirmed by medical records.

The calendar year of diagnosis was recorded and used to estimate a time-to-event month assignment for the purposes of survival analysis based on the month of questionnaire return. We defined a high-CVD risk profile as the diagnosis of all 3 clinical risk factors.

We conducted sensitivity analyses with alternative case definitions for hypercholesterolemia and hypertension to test the robustness of the association. First, we defined hypertension and hypercholesterolemia based on self-reported physician diagnosis only without considering medication use. Second, we restricted the cases of incident

![Figure 1. Formula to estimate the 20-year risk of cardiovascular disease (CVD) based on lifestyle predictors in women. BMI indicates body mass index.](https://circoutcomes.ahajournals.org/content/10/2/S78.full)
We conducted a test for linear trend across quintiles of the Healthy Heart Score by assigning the median value to each quintile and modeling this as a continuous variable. We examined potential deviation from linearity with a likelihood ratio test, comparing a model with the linear term plus a model including the linear term plus restricted cubic spline transformations.23 For this analysis, we excluded women with a Healthy Heart Score above the 99th percentile and below the first percentile (2.3% of total person-years) to make the estimates more stable and meaningful.

We tested for effect modification by age (<45 versus ≥45 years), smoking status (not current versus current), and BMI (<25 versus ≥25 kg/m²). For each potential modifier, we created a cross-product term between the modifier and the quintiles of the Healthy Heart Score. We used the quintile cut points established in the entire population to maintain consistency in the distribution of the score between different categories of the effect modifiers. We used likelihood ratio tests to compare models with and without the cross-product terms to test formally for an interaction. All analyses were performed using SAS statistical software, version 9.3 (SAS Institute Inc, Cary, NC).

### Results

During 20 years, we documented 3275 cases of diabetes mellitus, 17,420 of hypertension, and 24,385 of hypercholesterolemia. In total, 32,505 women were diagnosed with ≥1 clinical risk factor, 2794 women had ≥2 risk factors, and 1641 women had the high-CVD risk profile. In this population of women (mean age, 36±4.7 years), the mean 20-year risk of CVD at baseline, estimated by the Healthy Heart Score, was 0.83% (10th percentile, 0.28%; 90th percentile, 1.56%). Women with

### Table 1. Age-Adjusted Baseline Characteristics According to Quintiles of the Healthy Heart Score

<table>
<thead>
<tr>
<th>Predictive 20-y Risk of CVD (%) Based on the Healthy Heart Score*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
</tr>
<tr>
<td>-------------------------------------</td>
</tr>
<tr>
<td>Healthy Heart Score (20-y risk)†‡</td>
</tr>
<tr>
<td>No. of participants‡</td>
</tr>
<tr>
<td>Age, y</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
</tr>
<tr>
<td>Current smoker, %</td>
</tr>
<tr>
<td>Diet score (points)</td>
</tr>
<tr>
<td>Alcohol intake, g/d</td>
</tr>
<tr>
<td>Physical activity, MET-h/wk</td>
</tr>
<tr>
<td>Parental history of MI before 65 y, %</td>
</tr>
<tr>
<td>Postmenopausal status, %</td>
</tr>
<tr>
<td>Postmenopausal hormone use</td>
</tr>
<tr>
<td>Never users</td>
</tr>
<tr>
<td>Past users</td>
</tr>
<tr>
<td>Current users</td>
</tr>
<tr>
<td>Missing</td>
</tr>
<tr>
<td>Past oral contraceptive, %</td>
</tr>
<tr>
<td>Current oral contraceptive, %</td>
</tr>
<tr>
<td>Parity</td>
</tr>
<tr>
<td>Aspirin use (yes), %</td>
</tr>
</tbody>
</table>

BMl indicates body mass index; CVD, cardiovascular disease; MET, metabolic equivalent task; and MI, myocardial infarction.

*Continuous variables are presented as mean (SD) and categorical values as %.
†The formula to estimate the 20-year risk of CVD based on lifestyle predictors derived including smoking, BMI, physical activity, alcohol, and a composite diet score (fruit and vegetables, sugar-sweetened beverages, red/processed meats, and cereal fiber, nuts; Figure 1).
‡The quintiles were determined by the distribution of the Healthy Heart Score across the total person-time of the study.
a higher predicted CVD risk were more likely to be older, have a higher BMI, be a current smoker, have a family history of myocardial infarction, and use aspirin. In addition, women with a higher predicted CVD risk were less physical active and had a lower alcohol intake and diet score (Table 1).

A higher Healthy Heart Score was significantly associated with each clinical risk factor, and this score was associated most strongly with the risk of diabetes mellitus (Table 2). In multivariable models, women in the highest compared with those in the lowest quintile of the Healthy Heart Score had an HR of 18.1 (95% CI, 14.4–22.7) for diabetes mellitus, 5.10 (95% CI, 4.66–5.57) for hypertension, and 2.57 (95% CI, 2.40–2.75) for hypercholesterolemia (Table 2). Further adjustment for variables that may affect socioeconomic status did not appreciably alter the results (data not shown). For a 2% increment in the Healthy Heart Score, the HR was: 13.80 (95% CI, 11.51–16.54) for diabetes mellitus, 4.38 (95% CI, 4.04–4.74) for hypertension, and 2.40 (95% CI, 2.25–2.56) for hypercholesterolemia. The associations were not appreciably altered when we defined hypertension and hypercholesterolemia based only on self-reported physician diagnosis or when we restricted the cases of incident hypertension and hypercholesterolemia to women also reporting medication use (data not shown).

There was a strong, linear association between the Healthy Heart Score and the risk of the high-CVD risk profile ($P$ linear trend < 0.001; Figure 2). The HR for the high-CVD risk profile was 52.5 (95% CI, 33.6–82.1) comparing women in the highest with those in the lowest quintile of the Healthy Heart Score (Table 3). In addition, for a 2% increment in the predicted CVD risk based on the Healthy Heart Score, the HR was 1.51 (95% CI, 1.46–1.55) for developing ≥1 risk factor, 5.33 (95% CI, ≥2 risk factors, and 6.01 (95% CI, ≥3 risk factors).

### Table 2. Hazard Ratios (95% Confidence Interval) of the Clinical Risk Factors (Diabetes Mellitus, Hypertension, and Hypercholesterolemia) According to Quintiles of the Healthy Heart Score

<table>
<thead>
<tr>
<th>Clinical Risk Factors</th>
<th>Predictive 20-y Risk of CVD (%) Based on the Healthy Heart Score</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q5</th>
<th>$P$ Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diabetes mellitus</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median Healthy Heart Score (20-y risk)*</td>
<td>0.42</td>
<td>0.74</td>
<td>1.13</td>
<td>1.77</td>
<td>3.37</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>Cases</td>
<td>141</td>
<td>277</td>
<td>391</td>
<td>714</td>
<td>1752</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>Person-years</td>
<td>243,373</td>
<td>241,775</td>
<td>240,486</td>
<td>238,424</td>
<td>234,330</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>1 (reference)</td>
<td>2.30 (1.84–2.87)</td>
<td>4.00 (3.19–5.02)</td>
<td>8.46 (6.76–10.6)</td>
<td>25.1 (20.0–31.5)</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Model 2</td>
<td>1 (reference)</td>
<td>2.38 (1.90–2.97)</td>
<td>4.15 (3.31–5.20)</td>
<td>8.73 (6.98–10.9)</td>
<td>25.2 (20.1–31.7)</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Model 3</td>
<td>1 (reference)</td>
<td>2.26 (1.81–2.82)</td>
<td>3.71 (2.96–4.64)</td>
<td>7.26 (5.80–9.09)</td>
<td>18.1 (14.4–22.7)</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td><strong>Hypertension</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median Healthy Heart Score (20-y risk)*</td>
<td>0.40</td>
<td>0.70</td>
<td>1.06</td>
<td>1.62</td>
<td>3.02</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>Cases</td>
<td>1182</td>
<td>2191</td>
<td>3187</td>
<td>4613</td>
<td>6247</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>Person-years</td>
<td>219,229</td>
<td>216,967</td>
<td>214,992</td>
<td>212,239</td>
<td>208,080</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>1 (reference)</td>
<td>1.61 (1.48–1.75)</td>
<td>2.34 (2.15–2.54)</td>
<td>3.47 (3.19–3.78)</td>
<td>5.54 (5.08–6.06)</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Model 2</td>
<td>1 (reference)</td>
<td>1.61 (1.48–1.75)</td>
<td>2.34 (2.15–2.55)</td>
<td>3.47 (3.18–3.78)</td>
<td>5.52 (5.05–6.04)</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Model 3</td>
<td>1 (reference)</td>
<td>1.59 (1.46–1.73)</td>
<td>2.28 (2.09–2.48)</td>
<td>3.31 (3.03–3.60)</td>
<td>5.10 (4.66–5.57)</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td><strong>Hypercholesterolemia</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median Healthy Heart Score (20-y risk)*</td>
<td>0.39</td>
<td>0.68</td>
<td>1.02</td>
<td>1.56</td>
<td>2.93</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>Cases</td>
<td>2435</td>
<td>3462</td>
<td>4664</td>
<td>6081</td>
<td>7743</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>Person-years</td>
<td>201,696</td>
<td>199,607</td>
<td>197,529</td>
<td>195,070</td>
<td>191,326</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>1 (reference)</td>
<td>1.43 (1.35–1.52)</td>
<td>1.88 (1.76–2.00)</td>
<td>2.33 (2.19–2.49)</td>
<td>2.98 (2.78–3.18)</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Model 2</td>
<td>1 (reference)</td>
<td>1.41 (1.33–1.50)</td>
<td>1.83 (1.72–1.95)</td>
<td>2.24 (2.10–2.39)</td>
<td>2.79 (2.61–2.98)</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Model 3</td>
<td>1 (reference)</td>
<td>1.40 (1.32–1.48)</td>
<td>1.80 (1.69–1.92)</td>
<td>2.17 (2.03–2.31)</td>
<td>2.57 (2.40–2.75)</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
</tbody>
</table>

Model 1: adjusted for age. Model 2: model 1 + parental history of myocardial infarction before 60 y of age, aspirin use, menopausal status, postmenopausal hormone use, parity, and oral contraceptive use. Model 3: model 2 + adjusted by the other clinical risk factors, respectively (ie, model 3 with diabetes mellitus as outcome is further adjusted for hypertension and hypercholesterolemia). CVD indicates cardiovascular disease.

*The formula to estimate the 20-year risk of CVD based on lifestyle predictors derived including smoking, body mass index, physical activity, alcohol, and a composite diet score (fruit and vegetables, sugar-sweetened beverages, red/processed meats, cereal fiber, and nuts; Figure 1).
who were <45 years old, were nonsmokers, and had a BMI of <25 kg/m² (P interaction<0.001; Table 4).

Discussion

In this large prospective cohort of middle-age women, a higher predicted CVD risk, estimated by the Healthy Heart Score, was associated with a greater risk of developing clinical risk factors. Specifically, women with a higher predictive CVD risk had an 18-fold higher risk of type 2 diabetes mellitus, 5-fold higher risk of hypertension, and 3-fold higher risk of hypercholesterolemia during 20 years. Furthermore, a higher predictive CVD risk was associated with a 53-fold greater risk of developing a high-CVD risk profile, and this association was most pronounced among women who were younger, did not smoke, and had optimal weight.

Clinical risk factors during early and midadulthood are associated with an elevated long-term risk of CVD.2,3,24 Conversely, the maintenance of a low-risk profile, defined as blood glucose levels <120 mg/dL, untreated blood pressure <120/80 mm Hg, and untreated cholesterol <200 mg/dL, is associated with substantially lower risk of CVD.24–26 Adults aged 55 years with the low-risk profile have a lifetime risk of CVD of 5% to 8%.24,25 In contrast, adults who develop ≥2 risk factors have a lifetime risk of 29% to 50%.4,25 Furthermore, adults with the low-risk profile live free of CVD 14 years longer than individuals with ≥2 risk factors.26 Yet, the prevalence of optimal risk factor status is low. Among US adults aged >50 years, 38% have ideal levels of fasting glucose, 20% have ideal blood pressure, and 25% have ideal levels of total cholesterol.1,27 It has been posited that treating clinical risk factors is not equivalent to avoiding them because even with optimal treatment, the risk of CVD remains elevated.5,7,27,28 Thus, primordial prevention strategies are needed to prevent the development of CVD risk factors and eventual CVD.
Higher predicted CVD risk based on the Healthy Heart Score was strongly associated with the risk of type 2 diabetes mellitus, in particular. The findings in this study are consistent with previous studies that found that >90% of diabetes mellitus cases, compared with 57% of hypertension and 40% of hypercholesterolemia cases, may be attributed to poor lifestyle factors. Furthermore, several components of the Healthy Heart Score, such as sugar-sweetened beverages, red meats, and BMI, are extremely strong risk factors for diabetes mellitus. In fact, excess adiposity is the single most important lifestyle determinant of type 2 diabetes mellitus. In previous studies, 60% to 85% of cases of diabetes mellitus may be attributed to overweight (BMI≥25) in women. Furthermore, the magnitude of association between the Healthy Heart Score and the risk of diabetes mellitus was attenuated when we did not adjust for age in our multivariable models, suggesting that the lifestyle factor components in the score were more strongly associated with diabetes mellitus risk than age. In contrast, the association between the score and the risk of hypertension and hypercholesterolemia was similar when age was included and not included as a covariate in the multivariable model.

The Healthy Heart Score was most strongly associated with a higher CVD risk profile among women who were younger, were nonsmokers, and were at a healthy weight. In other words, even among women who may be considered low risk because they do not smoke or are at a healthy weight, other lifestyle factors that contribute to the Healthy Heart Score play an important role in the development of clinical CVD risk factors. These results highlight the need for educational strategies on CVD prevention that address many lifestyle factors simultaneously and further support the benefits of healthy lifestyle behaviors initiated in adolescence and young adulthood.

The Healthy Heart Score is a unique, scientifically derived lifestyle-based prediction model with important clinical and public health relevance. First, the Healthy Heart Score may identify individuals who are likely to develop clinical risk factors and ultimately CVD because of poor lifestyle habits but who would not be classified at high risk by existing primary prevention risk models. Second, many existing CVD prediction tools are based on clinical risk factors and ultimately CVD because of poor lifestyle habits but who would not be classified at high risk by existing primary prevention risk models. Third, physicians have limited time to assess lifestyle factors even among patients who would be classified as low risk by the Framingham Risk Score. The Healthy Heart Score may be a practical tool that can initiate the communication about primordial prevention among patients and clinicians and can complement existing primary prevention models. A predictive model that includes lifestyle measures without the need for clinical measurements...
may be useful beyond the clinical setting, such as workplace wellness programs or community-based health fairs.

BMI is a component of the Healthy Heart Score although BMI is not a true lifestyle behavior and is determined, in part, by other factors in the score. The magnitude of association between the Healthy Heart Score and the clinical risk factors was the greatest among women with a BMI of <25 kg/m². Notably, the Healthy Heart Score was also significantly associated with risk among women with elevated BMI. In previous studies, healthy lifestyle factors were associated with a lower risk of coronary heart disease among both obese and nonobese individuals.41 The findings from this study provide further support for the importance of weight control for the prevention of clinical risk factors even among individuals who maintain other behaviors.

This population is well suited to explore the Healthy Heart Score because its prospective design, large sample size of women free of clinical risk factors, long follow-up, and repeated dietary and lifestyle measurements. However, there are also limitations. First, the Healthy Heart Score prediction model includes key dietary and lifestyle factors associated with CVD. However, there are numerous emerging lifestyle factors
of CVD that are not included, such as sleep, and other dietary components. The Healthy Heart Score was created as a parsimonious, rather than comprehensive, model for CVD risk prediction given that time is already limited in the clinical setting. We focused on lifestyle factors that are modifiable on an individual level although an individual’s ability to choose a healthy lifestyle is facilitated and influenced by the built environment, social network, and public health policies that can influence the accessibility to healthy lifestyle options. Second, although some measurement error in self-reported lifestyle variables is inevitable, the data are collected prospectively. Therefore, this error is likely nondifferential with respect to the risk factors and would underestimate the true relative risk. We relied on self-reported diagnosis of hypertension and hypercholesterolemia rather than directly measured clinical factors. Among healthcare professionals, reporting of these risk factors is fairly reliable, but we cannot rule out the potential for misclassification. The generalizability of our results from a population of predominantly white, well-educated nurses to men, and individuals of diverse racial/ethnic or socioeconomic compositions is limited. Finally, although we adjusted for many confounders in our analysis, residual confounding remains a potential source of bias.

Conclusions

In this large population of middle-aged women free of clinical risk factors, the predicted CVD risk estimated by the Healthy Heart Score, a lifestyle-based prediction model, was strongly associated with the development of CVD clinical risk factors. Additional research that evaluates the use of this scientifically derived tool as a primordial prevention strategy in the clinical or community-based setting is warranted.

Acknowledgments

M. Sotos-Prieto formulated the study question and design, performed the statistical analyses, interpreted the results, and drafted the article. S. E. Chiuve contributed to the development of the study question, statistical modeling, and drafting of the article. J. Mattei, F.B. Hu, A.K. Shay, M. Sotos-Prieto, and S.E. Chiuve shared primary responsibility for the final content. All authors contributed to the interpretation of data and critical revision of the article and approved the final version. M.S. Sotos-Prieto and S.E. Chiuve shared primary responsibility for the final content.

Sources of Funding

The Nurses’ Health Study II (NHSII) was supported by research grants UM1 CA176726 from the National Institutes of Health.

Disclosures

Dr Sotos-Prieto was supported by a research fellowship from Fundación Alfonso Martín Escudero, Spain. Dr. Chiuve was supported by National Institutes of Health grant HL07068, and Dr Hu was supported by National Institutes of Health grant HL06712. The other authors report no conflicts.

References


Sotos-Prieto et al

Healthy Heart Score and Clinical Risk Factors


Association Between a Healthy Heart Score and the Development of Clinical Cardiovascular Risk Factors Among Women: Potential Role for Primordial Prevention

Circ Cardiovasc Qual Outcomes. 2016;9:S77-S85
doi: 10.1161/CIRCOUTCOMES.115.002372
Circulation: Cardiovascular Quality and Outcomes is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2016 American Heart Association, Inc. All rights reserved.
Print ISSN: 1941-7705. Online ISSN: 1941-7713

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circoutcomes.ahajournals.org/content/9/2_suppl_1/S77

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation: Cardiovascular Quality and Outcomes can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation: Cardiovascular Quality and Outcomes is online at:
http://circoutcomes.ahajournals.org/subscriptions/