Social relations and extent and severity of coronary artery disease

The Stockholm Female Coronary Risk Study

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Aims Social relations have been repeatedly linked to coronary heart disease in men, even after careful control for standard risk factors. Women have rarely been studied and results have not been conclusive. We investigated the role of social support in the severity and extent of coronary artery disease in women.

Methods and Results One hundred and thirty-one women, aged 30 to 65 years, who were hospitalized for an acute coronary event and were included in the Stockholm Female Coronary Risk Study, were examined with computer assisted quantitative coronary angiography. Angiographic measures included presence of stenosis greater than 50% in at least one coronary artery (severity) and the number of stenoses greater than 20% within the coronary tree (extent). Social factors included two measures of social support, which were previously shown to predict coronary disease in prospective studies of men.

After adjustment for age, lack of social support was associated with both measures of coronary artery disease. With further adjustment for smoking, education, menopausal status, hypertension, high density lipoprotein and body mass index, the risk ratio for stenosis greater than 50% in women with poor as compared to those with strong social support was 2.5 (95% confidence interval 1.2 to 5.3; \(P=0.003\)). Also, women with poor social support had more stenoses obstructing at least 20% of the coronary lumen with multivariate adjustment, but the difference from women with strong support was only of borderline significance \((P=0.09)\).

Conclusion The findings suggest that lack of social support contributes to the severity of coronary artery disease in women, independent of standard risk factors.

Key Words: Coronary disease, atherosclerosis, women, angiography, social support.

See page 1603 for the Editorial comment on this article

Introduction

Studies of social networks, social support and coronary heart disease in men have been remarkably consistent. Lack of social support, in terms of structural, quantitative and qualitative aspects have been found to increase mortality risk in previously healthy men and in men with coronary heart disease\(^{[1-10]}\). Also, new coronary heart disease events including acute myocardial infarction and sudden cardiac death were predicted by lack of social support in a Swedish male population study\(^{[11]}\). Women have been studied less frequently and results are inconsistent\(^{[12]}\).

Two large scale population studies, the Alameda County Study and the Swedish Survey of Living Conditions have shown that lack of social support increased the risk of coronary heart disease and total mortality in both men and women\(^{[3,6]}\), after controlling for standard risk factors. Other population-based studies using less elaborate measures of social support have reached inconclusive or contradictory results in women as compared to men\(^{[12]}\).

As gender differences in social relations have been clearly demonstrated, gender differences in the effects on health may also be expected\(^{[12-15]}\). However,


attempts have rarely been made to describe the various aspects of the social support concept in relation to gender or to specific disease end-points.

The Stockholm Female Coronary Risk (FemCorRisk) Study was designed to integrate psychosocial and biological risk factors for coronary heart disease in Swedish women. A population-based case-control approach was used\(^{[16]}\), in order to study all women with acute coronary heart disease events. In a subsample of the coronary heart disease patients, quantitative coronary angiography was performed using computer-assisted evaluation of angiographic films, in order to objectively assess and detect both early and advanced coronary artery disease\(^{[17,18]}\).

**Materials and Methods**

**Subjects**

In the FemCorRisk Study all patients, who between February 1991 and February 1994 were admitted with an acute event of coronary heart disease and resided in the greater Stockholm area, were asked to participate. The study group was restricted to female patients aged 65 or younger, who were Swedish speakers. The Swedish health care system provides care to all residents regardless of income, socio-economic status or insurance status. Thus we were certain to reach virtually all patients who needed and sought acute hospital care for an acute coronary heart disease event during this time. The study was approved by the Karolinska Institute Ethics Committee (No. 91:119) and all subjects gave their informed consent.

Recruitment was carried out through a network of contact nurses, working at the ten coronary care units in the Greater Stockholm area, who each week reported all hospitalized cases of suspected acute coronary heart disease events in female patients aged 65 or younger. Criteria for admission to intensive coronary care units were the same at all 10 cardiology clinics and patients were included in the study based on one of the following criteria: (1) definite or suspected acute myocardial infarction based on the World Health Organisation criteria of typical chest pain, typical enzyme patterns, and diagnostic ECG changes\(^{[19]}\) classified by the Minnesota code\(^{[20]}\); (2) unstable angina pectoris defined as severe angina pectoris of recent onset that had worsened during the 4 weeks before admission, with an increase in pain intensity and pain duration or with pain at rest or very low physical exertion\(^{[21]}\); or (3) spasmodina, defined as angina pectoris at rest with pathological ST-segment changes on an ECG and with normal coronary arteries on acute clinical coronary angiography.

During the 3-year study period, 335 women with coronary heart disease were identified in the ten units. Forty-three of the identified patients (13%) could not be included in the study. Reasons for non-response included death, disability and inability to speak Swedish fluently. Further details about recruitment have been previously reported\(^{[16]}\).

**Data collection**

A questionnaire on lifestyle factors and social support was mailed to the subjects prior to their visit to the research clinic. Subjects filled out the questionnaires at home and brought them to the clinic. The research nurse reviewed the questionnaires with the subjects and completed missing answers. Internal non-response was less than ten percent.

The first day of the study included a detailed cardiological examination and appointments for angiography. The second day included an extensive interview and questionnaire assessments of lifestyle and behavioural characteristics, anthropometric measures, and full fasting lipid and routine laboratory profiles. Anthropometric measures were obtained, after which subjects rested for 30 min. Blood pressure was measured and blood samples for lipid analyses were drawn, after which the subjects were served a standard breakfast.

**Angiographic procedures and measures**

Computer assisted quantitative angiographic evaluations were carried out in 131 of the 292 patients enrolled for the major study. Quantitative coronary angiography was performed within 3 months of the visit to the research clinic. All angiographies were carried out based on the study protocol, i.e. primarily because the patient was a participant in the FemCorRisk study. Patients who underwent quantitative angiography were compared with patients who did not undergo the procedure. No statistically significant differences in the risk factor profile were found. Age, marital status, educational level, exercise habits, cigarette smoking, medication, menopausal status, body mass index, waist-to-hip ratio, history of hypertension, diabetes mellitus and hyperlipidaemia were similar in the two groups. Of the patients who underwent angiography, 59% had a history of acute myocardial infarction compared to 50% of the non-angio patients (chi-squared=2.1, \(P=0.15\)). Residence and hospital catchment areas were equally distributed within the two groups, suggesting that referral for angiography was not dependent upon the hospital. The two measures of social support were also equally distributed in the two groups (chi-squared=3.5, \(P=0.17\) for social integration and chi-squared=1.8, \(P=0.17\) for emotional attachment). Thus, standard and psychosocial risk factors and geographical distribution did not differ in patients referred, as compared to patients not referred for quantitative angiography.

Computer-assisted quantitative analysis of angiographic films was used to objectively establish the severity and extent of coronary artery disease.
The methods have been developed over the past 10 years\cite{22,23} and have been previously described, validated and applied in a coronary artery disease progression/regression trial\cite{24}, in studies of coronary physiology\cite{17,18}, and in clinical drug trials.

Quantitative computer-assisted evaluations of angiographic films were performed at the Angiographic Image Processing Laboratory of the Division of Cardiology, University of Texas Medical School in Houston. For each angiogram, the absolute lumen diameter (mm) was measured along 10 pre-defined coronary segments (the left main coronary artery, the proximal left anterior descending coronary artery, the mid left anterior descending coronary artery, the first diagonal left anterior descending coronary artery, the proximal left circumflex, the mid left circumflex, the first obtuse marginal branch of the left circumflex, the proximal right coronary artery, the mid right coronary artery and the distal right coronary artery). From these measurements, the number of stenoses with a reduction of 20% or more in the lumen diameter, the severity (% diameter reduction, minimum diameter, length, mean stenotic diameter) of each segment, together with the segment’s average diameter were derived.

Stenoses creating a greater than 20% diameter reduction of the lumen were automatically detected in these segments, as was the projected true scale length of each segment. The total number of stenoses detected in these segments was then tabulated for each patient. Additionally, the number of coronary vessels with a stenosis greater than 50% was tabulated. Because of the small number of subjects with such stenoses in two or three vessels (n=9 and n=4, respectively), patients with one-, two- and three-vessel disease were collapsed into one group (n=53), resulting in a dichotomized variable ‘presence of stenosis greater than 50%’. In addition, a second measure of coronary artery disease was created by tabulating the ‘number of stenoses greater than 20%’ in each subject.

Nine of the 131 films could not be evaluated because of missing angiographic measures due to previous coronary artery bypass grafting. Four angiograms were excluded because of poorly documented films or failure to give the patient nitroglycerin, as indicated in the protocol. In summary, 118 patients were available for full quantitative coronary angiography analysis.

**Social support**

For the measurement of social support, a condensed version of the Interview Schedule for Social Interaction\cite{25,26} was used. This measure of social support has been modified for use in population studies, and examined for reliability and validity in our research laboratory\cite{25}. It has been found to predict cardiovascular disease in previously reported studies of Swedish men\cite{11,25}. The instrument yields two scales, one describing availability of deep emotional relationships or ‘attachments’ and the other the availability of more peripheral contacts or ‘social integration’. The attachment scale describes the availability of emotional support, mainly from family and close friends. It consists of six items with a minimum score of zero and a maximum score of six. The social integration scale describes both the quantitative characteristics of the extended network and its function. Functions include a sense of belonging, practical help and support\cite{11}. It is comprised of six items with a total score ranging from six to 36.

**Measures of standard risk factors**

Age at examination was obtained from the date of birth given in the census register. Educational level was classified into: (1) compulsory, (2) high/secondary school or some further education and (3) completion of college or university. Smoking status was categorized as: never smoked, smoked previously or currently smoking. Physical exercise was assessed according to the World Health Organisation criteria and categorized as sedentary lifestyle or non-sedentary lifestyle. Body mass index was calculated as weight (kg)/height (m$^2$) and waist-to-hip ratio as waist (cm)/hip (cm).

Menopausal status was assessed in a gynaecological interview by the research nurse. Post-menopausal status was defined as having had no menses for at least 6 months. A history of gynaecological surgery was obtained. A patient was classified as having had surgical menopause if she had undergone a bilateral oophorectomy. A complete history regarding hormone replacement therapy was also obtained. Women who had begun hormone replacement therapy before the menopause were considered menopausal if they were over 50 years of age.

A history of diabetes, of hypertension, of hyperlipidaemia and medication for these was obtained during the clinical examination and by scrutiny of hospital charts. Severity of angina pectoris symptoms was graded by the Canadian Cardiovascular Society scale for angina pectoris\cite{27}. Subjective health status was assessed by two questions about perceived general health status and degree of disability, as previously reported\cite{29}.

Total cholesterol was determined with CHOD-PAP (enzymatic cholesterol assay based on cholesterol esterase and cholesterol oxidase conversion followed by a Trinder-type sequence of reactions), and s-triglycerides with GPO-PAP (enzymatic determination of glycerol with glycerol-phosphate-oxidase (GPO) after hydrolysis with lipoprotein lipase. This quantitates the total glyceride in serum including the mono- and diglycerides and the free glycerol fractions) from Boehringer Mannheim (Germany). High density lipoproteins (HDL) were determined on the basis of the isolation by precipitation of low density lipoprotein (LDL) and very low density lipoprotein (VLDL) from serum. The cholesterol content of the supernatant, i.e., its high density lipoprotein cholesterol, was measured enzymatically.

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Statistical analyses

We used JMP Statistics for Apple Macintosh Version 3.1[29] and STATA 3.1[30] for all statistical analyses. Differences in the distribution of baseline characteristics between the angiographed and the non-angiographed group were evaluated by Kolmogorov–Smirnov tests for equality of distribution functions and by chi-square tests. To evaluate univariate associations between risk factors and severity and extent of coronary artery disease, chi-square tests and analyses of variance were performed. Spearman Rho correlations are reported. The number of stenoses >20% was not normally distributed and therefore log transformed in all analyses. Geometric means are reported. Standard errors (SEM) were estimated using the delta method. Multiple linear regression analysis was used to test the association between social support and number of stenoses greater than 20%. Least square means were estimated after controlling for other risk factors. The linear trend for the effect of social support on number of stenoses greater than 20% was assessed by computing the P-value for trend.

Risk ratios and the 95% confidence intervals for presence of stenosis greater than 50% were computed using generalized linear regression models with a logarithmic function and a binomial error structure[31]. With this approach, the model directly estimates the risk of stenosis greater than 50% among those in the lower quartiles relative to those in the upper quartile of social support measures.

Results

Seven patients had a total occlusion of at least one coronary artery. Of the 53 patients whose obstruction of at least one coronary artery was greater than 50%, 40 had one-vessel, nine two-vessel and four three-vessel disease. None of the patients was entirely free from stenoses detectable by quantitative coronary angiography. The mean number of stenoses greater than 20% in the entire group was 7·6 (SEM=2·9), ranging from 1 to 22.

The mean age in the study group was 55·5 years (SD=7·6), 57% of the women were cohabiting, and 77% of the women were currently and 23% previously employed. Patients with a low level of education had a trend towards a higher prevalence of stenosis greater than 50% (P=0·09). Patients who were previous smokers or had a waist-to-hip ratio above 0·85 had a higher prevalence of stenosis greater than 50% (P=0·05 for both associations). A history of diabetes mellitus was associated with a higher number of stenoses greater than 20% (P=0·02) and a history of hyperlipidaemia was positively associated with both the presence of a stenosis greater than 50% (P=0·02) and with the number of stenoses greater than 20% (P=0·01). All univariate associations of risk factors with atherosclerotic findings in the coronary arteries are shown in Table 1.

The scale scores on social integration were normally distributed. A comparison was made between women with low scores (lower quartile), women with intermediate scores (middle two quartiles) and women with high scores (upper quartile). The scale scores on attachment were skewed, 67% of the women having the maximum score of 6. Therefore the scale was dichotomized, using a cut off nearest the lowest quartile. Social integration was statistically significantly associated with both coronary artery disease measures but attachment was not.

After adjustment for age, education, menopausal status, history of hypertension, smoking, body mass index and HDL, the risk ratio for stenosis greater than 50% among women in the lower, relative to women in the upper social quartile, was 2·5 (95% confidence interval 1·2–5·3), while that of women in the two middle quartiles was 2·0 (95% confidence interval 0·9–4·3) (P-trend=0·003) (Table 2). Similarly, after multivariable adjustment, women in the lower social support quartile had 28% (95% confidence interval 6% to 75%) more stenoses greater than 20%, compared to women in the upper quartile. The multivariable adjusted means were 8·3 vs 6·6 (P-trend=0·09) (Table 2). Further adjustment for diabetes, total cholesterol and physical exercise yielded similar results. When analyses were repeated, treating social integration and attachment as continuous scales, similar results were obtained.

Poor social integration was significantly associated with a sedentary lifestyle (r=0·20, P=0·02). None of the other standard risk factors were significantly associated with social support scales. The proportion of women with a history of acute myocardial infarction was 66% in the low social support group, 57% in the intermediate group and 56% in the high social support group (chi-squared=0·85, P=0·66).

Social integration was associated with angina pectoris severity, as measured by the Canadian Cardiovascular Society scale; (r=0·20, P=0·03) but not with subjective health status (r=−0·01, P=0·91). Both angiographic outcome variables were unrelated to angina pectoris severity or to subjective health status. When the multivariate analyses were repeated, adjusting for subjective health status or angina pectoris severity, social integration remained a significant determinant of severity and extent of coronary artery disease. In addition, repeating the analyses in the subgroup of women hospitalized for acute myocardial infarction, did not substantially alter the results.

Discussion

In this study, we found that women with poor social support had more severe and more extensive coronary artery disease as measured by quantitative coronary angiography, than women with good social support. After adjustment for standard risk factors, women with poor, as compared to women with good, support had a
### Table 1 Association of risk factors with extent and severity of coronary artery disease (n=118)

<table>
<thead>
<tr>
<th>Risk factors</th>
<th>n</th>
<th>Presence of stenosis &gt;50%</th>
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<th>Number of stenoses &gt;20%</th>
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<tr>
<td></td>
<td></td>
<td>No (n=65) %</td>
<td>Yes (n=53) %</td>
<td>P</td>
<td>Mean</td>
</tr>
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<td></td>
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<td>21</td>
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<td>51–60</td>
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<td>61–65</td>
<td>38</td>
<td>29</td>
<td>36</td>
<td></td>
<td>7·5</td>
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<td>Education</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Compulsory</td>
<td>77</td>
<td>58</td>
<td>74</td>
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<td>High secondary school/university</td>
<td>41</td>
<td>42</td>
<td>26</td>
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<td>7·0</td>
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<td>Smoking</td>
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<td></td>
<td></td>
<td></td>
</tr>
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<td>34</td>
<td>36</td>
<td>21</td>
<td></td>
<td>7·7</td>
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<tr>
<td>Previous</td>
<td>63</td>
<td>44</td>
<td>66</td>
<td></td>
<td>7·7</td>
</tr>
<tr>
<td>Current</td>
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<td>13</td>
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<td></td>
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<td>31</td>
<td>25</td>
<td></td>
<td>7·1</td>
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<td>Post with hormones</td>
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<td>12</td>
<td>8</td>
<td></td>
<td>6·7</td>
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<tr>
<td>Post without hormones</td>
<td>73</td>
<td>57</td>
<td>67</td>
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<td>BMI &gt;28·6</td>
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<td>Abdominal fat distribution</td>
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<td>63</td>
<td>62</td>
<td>43</td>
<td></td>
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<td>57</td>
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<td>55</td>
<td>51</td>
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<tr>
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<td>52</td>
<td>45</td>
<td>49</td>
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<td>History of diabetes mellitus</td>
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</tr>
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<td>77</td>
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<tr>
<td>Yes</td>
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<td>12</td>
<td>23</td>
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<td>History of hyperlipidaemia</td>
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<tr>
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<td>99</td>
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<td>75</td>
<td></td>
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<tr>
<td>Yes</td>
<td>19</td>
<td>9</td>
<td>25</td>
<td>0·02</td>
<td>10·3</td>
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<tr>
<td>Social integration</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>38</td>
<td>25</td>
<td>42</td>
<td></td>
<td>8·7</td>
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<tr>
<td>Intermediate</td>
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<td>45</td>
<td>47</td>
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<td>7·5</td>
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<tr>
<td>High</td>
<td>25</td>
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<td>11</td>
<td>0·01</td>
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<tr>
<td>Attachment</td>
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<td>Low</td>
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<td>29</td>
<td>38</td>
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<td>8·3</td>
</tr>
<tr>
<td>High</td>
<td>77</td>
<td>71</td>
<td>62</td>
<td>0·32</td>
<td>7·2</td>
</tr>
</tbody>
</table>

SEM ± Standard error of mean; BMI=body mass index; WHR=waist to hip ratio.

### Table 2 Association between social support and severity and extent of coronary artery disease (n=118)

<table>
<thead>
<tr>
<th>Social integration</th>
<th>Low</th>
<th>Intermediate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤16 (n=38)</td>
<td>17–24 (n=54)</td>
<td>25–36 (n=25)</td>
</tr>
<tr>
<td>RR (95% CI)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of stenosis greater than 50%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age-adjusted risk ratio</td>
<td>2·37 (1·13–4·96)</td>
<td>1·89 (0·90–3·99)</td>
<td>1</td>
</tr>
<tr>
<td>Multivariable-adjusted risk ratio*</td>
<td>2·54 (1·22–5·31)</td>
<td>2·01 (0·94–4·32)</td>
<td>1</td>
</tr>
<tr>
<td>LSM ± SEM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of stenoses greater than 20%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age-adjusted LSM</td>
<td>8·65 ± 0·78</td>
<td>7·47 ± 0·56</td>
<td>6·27 ± 0·69</td>
</tr>
<tr>
<td>Multivariable-adjusted LSM*</td>
<td>8·25 ± 1·03</td>
<td>7·38 ± 0·87</td>
<td>6·57 ± 0·94</td>
</tr>
</tbody>
</table>

*Adjusted for age, smoking, education, menopausal status, history of hypertension, body mass index and cholesterol/HDL ratio. RR (95% CI)=risk ratio (95% confidence interval). LSM=least squares mean; SEM=standard error of mean.
Other than its cross-sectional design, other possible limitations of the study need to be considered. Selection bias may have impaired the representativeness of the study group at several stages. Although lower in women than in men, a substantial proportion of people with coronary heart disease never reach hospital because the first manifestation of the disease is sudden or non-sudden cardiac death. An average of 20% to 30% of female acute myocardial infarction patients of this age have been reported to die before reaching a hospital[37]. Morrison et al. reported this percentage to be 32% in women from the city of Glasgow aged 25 to 64 years[38]. A further group of patients not included in our study are those who died between admission to acute care and angiographic examination (n=5). Since poor social support is known to be strongly related to mortality[37], survival bias could have distorted the distribution of social support in our study. The effect of such a bias, however, would most likely lead to an under-estimation of the true strength of the association.

A further possible source of selection bias that needs to be considered is that women with low social support may delay going to hospital until their symptoms are very severe. Or conversely, the threshold for women with high social support to attend a hospital may be lower than that for women with low social support. If this occurred it could explain the findings of the present study. In an attempt to investigate this possibility we repeated our analyses in the more homogeneous subgroup of women hospitalized for acute myocardial infarction. This did not change the results, indicating that the association between low social support and coronary artery disease severity continues to exist in a sample with a more homogeneous clinical presentation. Selection bias could still have occurred where, despite a similar clinical presentation, women with low social support who had an acute myocardial infarction were less likely to be admitted to hospital unless they had severe stenoses. Conversely, women with strong social supports who had an acute myocardial infarction were admitted to hospital no matter how severe their stenoses. Although possible, this seems very unlikely.

Another potential source of selection bias in our study is that we were able to include only about half of the patients from the quantitative angiographic evaluation. Whether or not a patient was referred to quantitative coronary angiography depended largely upon the availability of personnel and space for the relatively resource- and time-consuming quantitative procedures. A comparison of angiographed with non-angiographed patients revealed a somewhat higher prevalence of previous acute myocardial infarction (59% vs 50%), but no differences in age, medication, history of hypertension, diabetes or hyperlipidaemia, or smoking, exercise, obesity or menopausal status. It is conceivable that a patient’s lack of social support may have decreased the likelihood of referral to an angiographic procedure, unless the patient had severe disease, resulting in an over-estimation of the association between social support and coronary artery disease. However, distributions
of social support scale scores were similar in the quantitative coronary angiography and non-quantitative coronary angiography group.

Possible mechanisms of the social support–coronary artery disease relationship

Social networks and social support fulfil basic human needs. They lay a foundation of emotional trust, leading to feelings of closeness and affection. In addition, such support answers basic needs, such as help in coping with stress and dealing with problems of daily life. It also provides a sense of belonging, the sharing of values and interests with other people. Lack of resources to meet these needs leads to health-damaging lifestyles, such as smoking and physical inactivity, but also seems to increase disease susceptibility by increasing neuroendocrine responses to stressors encountered in daily life\(^1\). Controlling for standard risk factors, including smoking and sedentary lifestyle did not abolish the association, so it is plausible that neuroendocrine factors play a role in women.

The social integration scale primarily describes the support derived from the peripheral network outside home, from co-workers, neighbours, relatives and friends. Colleague support is important as it provides a buffer against risk of coronary heart disease associated with psychosocial stress at work in both men and women\(^{39}\). In our study, all women were currently (77%) or previously (23%) employed outside the home, thus they all had at least a theoretical opportunity to receive support from co-workers.

In contrast, lack of attachment, such as that provided by emotional support from close friends and family, was not significantly related to coronary artery disease. These results are consistent with results by Seeman and Syme\(^{32}\), who found no significant association between emotional support and extent of coronary atherosclerosis. The authors attributed this to a possible measurement bias due to the social desirability of reporting that emotional support is available from family and/or close friends. The possibility of such bias was further suggested by the fact that only 8% of their sample reported no such network of emotional support\(^{32}\). In the present study, the emotional support measure was also found to be skewed, with only 4% reporting no emotional support. However, the same attachment scale was used in a previous study of Swedish men, and found to be equally skewed, but still predictive of coronary heart disease over a 6-year follow-up period, while controlling for standard risk factors\(^{11}\). A gender difference in the effects of close emotional support may explain differences in the relationship of emotional support to coronary artery disease. Emotional ties may sometimes be perceived as more stressful than supportive by women, as they may be associated with both emotional distress and family responsibilities\(^{40}\). These negative effects could counterbalance the supportive effects to produce a zero net effect of emotional support in women.

Studies of behavioural models in non-human primates may be helpful in understanding these relationships. Shively and co-workers have shown that female cynomolgus monkeys experience advancing coronary atherosclerosis when exposed to the stress of social isolation and subordination. Social subordination was characterized by receiving aggression from others, engaging in less affiliative behaviour and spending more time alone\(^{41}\). In our study, women with more advanced coronary artery disease had fewer social contacts and were more socially isolated. They also more often had had a poor education (of borderline statistical significance), a measure often used to describe low social status in society.

Animal studies may also be helpful in understanding the mechanisms through which social support influences the development of coronary artery disease. Our data, as well as that of other studies, suggest that the association is not merely a function of support leading to better standard risk profiles or health practices\(^{42,43}\). We found that standard risk factors, such as smoking, lack of exercise, high lipid levels and obesity did not explain the associations.

Lack of social support may be associated with emotional stress that influences neuroendocrine response patterns. Chronically elevated neuroendocrine stress responses may damage the arterial wall and facilitate other pathogenic processes involved in coronary artery disease\(^{42}\). In female cynomolgus macaques both social isolation and severity of coronary artery atherosclerosis were associated with impaired ovarian function, suggesting that part of the effect of social stress on atherosclerosis may be mediated by poor ovarian function\(^{43–45}\).

In our study, none of the women was entirely free of stenotic changes. Two women had only one detectable luminal narrowing of 20% and more than half (55%) the women had no coronary stenosis obstructing more than half of the lumen. This percentage has been previously reported to be lower in women as compared to men. In the Australian study, which comprised 594 consecutive patients (167 women), aged 65 years or under, only 54% of the women, as compared to 84% of the men, had at least one major coronary artery with a stenosis greater than 50%\(^{34}\). In a study by Romm et al. of 197 patients (72 women) who were referred to angiography for chest pain, 75% of the women and 85% of the men had a greater than 25% diameter stenosis in at least one major coronary artery\(^{35}\).

More than half of the patients (60%) had suffered a definite acute myocardial infarction and 40% had unstable angina pectoris or spasmangina. Twenty-three percent of the angina patients had a stenosis greater than 50%, as compared to 59% of the acute myocardial infarction patients. This finding is in accordance with more recent studies, showing that clinical symptoms and cardiac events are not always correlated with the degree of atherosclerotic changes, as expressed by percent lumen diameter obstruction of the coronary arteries. Several progression–regression studies have shown that
very small changes in the lumen diameters and athero-
sclerotic scores may correlate with important clinical
events, such as acute myocardial infarction, recurrent
angina and death[46]. Furthermore, it is now well
recognized that the majority of cases of acute myocardial
infarction and unstable angina are caused by plaque
disruption followed by intracoronary thrombosis[47–49].
Furthermore, the culprit lesion in many cases occurs at
the site of a vulnerable, but not necessarily severely
stenotic coronary plaque[47,48,50]. Therefore, studying
the occurrence of less severe stenoses (e.g. number of lesions
greater than 20%) may be an important indicator of
severity of coronary artery disease.

In summary, the results of this study demonstrate
a relationship between lack of social support and
severity of coronary artery disease in women, as
measured by quantitative coronary angiography. These
findings suggest that social factors, in particular support
from the peripheral network, need to be considered in
treatment, rehabilitation and even prevention of ad-
vanced coronary disease in women. A study of such
interventions is now under way[51].

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