Lifestyle Factors in Relation to Heart Failure Among Finnish Men and Women

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Background—The role of lifestyle factors in explaining the risk of heart failure (HF) is not properly established.

Methods and Results—The national population-based study included 18 346 Finnish men and 19 729 women who were 25 to 74 years of age and free of HF at baseline. Multivariable Cox proportional hazards regression models was used to examine the association between lifestyle factors (smoking, body mass index [BMI], physical activity, vegetable consumption, fruit consumption, and alcohol consumption) and HF risk. During a median follow-up of 14.1 years (interquartile range, 5.9 to 20.9 years), 638 men and 445 women developed HF. Fruit consumption and alcohol consumption were dropped out of the analyses because no significant associations with the risk of HF were found. When 4 modifiable lifestyle factors (smoking, BMI, physical activity, and vegetable intake) were included in the analysis, the multivariable-adjusted (age, education, systolic blood pressure, total cholesterol, and histories of myocardial infarction, valvular heart disease, diabetes and using antihypertensive drugs) hazard ratios (HRs) of HF associated with engaging in 0, 1, 2, 3, and 4 healthy lifestyle factors were 1.00, 0.69 (95% confidence interval [CI], 0.54 to 0.87), 0.45 (95% CI, 0.35 to 0.58), 0.34 (95% CI, 0.25 to 0.46), and 0.31 (95% CI, 0.17 to 0.56) (P<0.001 for trend) for men, and 1.00, 0.53 (95% CI, 0.33 to 0.85), 0.42 (95% CI, 0.26 to 0.67), 0.24 (95% CI, 0.14 to 0.39), and 0.19 (95% CI, 0.09 to 0.40) (P<0.001 for trend) for women, respectively.

Conclusions—The present study demonstrates an inverse association between healthy lifestyle patterns and the risk of HF in Finnish men and women. (Circ Heart Fail. 2011;4:607-612.)

Key Words: lifestyle factors • incidence • heart failure

Heart failure (HF) poses a great threat to people around the world with its high prevalence, poor clinical outcomes, and large health care costs.1,2 Except for the medical treatments for the cardiovascular risk factors of HF, modifiable lifestyle factors can also affect the development of HF. Compared with medical intervention, the prevention of HF through lifestyle approaches is free of side effects. Modifiable lifestyle factors, such as smoking,3–7 physical activity,7–10 adiposity,7,9–12 alcohol consumption,7,13–16 and dietary intake,7,17 have been shown to influence the risk of HF in several studies. In the only epidemiological investigation related to the joint effect of these modifiable lifestyle factors on HF risk,7 engaging in healthy lifestyle factors was associated with the remaining lifetime risk of HF in men. However, it is unclear if this observed finding is generalizable to other populations and to both sexes. To gain a more comprehensive understanding of the effect of engaging in lifestyle factors on HF risk, we aimed to examine the single and combined effects of smoking, body mass index (BMI), physical activity, and vegetable intake on HF risk in a large prospective cohort of Finnish men and women.

Clinical Perspective on p 612

Methods

Subjects
Five independent cross-sectional, population-based health examination surveys (FINRISK) were carried out in 6 geographic areas of Finland in 1982, 1987, 1992, 1997, and 2002.18 The original random sample was stratified by area, sex, and 10-year age group according to the World Health Organization (WHO) MONICA (MONitoring trends and determinants of Cardiovascular disease) protocol.19 The participation rate varied by year from 65% to 88%.18 The subjects included in the 5 surveys were 25 to 64 years of age, and the 1997 and 2002 surveys also included subjects aged 65 to 74 years. Subjects who participated in more than one survey were included only in the first survey cohort. The total sample size of the 5 surveys was 38 737. The final sample comprised 18 346 men and 19 729 women after excluding the participants with a history of HF (n=457) at baseline and the participants with incomplete data on any variables required for this analysis (n=205). The participants gave an informed consent (verbal from 1982 to 1992 and written in 1997 and 2002). These surveys were conducted according to the ethical rules of the National Public Health...
Institute, and the investigations were performed in accordance with the Declaration of Helsinki.

**Baseline Measurements**

A self-administered questionnaire was mailed to the participants to be completed at home and returned to the survey site. The questionnaire included questions on medical history, socioeconomic factors, physical activity, smoking habits, dietary intake, and alcohol consumption. Education level, measured as the total number of school years, was divided into birth cohort-specific tertiles. Data on the history of myocardial infarction or diabetes mellitus at baseline were obtained from the questionnaire and collected by hospital discharge diagnosis or drug register. Data on the use of antihypertensive agents at baseline were obtained from the questionnaire and drug register. Data on the history of valvular heart disease at baseline were collected by hospital discharge register.\(^{8,9,17,20}\)

A detailed description of the questions on occupational and leisure-time physical activity has been presented elsewhere.\(^{8,20}\) Because we found that moderate and high occupational or leisure time physical activity independently and significantly reduces risk of HF, the groups were merged into 3 categories: “low” when subjects reported light levels of both occupational and leisure time physical activity; “moderate” when subjects reported moderate or high level of either occupational or leisure time physical activity; and “high” when subjects reported moderate or high level of both occupational and leisure time physical activity. Participants were classified as never, ex-smokers and current smokers, based on their responses to the questionnaire. Alcohol consumption was categorized into 4 groups: none, 0.1 to 35, 35.1 to 70, and $>$70 g per week. The frequency of consumption of vegetables and fruits over the last week (<1 time/wk, 1 to 2 times/wk, 3 to 6 times/wk, $\geq$7 times/wk) were also inquired.\(^{21}\)

At the survey site, specially trained research nurses measured participants’ height and weight by using the standardized WHO MONICA protocol.\(^{16}\) Height and weight were measured without shoes and with light clothing. The measurements of height were rounded to the nearest centimeter and weight to nearest 100 g.\(^{18}\) BMI was calculated as weight in kilograms divided by the square of height in meters. Blood pressure was measured from the right arm after 5 minutes of sitting using a mercury sphygmomanometer in each survey. After blood pressure measurement, a venous blood specimen was taken. Total cholesterol was determined by an enzymatic method (CHOD-PAP, Boehringer MANNHEIM, Mannheim, Germany). All samples were analyzed in the same central laboratory at the National Public Health Institute.

**Prospective Follow-Up**

Follow-up information was from the Finnish Hospital Discharge Register and the National Social Insurance Institution’s Register on special reimbursement for HF drugs for nonfatal outcomes and the Finnish Causes of Death Register for fatal outcomes by record linkage using the personal identification numbers assigned to every citizen of Finland. The International Classification of Diseases (ICD) codes 427.00 and 427.10 (ICD-8), 428, 4029B (hypertensive heart disease with HF) and 4148A-X (ischemic HF with chronic coronary disease) and I 50, I11.0 (hypertensive heart disease) codes 427.00 and 427.10 (ICD-8), 428, 4029B (hypertensive heart disease with HF), I13.0 and I13.2 (hypertensive heart and renal disease with HF) (ICD-10) were used to identify HF cases in the above-mentioned national databases. A HF diagnosis was made by the treating physicians, based on a clinical assessment and examinations as considered relevant by the clinician in charge of treatment. Follow-up of each cohort member continued until the date of the diagnosis of HF from the Hospital Discharge Register, Causes of death register or from the National Social Insurance Institution’s Drug reimbursement Register or death resulting from causes other than HF, or December 31, 2007. This method to ascertain HF cases in prospective epidemiological studies has been used in Scandinavian countries, such as Sweden and Finland.\(^{11,22,23}\) A study from Sweden found the positive predictive value of HF diagnosis to be 82% (false-positive rate, 18%).\(^{23}\) Another study from Finland also found the specificity of the HF diagnoses to be acceptable for the epidemiological study.\(^{24}\)

**Statistical Analyses**

Cox proportional hazards regression was used to calculate the hazard ratio (HR) and 95% confidence intervals (CIs) for categories of each of the 6 modifiable lifestyle factors (smoking [never, ever, and current], BMI [normal weight: $\leq$25 kg/m², overweight: 25 to 29.9 kg/m², and obese: $\geq$30 kg/m²], physical activity [low, moderate, and high], vegetable consumption [<1, 1 to 2, 3 to 6, and $\geq$7 times per week], fruit consumption [<1, 1 to 2, 3 to 6, and $\geq$7 times per week], and alcohol consumption [none, 0.1 to 35, 35.1 to 70, and $>$70 g per week]).

Next, each lifestyle factor was dichotomized as unhealthy versus healthy: smoking (current versus never or ever), BMI ($\geq$25 vs. $<$25 kg/m²), physical activity (low versus moderate or high), and vegetable consumption ($\leq$2 vs. $\geq$3 times per week). Fruit consumption and alcohol consumption were dropped out of the analyses because no significant associations with HF risk were found. Given that healthy lifestyle factors were defined as never or ever smoking, BMI $<$25 kg/m², moderate or high levels of physical activity, and consumption of vegetable $\geq$3 times per week, each person could have a minimum of 0 and maximum of 4 healthy lifestyle factors. Differences in the general characteristics of study subjects who had 0, 1, 2, 3, or 4 healthy lifestyle factors were tested using general linear models after adjustment for age and study year. The number of healthy lifestyle factors was included in the Cox proportional hazards regression models as dummy and categorical variables, and the significance of the trend over different categories was tested in the same models by giving an ordinal numeric value for each dummy variable. The proportional hazards assumption in the Cox model was assessed with graphical methods and with models including time-by-covariate interactions.\(^{24}\) In general, all proportionality assumptions were appropriate.

All the above analyses were first carried out adjusting for age and study year, and further for education, systolic blood pressure, total cholesterol, and histories of myocardial infarction, valvular heart disease, diabetes, and using antihypertensive drugs. To avoid a potential bias due to severe disease at baseline, additional analyses were carried out excluding the subjects who died during the first 2 years of follow-up (n=290). Statistical significance was considered to be P<0.05. All the above statistical analyses were performed with PASW for Windows, version 18.0 (SPSS Inc, Chicago, IL).

To estimate the proportion of new HF cases occurring in this population that hypothetically could have been prevented if all subjects had been in the healthy lifestyle group, whereas the distribution of other modifiable and nonmodifiable risk factors is unchanged, the partial population attributable risk percent (PAR%)\(^{25}\) and 95% CI were calculated by using SAS for Windows, version 9.12 (SAS Institute, Cary, NC).

**Results**

During a median follow-up of 14.1 years (interquartile range, 5.9 to 20.9 years), 638 men and 445 women developed HF. General characteristics of the study population at baseline are presented by the number of healthy lifestyle factors in Table 1.

Except for fruit consumption and alcohol consumption, the other individual components of the lifestyle factors were independently and significantly associated with the risk of HF when they were simultaneously entered into the multivariable model (Table 2). The most important risk factor for HF was smoking status; the HR of HF was 1.86 (95% CI, 1.51 to 2.30) for men and 2.09 (95% CI, 1.59 to 2.74) for women who were current smokers, as compared with subjects who never smoked. Overweight or obesity was also associated with a significantly increased HF risk, whereas engagement in moderate-to-high levels of physical activity, the consumption of vegetable more than 3 times per week were associated with a significantly decreased HF risk.
The partial PAR% associated with engaging in any 3 or 4 of the healthy lifestyle indicators were 45.6% (95% CI, 36.5% to 53.8%) and 53.6% (95% CI, 31.3% to 70.2%), respectively, suggesting that 45.6% or 54.1% of new HF cases occurring in this population could have been prevented if all subjects had any 3 or 4 of the healthy lifestyle indicators. However, because PAR% assumes the lifestyle factors are causal, it should be interpreted with caution.

Exclusion of the participants who died during the first 2 years of follow-up did not appreciably change the results above (data not shown).

### Discussion

In the present study, we observed that maintaining a BMI \( \geq 25 \), consuming vegetable \( \geq 3 \) times a week, abstaining from smoking and engaging in moderate or high levels of physical activity were individually and jointly associated with a decreased risk of HF among both men and women. Furthermore, the dose-response relationship between the number of healthy lifestyle factors one engaged in and HF risk suggested that the closer one was engaging in a healthy lifestyle, the further the risk of HF was reduced.

Smoking, which was identified as the most powerful predictor of incident HF in the current cohort, was first shown to be the major independent risk factor of HF in a study conducted on 973 men born in 1913 in Gothenburg, Sweden. The authors found that smoking at age 50 was associated with a 60% higher risk of congestive HF (HR, 1.6; 95% CI, 1.2 to 2.0), and this relationship was independent of hypertension and other important risk factors of congestive HF. The finding has been confirmed by several other studies con-
Based on the evidence revealing the positive association between smoking and HF, the European Society of Cardiology, the American College of Cardiology, and the American Heart Association identified smoking as one of the risk factors as well as one of the targets of prevention and management of HF in their guidelines.26–28

The relation of physical activity4,8–10 and obesity4,9–12,29–33 to HF has been studied extensively. The results from these prospective studies consistently indicate that regular physical activity reduces the risk of HF, whereas both general obesity and abdominal obesity increase the risk of HF. Furthermore, research9,10 related to the joint effect of obesity and physical activity has shown that a higher number of healthy lifestyle factors is associated with a lower risk of HF.

### Table 2. Hazard Ratios of Heart Failure According to Lifestyle Factors

<table>
<thead>
<tr>
<th>Lifestyle Factors</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of Cases Person-Years</td>
<td>Multivariable Adjustment HR (95% CI)*</td>
</tr>
<tr>
<td>Physical activity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light</td>
<td>128 27 863</td>
<td>1.00</td>
</tr>
<tr>
<td>Moderate</td>
<td>334 118 082</td>
<td>0.79 (0.64–0.97)</td>
</tr>
<tr>
<td>High</td>
<td>176 115 186</td>
<td>0.67 (0.53–0.86)</td>
</tr>
<tr>
<td>Smoking status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>153 98 111</td>
<td>1.00</td>
</tr>
<tr>
<td>Ever</td>
<td>213 67 484</td>
<td>1.06 (0.86–1.31)</td>
</tr>
<tr>
<td>Current</td>
<td>272 95 537</td>
<td>1.86 (1.51–2.30)</td>
</tr>
<tr>
<td>Alcohol consumption, g/wk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>272 94 275</td>
<td>1.00</td>
</tr>
<tr>
<td>0.1–35</td>
<td>75 34 306</td>
<td>0.91 (0.70–1.18)</td>
</tr>
<tr>
<td>35.1–70</td>
<td>92 40 378</td>
<td>1.00 (0.79–1.27)</td>
</tr>
<tr>
<td>&gt;70</td>
<td>199 92 173</td>
<td>1.17 (0.96–1.42)</td>
</tr>
<tr>
<td>Body mass index, kg/m²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;25</td>
<td>142 95 701</td>
<td>1.00</td>
</tr>
<tr>
<td>25–29.9</td>
<td>293 122 376</td>
<td>1.15 (0.93–1.41)</td>
</tr>
<tr>
<td>≥30</td>
<td>203 43 055</td>
<td>1.75 (1.40–2.20)</td>
</tr>
<tr>
<td>Fruit consumption, times/wk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;1</td>
<td>109 36 062</td>
<td>1.00</td>
</tr>
<tr>
<td>1–2</td>
<td>261 99 472</td>
<td>1.14 (0.91–1.44)</td>
</tr>
<tr>
<td>3–6</td>
<td>153 74 523</td>
<td>1.00 (0.77–1.30)</td>
</tr>
<tr>
<td>≥7</td>
<td>115 51 074</td>
<td>1.11 (0.83–1.47)</td>
</tr>
<tr>
<td>Vegetable consumption, times/wk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;1</td>
<td>162 41 126</td>
<td>1.00</td>
</tr>
<tr>
<td>1–2</td>
<td>258 95 067</td>
<td>0.88 (0.72–1.08)</td>
</tr>
<tr>
<td>3–6</td>
<td>148 81 316</td>
<td>0.74 (0.58–0.94)</td>
</tr>
<tr>
<td>≥7</td>
<td>70 43 623</td>
<td>0.70 (0.51–0.96)</td>
</tr>
</tbody>
</table>

HR indicates hazard ratio; CI, confidence interval.

*Adjusted for age, study year, smoking, vegetable consumption, fruit consumption, education, alcohol consumption, history of myocardial infarction, history of valvular heart disease, history of diabetes, history of using antihypertensive drugs, body mass index, systolic blood pressure, and total cholesterol, other than the variable in the analytic model.

The relation of physical activity and obesity to HF has been studied extensively. The results from these prospective studies consistently indicate that regular physical activity reduces the risk of HF, whereas both general obesity and abdominal obesity increase the risk of HF. Furthermore, research related to the joint effect of obesity and physical activity has shown that a higher number of healthy lifestyle factors is associated with a lower risk of HF.

### Table 3. Hazard Ratios of Heart Failure According to Number of Healthy Lifestyle Factors Restricted to Adiposity, Smoking, Physical Activity, and Vegetable Consumption

<table>
<thead>
<tr>
<th>No. of Healthy Lifestyle Factors</th>
<th>No. of Cases Person-Years</th>
<th>Age and Study Years Adjusted HR (95% CI)*</th>
<th>Multivariable Adjustment HR (95% CI)*</th>
<th>P for Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>97 19 441</td>
<td>1.00</td>
<td>1.00</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>1</td>
<td>271 72 805</td>
<td>0.64 (0.50–0.80)</td>
<td>0.68 (0.54–0.86)</td>
<td>0.001</td>
</tr>
<tr>
<td>2</td>
<td>191 93 954</td>
<td>0.39 (0.31–0.50)</td>
<td>0.44 (0.35–0.57)</td>
<td>0.001</td>
</tr>
<tr>
<td>3</td>
<td>67 59 020</td>
<td>0.28 (0.20–0.38)</td>
<td>0.33 (0.24–0.45)</td>
<td>0.001</td>
</tr>
<tr>
<td>4</td>
<td>12 15 912</td>
<td>0.25 (0.14–0.46)</td>
<td>0.30 (0.16–0.54)</td>
<td>0.001</td>
</tr>
</tbody>
</table>

HR indicates hazard ratio; CI, confidence interval.

*Adjusting for age, study year, education, history of myocardial infarction, history of valvular heart disease, history of diabetes, history of using antihypertensive drugs, systolic blood pressure, and total cholesterol.
activity on HF risk indicates that lean and active individuals had the lowest HF risk. Therefore, preventing of HF by maintaining optimal weight and involving in regular physical activity may be promising in reducing the public health burden of HF worldwide.

Although dietary pattern and food choices have been associated with risk factors for HF such as hypertension, coronary heart disease and type 2 diabetes, the role of diet on HF has not been studied adequately to date. Djousse et al.7,34 have done extensive work to evaluate the associations between dietary factors on the risk of HF by using the data from the Physicians’ Health Study: their studies showed that fruit and vegetable consumption7 and whole-grain breakfast cereals consumption35 were associated with a reduced risk of HF. The Swedish Mammography Cohort showed that diets consistent with the DASH diet, a diet features high intake of fruits, vegetables, low-fat dairy products, and whole grains, were associated with a decreased risk of HF.36 In the current study, fruit consumption was not associated with the risk of HF, which is different from the findings from the study conducted by Djousse et al.7 The inconsistency might be partly explained by the different questionnaires used to assess fruit consumption, and the differences in the dietary habits between the Finish population and Americans. All these studies together with the current study suggest that the prevention of HF through dietary approaches should be stressed.

The studies that have addressed alcohol consumption and the risk of HF have yielded inconsistent results.7,13–16 Like us, Bryson et al.14 did not find a significant association between alcohol consumption and the risk of HF. In contrast, several studies7,14–16 showed that moderate alcohol consumption was associated with a reduced risk of HF, whereas alcohol abuse was associated with a higher risk of HF.3 The discrepancy among these findings may be partly explained by the different assessment of alcohol consumption, and the age and race difference between the study samples of these studies. To establish the association between alcohol consumption and HF and make appropriate recommendations to the general public especially those at high risk for HF, further studies are needed.

To the best of our knowledge, the only study addressing the association between the joint effect of modifiable lifestyle factors on HF risk was conducted among male physicians, who are more aware of the consequences of unhealthy lifestyle than the general public. The results of the present study support their finding that engaging in healthy lifestyle factors is associated with a lower HF risk in men. Moreover, for the first time, the present study demonstrated a similar association in women. Although each of these 4 modifiable lifestyle factors has been shown to be independently associated with the risk of HF in various studies, the general public does not have enough awareness of these associations, and the prevalence of unhealthy lifestyle continues to be high. Large social and community-based lifestyle intervention may help to prevent and manage HF.

There are several strengths and limitations in our study. First, a major strength of the study is the large number of both men and women from a homogeneous population who participated in the study. Second, the follow-up time was sufficiently long to ascertain a large number of HF end point events. Finally, we also carried out additional analyses excluding the subjects who died during the first 2 years of follow-up to avoid a potential bias due to a severe disease at baseline. A limitation of our study is that information on self-reported physical activity, smoking habits, and vegetable and alcohol consumption was recorded only once at baseline. We have no data on possible changes in the lifestyle factors during the follow-up. However, the misclassification of the levels of these lifestyle factors during the follow-up is most probably not systematically related to the outcome but may weaken the observed association. Ascertainment of HF status was based on the National Hospital Discharge Registry, the National Social Insurance Institution’s Register on special reimbursement for HF drugs, and Causes of Death Register. These data are primarily collected for administrative purposes and not for a scientific study. There are guidelines for assigning diagnoses in these register and established quality control procedures, but the diagnoses may vary over time and between the hospitals. This method for ascertaining the HF outcome has, however, been successfully used in prior studies in Scandinavian countries, such as Finland and Sweden.8,9,11,17,22,23 Also, we cannot completely either exclude the effects of residual confounding due to measurement error in the assessment of confounding factors, or some unmeasured dietary factors. An additional limitation is the use of the healthy lifestyle point system. Each healthy lifestyle factor was weighted the same, which implies that each is equally important, though the results indicated that smoking was the strongest risk factor for HF. This may lead to heterogeneous people being in the same category.

In conclusion, there was a graded inverse association between the number of healthy lifestyle factors and the risk of HF in Finnish men and women. Therefore, to reduce the incidence of HF, more efforts should be put into promoting healthy lifestyles and their associated health benefits.

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Disclosures
None.

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