Short stature and cardiovascular disease among men and women from two southeastern New England communities

Donna R Parker, a,b Kate L Lapane, a,b Thomas M Lasater a,b and Richard A Carleton a,c

Background

Short stature has been associated with an increased risk of coronary heart disease (CHD), although the reason for the association remains unclear. Data on the relation between stature and stroke is more limited. We examined the association between stature and CHD as well as between stature and stroke in men and women from two communities in southeastern New England.

Methods

Coronary heart disease and stroke events were abstracted from medical records between January 1980 and December 1991. An epidemiological diagnostic algorithm developed to measure CHD was used in the present analysis. Unadjusted relative risks (RR) and RR adjusted for age, smoking status, obesity, high-density lipoprotein (HDL) cholesterol <0.91 mmol/l, total cholesterol >6.21 mmol/l, hypertension, diabetes, education, and being foreign born were computed by gender-specific height categories separately for men (n = 2826) and women (n = 3741).

Results

A graded inverse association between stature and risk of CHD was observed among men which persisted after adjustment for confounders. Men >69.75 inches had an 83% lower risk of CHD compared with men ≤65 inches. In addition, the tallest men had a 67% decreased risk of stroke compared with the shortest men. No significant relation between stature and CHD or stroke was observed among women.

Conclusions

These data support the hypothesis that stature is inversely related to both risk of CHD and stroke at least among men. Factors which might explain this association remain to be determined.

Keywords

Stature, coronary heart disease, stroke, relative risk

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community in Massachusetts which helped individuals adopt new behaviours and to create a supportive physical and behavioural environment. The programme targeted: (1) risk factors (e.g. elevated blood cholesterol, elevated blood pressure, cigarette smoking, obesity, and physical inactivity); (2) behaviour change (e.g. training in behaviour skills and assisting in the development of social supports) and (3) community activation (working closely with groups and organisations to which they belong and providing programmes to all community members—weight loss contests). The PHHP completed six biennial surveys between 1981 and 1993. For the present analyses, data from surveys one (1981–1982) through five (1989–1990) were used. Survey six was not used since medical record abstraction for ascertainment of cardiovascular disease ended during this survey.

Survey participants were identified by randomly selecting households and then randomly selecting one participant, aged 18–64 years, from each household using the methods of Kish and Deming. Trained interviewers obtained information on demographic characteristics and on cardiovascular disease-related knowledge, attitudes, and behaviours. Current medication use was based on self-report in response to a series of medication questions. All currently used medications that were present in the home at the time of the interview were reviewed and recorded by the interviewers.

The interviewers measured standing height (without shoes) and weight (in light clothing) using a Centers for Disease Control protocol. Systolic and fifth phase diastolic blood pressure readings were taken on the right arm, using a Baumanometer mercury sphygmomanometer and the appropriate cuff size. The second of two measures taken 20 min apart was used. Blood samples, taken without regard to fasting status, were analysed for total cholesterol and high-density lipoprotein (HDL) cholesterol in a Centers for Disease Control-standardized laboratory.

Smoking status was determined by asking whether respondents currently smoked cigarettes or whether they had quit smoking cigarettes within the past 12 months or longer or never smoked cigarettes. Status of diabetes mellitus was determined by use of oral hypoglycaemic agents and/or use of insulin. A person was classified as having hypertension if they reported current use of antihypertensive medication (including diuretics), the diastolic blood pressure was \( \geq 90 \text{ mmHg} \), or the systolic blood pressure was \( \geq 140 \text{ mmHg} \). Body mass index was calculated as (weight in kg)/(height in m\(^2\)). People were classified as obese if the body mass index was \( >27.8 \text{ kg/m}^2 \) for men or \( >27.3 \text{ kg/m}^2 \) for women which corresponds to \( \geq 20\% \) above ideal body weight for men and women respectively.

Menopausal status was determined using an algorithm based upon age, menstrual status, pregnancy, and medication use. Women were defined as premenopausal if they had not undergone surgical menopause, were either pregnant or <60 years of age, and reported a menstrual period in the past year in the absence of oestrogen therapy. Women were defined as menopausal if they indicated that their menstrual cycle had stopped or if they were \( >55 \) years of age and were missing menopausal status data. For the present analysis, oestrogen use was defined as current use of oestrogen other than oral contraceptives.

As the relation between stature and cardiovascular disease was not expected to be altered by the intervention, data from surveys one through five were pooled from the intervention and comparison city. Of the 7272 individuals surveyed who were \( \geq 35 \) years, 705 individuals were excluded from the analyses for the following reasons: 16 women were pregnant, 68 individuals had missing data on height, 209 individuals had a history of cardiac problems, and 412 individuals reported use of cardiac medication (including B-blockers, ACE inhibitors, nitrates, digoxin, anti-arrhythmic medication and/or calcium antagonists). The final population consisted of 2826 men and 3741 women free of reported cardiovascular disease at baseline.

The outcome events of interest included CHD and stroke events which were abstracted from medical records between 1 January 1980 and 31 December 1991. A standardized retrospective surveillance system was used by the Pawtucket Heart Health Program. Hospital records were abstracted from patients aged 35–74 years who lived in Pawtucket or the comparison city and had CHD or stroke as indicated by the assignment of ICD-9-CM (International Classification of Diseases, 9th Revision, Clinical Modification) codes 410 (acute myocardial infarction), 411 (other acute and subacute forms of ischaemic heart disease), 412 (old myocardial infarction), 413 (angina pectoris), 414 (other forms of chronic ischaemic heart disease), or 430 through 437 (cerebrovascular disease). Cases with multiple target ICD-9-CM codes were selected on the basis of the lowest ICD-9-CM code assigned (i.e. a person with a 410 code plus a 414 code was considered to be a 410 code).

An epidemiological diagnostic algorithm developed to measure CHD for the Pawtucket Heart Health Program, the Stanford Five City Study and the Minnesota Heart Health Program was used in the present analysis. Implementation of the algorithm relied on composite clinical judgment as summarized by the ICD-9-CM codes. Ischaemic heart disease events were defined as definite or probable algorithm defined myocardial infarction or definite fatal CHD. If a patient was discharged with an acute form of ischaemic heart disease (codes 410 or 411), a finding of abnormal creatinine kinase levels (e.g. more than twice the upper limit of normal) resulted in an assigned diagnosis of definite myocardial infarction. For the remainder of the patients with discharge codes of 410 or 411, determination of a definite event was corroborated with electrocardiograms. For chronic forms of ischaemic heart disease (codes 412 through 414), a finding of abnormal enzymes with electrocardiogram corroboration resulted in an algorithm determined diagnosis of definite myocardial infarction.

For cerebrovascular disease, ICD-9 codes 430–437 were used to determine the outcome for each admission.

Statistical analysis
Data analyses were performed using the Statistical Analysis System (SAS). Correlation coefficients (r) were used to measure the association between stature and several continuous variables. Height was grouped into gender-specific quintiles and all analyses were conducted separately for men and women. The unadjusted relative risks (RR) were computed by height category and were compared using the shortest quintile as referent. Adjusted RR were derived from multivariable logistic regression models controlling for city, survey, age, obesity, cigarette smoking, hypertension, drug-treated diabetes, elevated serum cholesterol, low serum high-density lipoprotein cholesterol, education, and being foreign born. Age and education were entered as continuous variables. Except for survey, all other
variables were entered as dichotomous. For each RR, 95% confidence intervals (CI) were derived from these models. To test for a linear trend, a continuous term for height was included in the model.

The research protocol was approved by the Memorial Hospital Institutional Review board. Permission to obtain medical records for the study was granted by the respective departments of health and regional hospitals and all seven hospitals surveyed.

Table 1 Baseline characteristics of study participants by gender in two Southeastern New England Communities, 1981–1990

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Men (N = 2826)</th>
<th>Women (N = 3741)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Race (%)</td>
<td>92.4</td>
<td>90.8</td>
</tr>
<tr>
<td>Ethnicity (% Portuguese)</td>
<td>33.6</td>
<td>29.1</td>
</tr>
<tr>
<td>Foreign born (%)</td>
<td>29.7</td>
<td>24.3</td>
</tr>
<tr>
<td>Education (% &gt;12 years)</td>
<td>30.9</td>
<td>23.8</td>
</tr>
<tr>
<td>Smoking status (% current smoker)</td>
<td>40.8</td>
<td>30.1</td>
</tr>
<tr>
<td>Age (years)</td>
<td>48.6 ± 9.2</td>
<td>49.2 ± 9.3</td>
</tr>
<tr>
<td>Height (inches)</td>
<td>67.3 ± 2.9</td>
<td>62.3 ± 2.6</td>
</tr>
<tr>
<td>Weight (pounds)</td>
<td>176.5 ± 11.6</td>
<td>151.6 ± 33.9</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>27.3 ± 4.4</td>
<td>27.5 ± 6.0</td>
</tr>
<tr>
<td>Total cholesterol (% &gt;6.21 mmol/l)</td>
<td>33.7</td>
<td>33.4</td>
</tr>
<tr>
<td>HDL cholesterol (%) (&lt;0.91 mmol/l)</td>
<td>22.1</td>
<td>7.5</td>
</tr>
<tr>
<td>Diabetes (%)</td>
<td>2.2</td>
<td>3.1</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>132.9 ± 16.8</td>
<td>128.0 ± 18.7</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>82.2 ± 10.5</td>
<td>78.0 ± 10.7</td>
</tr>
</tbody>
</table>

Results

Characteristics of participants are shown in Table 1. The mean height of men was 5 feet 7 inches which was shorter than the mean height of 5 feet 9 inches in US men of the same age group which may partially be attributed to the high proportion of Portuguese men (33.6%). Similarly, the mean height of women was 5 feet 2 inches which was shorter than the mean height of 5 feet 4 inches in US women of the same age distribution which also may be partially attributed to the high proportion of Portuguese women (29.1%).

To investigate the role of potential confounders, we examined the correlation between stature and several continuous variables. Shorter stature was weakly associated with older age (r(men) = -0.17; r(women) = -0.14; P < 0.001, higher body mass index r(men) = -0.06; r(women) = -0.14; P < 0.001, higher total cholesterol levels r(men) = -0.07; r(women) = -0.08; P < 0.001, and higher systolic blood pressure r(men) = -0.05; r(women) = -0.08; P ≤ 0.008. Among both men and women, shorter stature was also associated with less education r(men) = 0.38; r(women) = 0.32; P < 0.001. Taller men had lower HDL cholesterol levels r = -0.06; P < 0.001 while among women, shorter individuals had lower HDL cholesterol levels r = 0.06; P < 0.001. Stature was not associated with diastolic blood pressure.

The risks and 95% CI associated with different height categories for CHD are presented in Table 2. Risks were first calculated unadjusted for other covariates and then adjusted for age, smoking status, obesity, HDL cholesterol <0.91 mmol/l, total cholesterol >6.21 mmol/l hypertension, diabetes, education, foreign born, city, and survey. A graded inverse association between stature and risk of CHD was observed among men which persisted after adjustment for confounders. Men >69.75 inches had an 83% lower risk of CHD compared with men <65 inches (χ² test for trend = 14.86; P < 0.001). Among women, there was no significant relation between stature and CHD (χ² test for trend = 0.35; P = 0.56).

Table 2 Crude and adjusted relative risks (RR) and 95% confidence intervals (CI) for coronary heart disease by height category and gender

<table>
<thead>
<tr>
<th>Height (Inches)</th>
<th>No. of events</th>
<th>Unadjusted RR</th>
<th>95% CI</th>
<th>Adjusted RR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤65</td>
<td>25</td>
<td>1.0</td>
<td>−</td>
<td>1.0</td>
<td>−</td>
</tr>
<tr>
<td>65.1-66.75</td>
<td>16</td>
<td>0.73</td>
<td>0.38-1.37</td>
<td>0.57</td>
<td>0.29-1.13</td>
</tr>
<tr>
<td>66.76-68.0</td>
<td>11</td>
<td>0.46</td>
<td>0.23-0.95</td>
<td>0.31</td>
<td>0.15-0.67</td>
</tr>
<tr>
<td>68.1-69.75</td>
<td>11</td>
<td>0.49</td>
<td>0.24-0.99</td>
<td>0.36</td>
<td>0.17-0.77</td>
</tr>
<tr>
<td>&gt;69.75</td>
<td>5</td>
<td>0.22</td>
<td>0.08-0.57</td>
<td>0.17</td>
<td>0.06-0.48</td>
</tr>
<tr>
<td>Women</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤60</td>
<td>10</td>
<td>1.0</td>
<td>−</td>
<td>1.0</td>
<td>−</td>
</tr>
<tr>
<td>60.1-61.5</td>
<td>5</td>
<td>0.51</td>
<td>0.17-1.49</td>
<td>0.59</td>
<td>0.20-1.78</td>
</tr>
<tr>
<td>61.51-62.75</td>
<td>8</td>
<td>0.82</td>
<td>0.32-2.08</td>
<td>1.05</td>
<td>0.40-2.78</td>
</tr>
<tr>
<td>62.76-64.5</td>
<td>9</td>
<td>0.83</td>
<td>0.34-2.05</td>
<td>0.99</td>
<td>0.38-2.60</td>
</tr>
<tr>
<td>&gt;64.5</td>
<td>8</td>
<td>0.91</td>
<td>0.36-2.32</td>
<td>1.18</td>
<td>0.43-3.25</td>
</tr>
</tbody>
</table>

a Adjusted for age, smoking status, obesity, HDL <0.91 mmol/l, total cholesterol >6.21 mmol/l, hypertension, diabetes, education, foreign born, city, and survey.

b χ² test for trend: C² = 14.86; P < 0.001; d.f. = 1.

c χ² test for trend: C² = 0.35; P = 0.56; d.f. = 1.
The analyses were repeated using stroke (ICD-9 codes 430–437) as the outcome (Table 3). An inverse association between stature and stroke was observed among men which also persisted after adjustment for confounders. The tallest men had a 67% decreased risk of stroke compared with the shortest men ($\chi^2$ test for trend = 8.74; $P = 0.003$). No apparent association between stature and risk of stroke was observed among women ($\chi^2$ test for trend = 0.60; $P = 0.44$).

We also examined RR that have been adjusted for weight. Substitution of weight for body mass index (data not shown) resulted in a slightly stronger inverse association between stature and CHD only among men. With stroke as the outcome, the trend in RR estimates among men was weaker with wide CI ($\chi^2$ test for trend = 6.10; $P = 0.01$). Among women, there was no evidence of an association between stature and risk of either CHD or stroke when weight was substituted for body mass index. To control for confounding, the multivariable analyses presented included body mass index.

In addition, we examined RR that were adjusted for Portuguese (data not shown) and results remained essentially unchanged.

### Discussion

For the past several years there has been renewed interest in the relation between stature and cardiovascular disease. In our study, short stature was an independent predictor of CHD and stroke in men even after controlling for a number of risk factors. Among women, no relation between stature and both CHD and stroke was observed.

These data are consistent with several previous studies in men which showed an association between short stature and increased risk for CHD. However, these studies did not adjust for potential confounders such as socioeconomic status or body mass index. More recently, the Physicians' Health Study reported that the tallest quintile of male physicians had a 35% lower risk for myocardial infarction compared with the shortest quintile of physicians after adjustment for age, body mass index, B-carotene assignment, smoking, hypertension, diabetes, parental history of a myocardial infarction, alcohol intake, hypercholesterolaemia, angina, and exercise frequency. Similarly, Rimm et al., in a study of 29,122 US men aged 40–75 years, observed that taller men (>73 inches) had a 32% lower risk for CHD compared with shorter men (<68 inches), after adjusting for age, smoking, calories, alcohol, family history of myocardial infarction, profession, Vitamin E, body mass index, and waist-to-hip ratio. In addition, Yarnell et al., in a study of 4,860 English men, also reported that the shortest quintile of men had twice as many myocardial infarcts as the tallest quintile of men after adjustment for age, social class, and smoking. In contrast, other studies have found no relationship.

Socioeconomic status has been reported to be inversely correlated with CHD. Allebeck and Bergh, in a study of 50,465 Swedish men, found that the inverse association between stature and mortality was reduced after controlling for social factors. Although we were unable to adjust for occupation in the present study, we did adjust for education and found that it did not confound the association between stature and cardiovascular mortality.

Our finding of no association between stature and risk for CHD among women is in contrast to other recent studies. However, the relation between stature and cardiovascular disease remains unclear since we had limited statistical power with only 40 CHD events among women.

Only two other studies have examined the relation of stature to risk of stroke: the Physicians' Health Study and the Nurses' Health Study. Both of these studies found no association between stature and stroke. Nevertheless the Physicians' Health Study found that men in the tallest quintile had a 23% lower (although non-significant) risk for stroke compared to men in the shortest quintile which was similar to our findings. Further investigations are therefore needed to determine whether stature predicts the risk of stroke and to examine possible pathophysiological mechanisms.

There is no single biological hypothesis to explain the association between stature and cardiovascular disease although it...
has been suggested that short stature is related to coronary artery lumen diameter. This has been postulated as a source of gender difference in CHD surgery mortality. Results from the Coronary Artery Surgery Study (CASS) indicated that in fact, shorter individuals of both sexes who underwent coronary bypass surgery had a higher mortality rate than taller individuals. One possible explanation is that shorter individuals may have narrower coronary arteries which predispose them to an increased risk for an obstructive thrombus. Preliminary data on the correlation of stature and intraoperative measurements of coronary lumen diameter among 923 men showed weak but significant correlations (Spearman's correlation = 0.092; P = 0.004).

With respect to nutritional status, inadequate nutrition during infancy and childhood, which is correlated with adult stature, may increase the risk of CHD in adulthood. There is some evidence that impaired fetal and infant growth (and adult stature) may be linked to haemostatic factors (e.g. plasma fibrinogen and factor VII levels) and increased cardiovascular disease in adulthood. Barker et al. reported that haemostatic factors were inversely correlated with weight at one year of age. In addition, they reported that taller individuals had lower levels of haemostatic factors. However, the correlation between weight at one year of age and current height was not reported.

A few constraints on the interpretation of these data must be considered. We were unable to adjust for a few factors that might be linked with stature and cardiovascular disease such as lung function, body fat distribution, and childhood nutrition. However, lung function has been measured in several studies and failed to explain the association between stature and cardiovascular disease. We also did not have information on nutrition in childhood which may affect adult stature. Obesity localized to the abdomen may be a more powerful predictor of cardiovascular disease than generalized obesity. We were unable to determine whether shorter individuals were more likely to have abdominal obesity than taller individuals in the present investigation. However, when we controlled for generalized obesity, the association between stature and cardiovascular disease persisted among men.

Our study had several advantages over other studies. Misclassification of disease status based on ICD-9-CM codes alone may be decreased by using an epidemiological diagnostic algorithm. This algorithm provided a refinement to the ICD-9-CM codes which resulted in highly specific outcomes. In addition, we were able to examine the association between stroke and stature which has only been examined in two other studies which controlled for other risk factors.

In summary, in our population we found an increase in risk for both CHD and stroke among shorter men after adjusting for other risk factors. We did not find an increase in risk for cardiovascular disease in shorter women, although we had limited statistical power with only 40 CHD events among women. Factors which might explain the association between stature and cardiovascular disease (e.g. early nutrition, coronary artery lumen diameter) remains to be determined. While height is not modifiable, it may be useful to measure in order to identify individuals of shorter stature who have other risk factors for cardiovascular disease that are alterable.

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References


