Ideal Cardiovascular Health Is Inversely Associated With Incident Cancer
The Atherosclerosis Risk in Communities Study

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Background—The American Heart Association (AHA) has defined the concept of ideal cardiovascular health in promotion of the 2020 Strategic Impact Goals. We examined whether adherence to ideal levels of the 7 AHA cardiovascular health metrics was associated with incident cancers in the Atherosclerosis Risk In Communities (ARIC) study over 17 to 19 years of follow-up.

Methods and Results—After exclusions for missing data and prevalent cancer, 13,253 ARIC participants were included for analysis. Baseline measurements were used to classify participants according to 7 AHA cardiovascular health metrics. Combined cancer incidence (excluding nonmelanoma skin cancers) from 1987 to 2006 was captured using cancer registries and hospital surveillance; 2880 incident cancer cases occurred over follow-up. Cox regression was used to calculate hazard ratios for incident cancer. There was a significant (P trend <0.0001), graded, inverse association between the number of ideal cardiovascular health metrics at baseline and cancer incidence. Participants meeting goals for 6 to 7 ideal health metrics (2.7% of the population) had 51% lower risk of incident cancer than those meeting goals for 0 ideal health metrics. When smoking was removed from the sum of ideal health metrics, the association was attenuated with participants meeting goals for 5 to 6 health metrics having 25% lower cancer risk than those meeting goals for 0 ideal health metrics (P trend =0.03).

Conclusions—Adherence to the 7 ideal health metrics defined in the AHA 2020 goals is associated with lower cancer incidence. The AHA should continue to pursue partnerships with cancer advocacy groups to achieve reductions in chronic disease prevalence. (Circulation. 2013;127:1270-1275.)

Key Words: cardiology ■ health ■ neoplasms ■ prevention and control

In 2010 the American Heart Association (AHA) announced the following strategic impact goal: "By 2020, to improve the cardiovascular health of all Americans by 20% while reducing death from cardiovascular diseases and stroke by 20%."1 To accomplish this goal, the concept of ideal cardiovascular health was defined according to 7 health behaviors or factors, which include smoking, physical activity, obesity, dietary intake, total cholesterol, blood pressure, and blood sugar. The idea of working to attain the ideal goals for these 7 health factors and behaviors is now being promoted through the use of the My Life Check online health assessment tool and the Life’s Simple Seven health campaign from the AHA and American Stroke Association. After the announcement of these goals, research in a variety of populations has demonstrated that meeting the goals for a higher number of ideal health metrics is associated with more favorable health outcomes. In the Atherosclerosis Risk In Communities (ARIC) study, there was a strong inverse relationship between the number of ideal health metrics met at baseline (when participants were aged 45–64 years) and incident cardiovascular disease (CVD) over 20 years of follow-up.2 The Cardiovascular Risk in Young Finns Study demonstrated that the number of ideal cardiovascular health metrics present in childhood predicts subsequent cardiometabolic health in adulthood.3 Finally, analyses of the National Health and Nutrition Examination Survey demonstrated that the number of ideal metrics met was significantly and inversely related to mortality from...
all causes and mortality from diseases of the circulatory system.4

Although the health metrics identified by the AHA Strategic Planning Task Force and Statistics Committee were selected primarily because of their strong associations with CVD,1 many of the metrics, such as diet,3-7 physical activity,8-11 body mass index (BMI),12-14 and smoking,15-17 are also established risk factors for many types of cancer. Because of these shared risk associations, we investigated whether the number of achieved ideal cardiovascular metrics (as defined by the AHA) is also significantly inversely associated with incident cancer. We chose to pursue this analysis in the ARIC Study, which has information on both incident cancer and cardiovascular disease in a large population-based, biracial, geographically diverse cohort, to facilitate informal comparisons between the association of ideal cardiovascular health metrics with incident CVD and cancer.

Methods

The ARIC study is a multicenter prospective study originally conceived to investigate cardiovascular disease.18 White and black men and women aged 45 to 64 years were recruited in 1987 to 1989 from 4 communities: Forsyth County, North Carolina; Jackson, Mississippi; suburban areas of Minneapolis, Minnesota; and Washington County, Maryland. A total of 15792 subjects participated in the baseline examination. Three triennial follow-up examinations were performed. The institutional review board at each field center approved the study, and all participants gave informed consent, which included consent for follow-up disease occurrence.

Of the 15792 ARIC participants, we excluded anyone lacking any one of the measurements necessary to classify the participant on all seven ideal health metrics (n=1536). Additionally, we excluded anyone who did not give permission for their data to be used in noncardiovascular disease research (n=11), and participants who self-reported a race other than white or black (n=42). Participants were queried about their history of cancer at baseline, and participants who reported a personal history of cancer at baseline were excluded (n=950), resulting in a final sample size of 13253.

Exposure Measurements

Home interviews and medical examinations were conducted at each study visit. Baseline exposure information was used to classify all participants on 7 ideal cardiovascular health metrics outlined in the AHA 2020 goals1 (please see a complete description of the 7 ideal cardiovascular health metrics in Table 2 of the AHA 2010 Scientific Statement “Defining and Setting National Goals of the 7 ideal cardiovascular health metrics in Table 2 of the AHA 2010 Scientific Statement “Defining and Setting National Goals for Cardiovascular Health Promotion and Disease Reduction: The American Heart Association’s Strategic Impact Goal Through 2020 and Beyond” available at http://my.americanheart.org/professional/StatementsGuidelines/ByPublicationDate/PreviousYears/2010-Publications_UCM_322319_Article.jsp). We refer to these simply as ideal health metrics. Per the AHA 2020 report, 4 ideal health metrics (never smoking or quitting >12 months ago; BMI <25 kg/m²; having 4-5 components of a healthy diet score; and having ≥75 minutes/week of vigorous physical activity [or 150 minutes/week of moderate or moderate + vigorous activity]) were identified as ideal health behaviors, and 3 ideal health metrics (having untreated total cholesterol <200 mg/dL, having untreated blood pressure <120 mmHg systolic and 80 mmHg diastolic, and having untreated fasting serum glucose <100 mg/dL) were identified as ideal health factors. Specific methods to classify ARIC participants according to the 7 ideal health metrics have been described in-depth previously, and every effort was made to use identical classifications for this analysis.2 Briefly, diet was assessed by a slightly modified 66-item Harvard food frequency questionnaire3 (modified for application in a biracial cohort)20 and then categorized based on achievement of the 5 AHA ideal cardiovascular health diet components. Physical activity was reported with the Baecke questionnaire,21 and smoking status was derived from interviews. Use of antihypertensive, cholesterol-lowering, and glucose-lowering medications within the past 2 weeks of baseline interview were self-reported or taken from prescription bottles. Fasting plasma total cholesterol was measured by enzymatic methods. Serum fasting glucose was measured by a hexokinase/glucose-6-phosphate dehydrogenase method. Sitting blood pressure was measured 3 times using a random-zero sphygmomanometer, and the average of the 2nd and 3rd measurements used for analysis. BMI (kg/m²) was computed from weight while wearing a scrub suit and standing height.

Ascertainment of Incident Cancer

The ascertainment of incident cancer cases in ARIC has been described previously.22 Incident cancer cases from 1987 to 2006 were obtained by linking to cancer registries. ARIC hospital surveillance was used to identify additional cancer cases. For participants who had hospital ICD codes for cancer but were not in cancer registries, including those who may have moved, records of hospitalized events were obtained on a yearly basis. Primary site and date of cancer diagnosis were obtained. For analysis, we combined all incident cancer cases, except for cases of nonmelanoma skin cancer. We conducted secondary analyses on female breast, colorectal, prostate, and lung cancer, because these are the 4 most common types of incident non-skin cancer observed both in the ARIC cohort and the United States population. If a participant had >1 type of incident cancer during follow-up, the earliest date of cancer incidence was chosen for analysis of the combined end point.

Statistical Methods

All statistical analyses were performed in SAS, version 9.2. If a participant was classified as having a given ideal health metric at baseline, the participant was coded as 1 for this metric (others were coded as 0). The total number of ideal health metrics was summed for each individual, resulting in a score of 0 (having no ideal health metrics at baseline) to 7 (having all 7 ideal health metrics at baseline). Because so few ARIC participants had all 7 ideal health metrics, participants having 6 or 7 ideal health metrics (a score of 6 or 7) were grouped together for analysis. Poisson regression was used to calculate age, sex, race, and ARIC center adjusted rates (and 95% confidence intervals) for combined cancer incidence. Adjusted hazard ratios for combined cancer incidence by ideal health metrics were calculated using Cox proportional hazards models. Individuals who died or were lost to follow-up were censored in Poisson and Cox analyses. Tests of trend for hazard ratios across ideal health metrics were performed by including the ordinal ideal health metric variable modeled as a continuous variable in Cox models. We tested the proportional hazard assumption for the association of ideal health metrics with incident cancer using an interaction of the ideal health variable with follow-up time and found the assumption was not violated (P=0.59). Survival functions by number of ideal health metrics were calculated using the life-table method in PROC LIFETEST. Secondary analyses were performed examining associations of ideal health metrics with types of incident cancer individually.

Results

Table 1 presents the characteristics of the 13253 ARIC participants reporting no history of cancer at baseline, by sex. The proportions of participants (both sexes combined) who had ideal levels of individual health metrics were very similar to the proportions reported previously in the 12744 ARIC participants free of cardiovascular disease at baseline:2 71.5% had ideal levels of (not) smoking, 33.2% had ideal levels of BMI, 36.9% had ideal levels of total cholesterol, 5.3% had ideal diet, 37.9% had ideal levels of physical activity, 51.8% had ideal levels of blood sugar, and 41.6%
had ideal levels of blood pressure. When the total number of ideal metrics was summed, most individuals had 2 or 3 ideal health metrics, with only 16 individuals (0.1%) having all 7 ideal health metrics.

Over the 17 to 19 years of follow-up for which cancer outcomes were available, 2880 ARIC participants developed incident cancer. There were 418 incident lung cancer cases, 322 incident colorectal cancer cases, 613 incident prostate cancer cases, and 526 incident female breast cancer cases. Table I in the online-only Data Supplement presents the number of incident cancers 1989 to 2006 by demographic subgroups. Table 2 presents the adjusted incidence rates and hazard ratios for combined cancer according to the number of ideal health metrics. There was an inverse, graded combined cancer incidence rate in relation to a larger number of ideal health metrics; participants with 3 ideal health metrics had 25% lower risk of incident cancer than those with 0 ideal health metrics. The trend test for number of ideal health factors, the hazard ratio for combined cancer incidence in individuals with 3 to 4 ideal health metrics was examined with prostate cancer, a modest but significant trend of higher cancer incidence with larger number of ideal health metrics was observed for breast cancer (P trend <0.0001), lung cancer (P trend <0.0001), and colorectal cancer (P trend =0.0092). When the association of all 7 ideal health metrics was examined with prostate cancer, a modest but significant trend of higher cancer incidence with larger number of ideal health metrics was observed (P trend =0.02).

Figure 2 displays adjusted hazard ratios for combined cancer incidence by both number of ideal health behaviors (diet, smoking, physical activity and BMI) and factors (blood pressure, blood sugar, and total cholesterol) with individuals having 0 ideal health factors and 0 ideal health behaviors being the referent group. A pattern of lower cancer incidence is generally observed across higher numbers of ideal health behaviors, whereas no consistent pattern in cancer incidence was observed across number of ideal health factors. In all categories of ideal health factors, the hazard ratio for combined cancer incidence in individuals with 3 to 4 ideal health behaviors compared with those with 0 ideal health behaviors was significantly less than 1. Participants with 3 ideal health factors and 3 to 4 ideal health behaviors had 52% lower risk of incident cancer than those with 0 ideal health factors and 0 ideal health behaviors.

Discussion

In this prospective study, there was a significant, graded, inverse association between the number of ideal cardiovascular health metrics.
health metrics (as defined by the AHA) during middle age and combined cancer incidence (excluding nonmelanoma skin cancers) over nearly 20 years of follow-up. This result is consistent with other analyses that have demonstrated a significant association between adherence to lifestyle guidelines similar to the behaviors endorsed by the AHA and lower incidence of cancer, such as an analysis in the Iowa Women’s Health Study Cohort which showed a negative association between adherence to American Institute for Cancer Research guidelines and cancer incidence and mortality.\textsuperscript{23} Our objective was not to determine whether this association is entirely independent of other known cancer risk factors, and thus we did not attempt to control for confounding with extensive adjustment. Instead, we sought simply to demonstrate that adherence to ideal cardiovascular health, as proposed by the American Heart Association, is associated with a lower incidence of cancer.

A previous article from the ARIC study demonstrated a strong and graded association between the number of ideal health metrics at baseline and incident CVD over 20 years of follow-up.\textsuperscript{2} The association of ideal health metrics with incident CVD is stronger than that for incident combined cancer (for example, the HR for CVD comparing individuals with 5 ideal metrics at baseline with those with 0 was 0.18,\textsuperscript{2} the same HR for combined cancer was 0.61). However, the association of incident combined cancer with ideal health metrics was strongly significant, and having ≥6 ideal health metrics was associated with a substantial (ie, 51%) reduction in cancer risk.

To address the concern that the observed association was solely attributable to one component of ideal cardiovascular health (smoking) or one type of cancer (lung), we conducted additional analyses removing smoking from the score of ideal health metrics and repeated our analyses for the 4 most common incident cancers individually. The test of trend for the association of ideal health metrics with incident cancer was attenuated after smoking was removed from the score, but the association remained statistically significant; Figure I in the online-only Data Supplement demonstrates the survival curves for those with ≥4 ideal health metrics (representing ≈15% of the sample) diverging from curves for those with

![Figure 1](image1.png)  
**Figure 1.** Survival curves for combined cancer incidence by total number of ideal health metrics, Atherosclerosis Risk in Communities Study (ARIC), 1987 to 2006.

![Figure 2](image2.png)  
**Figure 2.** Hazard ratios\textsuperscript{*} of combined cancer according to the number of ideal health behaviors and ideal health factors, Atherosclerosis Risk in Communities Study (ARIC), 1987 to 2006. \textsuperscript{*All hazard ratios are adjusted for age, sex, race, and ARIC study center. The referent category (farthest left) is participants having 0 ideal health factors (blood pressure, blood sugar, and total cholesterol) and 0 ideal health behaviors (diet, smoking, physical activity, and body mass index) at baseline. Across all categories of ideal health factors, the hazard ratio for combined cancer incidence in individuals with 3 to 4 ideal health behaviors compared with those with 0 ideal health behaviors was significantly <1.}
fewer baseline ideal health metrics. In addition to lung cancer, there was a significant inverse relationship between number of ideal health metrics and colorectal cancer, and the association with breast cancer was also approaching statistical significance ($P=0.11$). Nonetheless, it appears that ideal levels of smoking are responsible for driving a large portion of the negative association between ideal cardiovascular health and cancer incidence. Also, once smoking is removed from the score, only a small percentage of the sample was achieving the number of healthy behaviors or factors (4–6) that might notably reduce their risk of cancer.

We were surprised to observe a modest but significant trend of higher prostate cancer incidence with larger number of ideal health metrics. We hypothesize this association might be driven by the inclusion of smoking in the ideal health metrics score because, in a previous cohort study including >250,000 men, smoking was inversely associated with nonadvanced prostate cancer, but positively associated with fatal prostate cancer.24 We could not examine the association of ideal health metrics with incident prostate cancer by stage in ARIC, but, when we removed smoking from the score of ideal health metrics, the association of the score with higher prostate cancer incidence was no longer observed ($P$ trend = 0.40).

The results presented in Figure 2 demonstrate that, as one might expect, incident combined cancer was significantly associated with ideal health behaviors (not smoking, physical activity, low BMI, and healthy diet) and not with ideal health factors (blood sugar, blood pressure, and total cholesterol). This result may be explained, in part, by the relatively low concordance between ideal diet and ideal health factors because of the particularly low prevalence of ideal diet as defined by the AHA. It is also important to note that some of the cardiovascular ideal health behavior definitions may not be optimal for cancer prevention; for example quitting smoking only 12 months ago and having an underweight BMI may not be the best classification of a healthy behavior in relation to cancer. However, we believe that the most important overall message from this study is that adherence to the 7 ideal (cardiovascular) health metrics as proposed by the AHA is associated not only with lower CVD incidence and total mortality but also with lower cancer incidence. There are many health messages presented in the popular press and frequent (and sometimes contradictory) reports of novel risk factors for disease. These messages sometimes confuse consumers, leaving them unsure of the most important steps to take for disease prevention. We hope emphasizing a unified approach from multiple chronic disease advocacy groups that promotes some common steps for disease prevention will be particularly effective in helping the public to prevent chronic disease.

This analysis demonstrates that promoting the ideal health metrics proposed by the AHA (and communicated to the public through the Life’s Simple Seven campaign) could reduce both CVD and cancer incidence. Cancer advocacy groups are likely willing partners in the promotion of Life’s Simple Seven, perhaps with slight modifications; recent guidelines from the American Cancer Society on diet and nutrition are similar to elements of AHA’s ideal cardiovascular health metrics as ACS sought to be “consistent with guidelines from the American Heart Association and the American Diabetes Association for the prevention of coronary heart disease and diabetes.”25 In addition, a group from the American Cancer Society recently published a report showing that adherence to American Cancer Society guidelines resulted in a reduction in CVD mortality.26

Our study has several strengths. The ARIC study’s prospective design allows for the examination of baseline ideal health factors with subsequent cancer diagnoses, analyses not possible in most cancer case–control studies. The large sample size and long-follow up of the ARIC study provides many cases of cancer, allowing good power to detect associations with ideal health metrics. The use of cancer registries plus hospital records to capture cancer diagnoses allows for good ascertainment of cancer cases. However, there was likely incomplete ascertainment of cancer cases in the Mississippi cohort as a state registry has not covered the Jackson, MS ARIC study center continuously. Additionally, cancer cases that migrated from the ARIC study areas and were not hospitalized as a result of their cancer may also not have been captured. As discussed in the previous analysis of incident CVD and ideal health metrics in ARIC, the use of ideal health metrics measured at baseline does not take into account changes in risk factor levels that occurred over the lengthy period of follow-up.2 Also, self-reported diet and exercise likely have measurement error compared with objective measures of the same variables.19,27 We believe both these potential instances of exposure misclassification would most likely have occurred at random with respect to future cancer incidence and thus would be expected to bias our estimate of the association between ideal health metrics and incident combined cancer toward the null.

In conclusion, in the ARIC cohort, there was a significant inverse relation between the number of ideal cardiovascular health metrics at baseline, as defined by the AHA,28 and combined cancer incidence. These results should encourage the AHA in their efforts to partner with cancer and other chronic disease advocacy groups to promote the AHA 2020 goals to reduce the burden of CVD as well as other highly prevalent chronic diseases.

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Disclosures

None.
In 2010, the American Heart Association (AHA) defined the concept of ideal cardiovascular health according to 7 health behaviors or factors, which include smoking, physical activity, obesity, dietary intake, total cholesterol, blood pressure and blood sugar. The idea of working to attain the ideal goals for these 7 health metrics is now being promoted through the use of the My Life Check online health assessment tool and the Life’s Simple Seven health campaign from the AHA and American Stroke Association. Several earlier studies have demonstrated that adherence to ideal levels of the metrics is associated with lower cardiovascular disease incidence. In this study we used data from the Atherosclerosis Risk in Communities Study to demonstrate that adherence to ideal levels of the AHA cardiovascular health metrics was associated with significantly lower rates of incident cancer over 17–19 years of follow-up. Atherosclerosis Risk in Communities Study participants meeting goals for 6–7 ideal health metrics at baseline had 51% lower risk of incident cancer than those meeting goals for 0 ideal health metrics. This association remained significant even after smoking was removed from the ideal health score. We believe clinicians can use this information to further motivate patients to adhere to a healthy lifestyle and monitor their blood sugar, blood pressure, and blood cholesterol. We also hope these results will encourage the AHA in their efforts to partner with cancer and other chronic disease advocacy groups to promote primordial prevention.
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### Supplementary Table 1. Number of incident cancers, by demographic subgroups, ARIC study

<table>
<thead>
<tr>
<th>Subgroup (n)</th>
<th>Number incident cancer cases 1986-2006</th>
<th>Percent of subgroup with incident cancer 1986-2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Women (7723)</td>
<td>1343</td>
<td>18.6</td>
</tr>
<tr>
<td>Men (6030)</td>
<td>1537</td>
<td>25.5</td>
</tr>
<tr>
<td>African Americans (3329)</td>
<td>672</td>
<td>20.2</td>
</tr>
<tr>
<td>Whites (9924)</td>
<td>2208</td>
<td>22.3</td>
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<tr>
<td>Age 44-49 at baseline (3611)</td>
<td>517</td>
<td>14.3</td>
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<tr>
<td>Age 50-54 at baseline (3425)</td>
<td>690</td>
<td>20.1</td>
</tr>
<tr>
<td>Age 55-59 at baseline (3245)</td>
<td>784</td>
<td>24.2</td>
</tr>
<tr>
<td>Age 60-66 at baseline (2972)</td>
<td>889</td>
<td>29.9</td>
</tr>
</tbody>
</table>

### Supplementary Table 2. Hazard ratios for incident cancers by number of ideal health metrics: The ARIC Study, 1987-2006

<table>
<thead>
<tr>
<th># Ideal health metrics</th>
<th>Hazard Ratio for lung cancer (95% C.I)*†</th>
<th>Hazard Ratio for colorectal cancer (95% C.I)*†</th>
<th>Hazard Ratio for breast cancer (95% C.I)*†</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.0 (referent)</td>
<td>1.0 (referent)</td>
<td>1.0 (referent)</td>
</tr>
<tr>
<td>1</td>
<td>0.46 (0.30-0.73)</td>
<td>0.81 (0.41-1.59)</td>
<td>0.69 (0.42-1.16)</td>
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<tr>
<td>2</td>
<td>0.42 (0.28-0.65)</td>
<td>0.97 (0.50-1.86)</td>
<td>0.71 (0.43-1.17)</td>
</tr>
<tr>
<td>3</td>
<td>0.37 (0.24-0.57)</td>
<td>0.84 (0.44-1.63)</td>
<td>0.59 (0.36-0.98)</td>
</tr>
<tr>
<td>4</td>
<td>0.27 (0.17-0.44)</td>
<td>0.63 (0.31-1.25)</td>
<td>0.60 (0.36-1.00)</td>
</tr>
<tr>
<td>5</td>
<td>0.18 (0.09-0.33)</td>
<td>0.64 (0.30-1.37)</td>
<td>0.68 (0.40-1.16)</td>
</tr>
<tr>
<td>6-7</td>
<td>0.04 (0.01-0.27)</td>
<td>0.20 (0.04-0.91)</td>
<td>0.52 (0.26-1.03)</td>
</tr>
</tbody>
</table>

*adjusted for age, sex, race, and ARIC center

†p-trend for the lung cancer association < .0001, p-trend for the colorectal cancer association = .0092, p-trend for the breast cancer association = .11
Supplemental Figures

Supplementary Figure 1. Survival curves for combined cancer incidence by total number of ideal health metrics (with the ideal smoking metric omitted).

Cumulative cancer-free* survival according to number of ideal health metrics (with ideal smoking metric omitted), ARIC study 1987-2006

*Non-melanoma skin cancers were excluded from the combined cancer endpoint.