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Associations between emotional support and cardiovascular risk factors and subclinical atherosclerosis in middle-age

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ABSTRACT

Objective: To test the hypothesis of low emotional support being associated with lifestyle and biomedical cardiovascular disease (CVD) risk factors, estimated risk of CVD morbidity and mortality, and subclinical atherosclerosis in middle-aged healthy adults.

Methods and measures: Cross-sectional data were obtained from participants aged 40–60 years who had one or more conventional CVD risk factor. They underwent assessment based on questionnaires, clinical examination, blood sampling, and carotid ultrasound of plaque formation and carotid intima-media wall thickness (cIMT). Based on the Interview Schedule for Social Interaction, the participants were categorised as either low in emotional support (\(n=884\)) or as a referent (\(n=2570\)). Logistic regression analyses were conducted to study the associations.

Results: Logistic regression analyses showed that low emotional support was significantly associated with smoking, alcohol consumption and physical inactivity (OR = 1.53–1.94), estimated risk of CVD morbidity and mortality (OR = 1.56–1.68), and plaque formation (OR = 1.39). No significant associations were found regarding biomedical CVD risk factors or cIMT.

Conclusion: The findings suggest that low social support is associated with lifestyle CVD risk factors, estimated risk of CVD morbidity and mortality, and subclinical atherosclerosis in middle-aged healthy adults, encouraging causal evaluation with longitudinal data investigating an impact of emotional support on mechanisms underlying CVD.

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Introduction

Cardiovascular disease (CVD) is the leading global cause of death, accounting for more than 17.6 million deaths per year, a number that is expected to grow to more than 23.6 million by 2030 (Benjamin et al., 2019). A large majority of CVD events are caused by modifiable factors related to lifestyle (World Health Organization, 2007), including psychosocial factors causing long-term stress (Rosengren et al., 2004). A growing body of evidence demonstrates that psychosocial stress is an important and often underestimated risk factor for CVD (Kronenberg et al., 2017). According to early documentation, repeated episodes of acute or chronic psychogenic stress activate the sympathetic nervous system, the hypothalamic pituitary axis, and the renin angiotensin system, causing chronic inflammatory changes which may result in atherosclerosis (Black, 2002). Hence, atherosclerosis may develop as a result of psychosocial stressors (Black & Garbutt, 2002; Serban & Dragan, 2014; Kattoor et al., 2017). Overall degree of psychological strain (e.g. fatigue, depression and anxiety) has been shown to be associated with carotid atherosclerosis (Wolff et al., 2005).

Social support has a positive effect on mood and sense of control, buffering against the impact of stress, and contributing to promotion of health-related lifestyle and prolonged life (Bowen et al., 2014; Cohen & Wills, 1985; House et al., 1988; Holt-Lunstad et al., 2015; Uchino, 2006). The extent to which the support is perceived by the person is more health-promoting than the extent to which the support is provided (Barrera, 1986), and has been shown to be associated with CVD incidence and mortality (Brummett et al., 2001; Frasure-Smith et al., 2000; Nagayoshi et al., 2014). Instrumental, informative and emotional support have been identified as important components of social support (Berkman & Krishna, 2014; Lakey & Cohen, 2000), of which emotional support appears to buffer strongest against a CVD event (Greenwood et al., 1996; Williams et al., 1992). Emotional support covers aspects such as confirmation, comfort and encouragement. Affection is an important social function regarding emotional support, and typically refers to the experience of emotional closeness that brings a sense of security and well-being (Cutrona & Russell, 1983).

Biological sex and gender may play important roles in this context. They have been reported to shape adoption of a healthy lifestyle (e.g. physical activity, smoking and alcohol consumption), play a role in psychosocial stress with regards to a variety of stresses, and explain differences in CVD burden, for example in terms of autonomic functioning (O’Neil et al., 2018). Early work on social support has shown that social connectedness varies considerably by gender (Vaux, 1985). Women report larger and more varied social networks and more social support than men (Paskulin & Vianna, 2007; Shye et al., 1995), whereas men tend to have intimate relationships with only a few people (Antonucci & Akiyama, 1987). This motivates the study of CVD risk factors related to sex/gender.

CVD prevention efforts are often focused on persons at high risk of CVD, whereas 60–70% of acute CVD events (e.g. myocardial infarction, stroke and aneurysm) occur among those at low or moderate risk (Polonsky & Greenland, 2012). Hence, improved CVD prevention calls for investigation of its risk factors in conditions that precede CVD events, such as subclinical atherosclerosis. To take this a step further, the aim of the present study was to better understand the role of low emotional support,
not only in relation to subclinical atherosclerosis, but in relation to several conventional CVD risk factors as well, in a population-based sample of persons with low or intermediate risk of CVD.

The objective of the present study was to test the hypothesis of low emotional support being associated with (i) lifestyle CVD risk factors, (ii) biomedical CVD risk factors, (iii) algorithm-based scores on 10-year risk of CVD morbidity and mortality, and (iv) measures of subclinical atherosclerosis. This was addressed by conducting binary logistic regression analysis on a total sample as well as by stratifying for sex.

**Materials and method**

**Study design and population**

Baseline data were used from the Visualisation of Asymptomatic Atherosclerotic Disease for Optimum Cardiovascular Prevention (VIPVIZA) trial. This is a randomised controlled trial nested within the Västerbotten Intervention Program (VIP) in Northern Sweden (Norberg et al., 2010; Näslund et al., 2019), with the overall aim to investigate whether pictorial representation of subclinical carotid atherosclerosis, based on ultrasound examination, has an impact on adherence to lifestyle and pharmacological preventive treatment. The VIP, on which VIPVIZA is based, is a population-based screening and prevention program for CVD and diabetes. In this program, inhabitants in the Västerbotten County at the age of 40, 50, or 60 years are invited to a primary healthcare survey. The survey includes assessment with questionnaire (e.g. psychosocial factors and lifestyle) and examinations (e.g. BMI, blood pressure, and blood glucose and lipids) as well as an individual motivational interview to promote a healthy lifestyle, and pharmacological CVD prevention. Participation rates during 2007–2016 were 68%, with minor social selection bias (Blomstedt et al., 2015; Norberg et al., 2010, 2012).

VIP participants with predominantly low or intermediate risk of CVD (Näslund et al., 2019) were invited to the VIPVIZA (n=4177) when participating in the VIP based on the following inclusion criteria: (1) aged 40 years and having a first-degree relative with a history of CVD when younger than 60 years; (2) aged 50 years and having at least one CVD risk factor (smoking, diabetes, hypertension, serum LDL cholesterol of ≥4.5 mmol/L, abdominal obesity defined as a waist circumference of ≥102 cm for men and ≥88 cm for women, or a first-degree relative with a history of CVD when younger than 60 years); or (3) aged 60 years (irrespective of other CVD risk factors). Of the 4177 invited persons, in total 645 were excluded due to declining participation (n=345), withdrawing consent (having changed their mind regarding participation; n=121), dying before ultrasound examination (n=3), not showing up at appointment for ultrasound examination (n=154), and significant stenosis (≥50% luminal narrowing) detected by ultrasound examination (n=22, resulting in referral to healthcare). The participants (n=3532) were enrolled from April 2013 to June 2016. The VIPVIZA was approved by the Regional Ethical Review Board, Umeå (Dnr 2011-445-31 M, 2012-463-32 M, 2013-373-32 M). Written informed consent was obtained from all participants.
Emotional support

Perceived emotional support, referring to availability of deep emotional relations, was assessed with a modified version of the Availability of Attachment (AVAT) subscale of the Interview Schedule for Social Interaction (Henderson et al., 1980), using six of the original eight items. This, presently used, version has been shown to provide results very similar to those obtained with the original version when studying CVD (Undén & Orth-Gomér, 1984), and to have satisfactory construct and discriminant validity (Eklund et al., 2007). The items are (1) ‘Is there someone special from whom you really can feel support?’, (2) ‘Is there someone special who feels close to you?’, (3) ‘Is there someone special with whom you share feelings of happiness?’, (4) ‘Is there someone with whom you can share your inner thoughts?’, (5) ‘Does anyone ever hold or embrace you to give comfort and support?’, and (6) ‘Do you think people, those at home or others, really appreciate what you do for them?’ The third, fourth and fifth items have the response alternative ‘Yes’ or ‘No’, whereas the first, second and sixth items have the additional response alternatives ‘Yes, but I do not need it’, ‘I am not sure’ and ‘Not enough’, respectively. The mean number of ‘Yes’ responses constituted the presently used score on emotional support, which could range from 0 to 6. The internal consistency according to the Kuder-Richardson 20 test for the present sample was 0.761. For the logistic regression analyses, the quartiles were determined for the entire sample, and the participants in the quartile with the lowest score were considered as low emotional support, and the remaining participants were considered as high in emotional support, referred to as referents. Dichotomisation of emotional support using an arbitrary cutoff at the first quartile enables presentation of the results as an odds ratio that is easy to interpret. However, it also implies an information loss in data and a possible loss of power. Therefore, the hypothesis was also tested using emotional support as a continuous variable by applying restricted cubic spline regression in a complementary analysis. For the cubic spline analyses, the proportion of a full score (6) was used.

Lifestyle and biomedical risk factors and morbidity and mortality risk scores

Data from questionnaires and examinations that VIPVIZA participants completed in the baseline VIP survey were used (Norberg et al., 2010). Single questionnaire-based questions were used to assess smoking habits and physical activity, and the Alcohol Use Disorders Identification Test (AUDIT; Babor et al., 2001) was used to assess alcohol consumption. Blood samples were drawn for measurement of lipids and glucose, and waist circumference and blood pressure were measured as well. The sex-specific algorithms Framingham Risk Score (FRS; D'Agostino et al., 2008) and the European Systematic Coronary Risk Evaluation (SCORE; Piepoli et al., 2016) were used to assess a combination of 10-year risk of (non-fatal) CVD morbidity and mortality, and 10-year risk of CVD mortality, respectively, based on well-documented cardiovascular risk factors. Further descriptions of the variables used in the statistical analyses are given in Table 1.
Ultrasound examination of atherosclerosis

Atherosclerosis was assessed with ultrasound examination, which provided information on prevalence of plaque and carotid intima-media thickness (cIMT). The examination was performed by trained sonographers, following standardised protocol (Stein et al., 2008), using a portable ultrasound instrument with real-time automatic cIMT measurements (CardioHealth Station, Panasonic Healthcare Corporation of North America, Newark, NJ, USA; Vanoli et al., 2013). cIMT was measured automatically in the left and right common carotid arteries at insonation angles 120, 150, 210, and 240 degrees (Touboul et al., 2012). The highest of the mean values of the cIMT measurements, irrespective of side and angle, was used as a continuous variable, whereas its categorisation into the highest quartile vs the three lowest quartiles was used as a categorical variable. Atherosclerotic plaque was assessed on both carotid sides according to the Mannheim consensus (Stein et al., 2008; Nyman et al., 2020). Prevalence of plaque was defined as having plaque on either one or both sides. See also Table 1.

Statistical analysis

Participants were excluded from further analysis due to missing values on the main variables emotional support and atherosclerosis. These participants were compared with included participants on variables used in the main analyses, using independent t-tests and χ² analyses. Such analyses were also conducted to compare the group with low emotional support and the referent group on background variables, for the total sample and separately for men and women.

Binary logistic regression analyses were conducted to study associations, expressed as odds ratios (ORs), between low emotional support and the lifestyle and biomedical CVD risk factors, and ultrasound measures of atherosclerosis, adjusted for age and education level, and FRS and SCORE adjusted for education level. Again, analyses were conducted for the total sample as well as separately for men and women, with corresponding reference groups as referents.

Table 1. Criteria for risk factors for cardiovascular disease (CVD).

<table>
<thead>
<tr>
<th>CVD risk factor</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoking</td>
<td>Presently or occasionally smoking cigarettes, cigars and/or pipe</td>
</tr>
<tr>
<td>Alcohol consumption</td>
<td>Probably risky alcohol consumption or probably alcohol dependence based on AUDIT score*</td>
</tr>
<tr>
<td>Physical inactivity</td>
<td>Neither (i) regular leisure exercise, (ii) ≥3 h/week moderately strenuous activities, nor (iii) moderate leisure exercise and ≥1 h/week moderately strenuous activities</td>
</tr>
<tr>
<td>Abdominal obesity</td>
<td>≥102/88 cm in waist circumference in men/women</td>
</tr>
<tr>
<td>Hypertension</td>
<td>Systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg, and/or antihypertensive medication in the past 2 wk</td>
</tr>
<tr>
<td>Hypercholesterolemia</td>
<td>Low-density lipoprotein cholesterol ≥4.5 mmol/L and/or lipid-lowering medication in the past 2 wk</td>
</tr>
<tr>
<td>Fasting hyperglycemia</td>
<td>Fasting serum glucose ≥6.1 mmol/L</td>
</tr>
<tr>
<td>Morbidity/mortality</td>
<td>Moderate to high (≥10%) 10-year risk of CVD morbidity or mortality risk (FRS)</td>
</tr>
<tr>
<td>Mortality risk (SCORE)</td>
<td>Moderate to very high (≥1%) 10-year risk of CVD mortality</td>
</tr>
<tr>
<td>Carotid plaque</td>
<td>Plaque on right and/or left side</td>
</tr>
<tr>
<td>cIMT</td>
<td>Highest cIMT quartile</td>
</tr>
</tbody>
</table>

Note: AUDIT = Alcohol Use Disorders Identification Test; *≥8 for men and ≥6 for women; FRS = Framingham Risk Score; SCORE = European Systematic Coronary Risk Evaluation; cIMT = carotid intima-media thickness.

Ultrasound examination of atherosclerosis

Atherosclerosis was assessed with ultrasound examination, which provided information on prevalence of plaque and carotid intima-media thickness (cIMT). The examination was performed by trained sonographers, following standardised protocol (Stein et al., 2008), using a portable ultrasound instrument with real-time automatic cIMT measurements (CardioHealth Station, Panasonic Healthcare Corporation of North America, Newark, NJ, USA; Vanoli et al., 2013). cIMT was measured automatically in the left and right common carotid arteries at insonation angles 120, 150, 210, and 240 degrees (Touboul et al., 2012). The highest of the mean values of the cIMT measurements, irrespective of side and angle, was used as a continuous variable, whereas its categorisation into the highest quartile vs the three lowest quartiles was used as a categorical variable. Atherosclerotic plaque was assessed on both carotid sides according to the Mannheim consensus (Stein et al., 2008; Nyman et al., 2020). Prevalence of plaque was defined as having plaque on either one or both sides. See also Table 1.
The associations between emotional support and the lifestyle and biomedical CVD risk factors, and ultrasound measures of atherosclerosis were further investigated using corresponding logistic regression models, but where emotional support was modelled as a continuous variable using restricted cubic splines with three knots placed at the proportions 0.125, 0.5, and 0.875 of full emotional support. This analysis allowed for estimation of non-linear associations between emotional support and outcome.

Post-hoc analyses of covariance (ANCOVAs) were conducted to investigate which specific items of the AVAT subscale that were associated with FRS score. The AVAT items (‘yes’ vs ‘No’) were the statistical independent variables, and FRS score the dependent variable, with education level as covariate.

The α-level was set at 0.05 for all analyses. Statistical analyses were performed using the Statistical Package for the Social Sciences (IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY) and R version 4.1.3.

Results

Study sample

Since emotional support and subclinical atherosclerosis were considered as main variables, 78 (2.2%) participants with missing values on at least one of these variables were excluded from further analyses (AVAT: \( n = 76 \); carotid plaque: \( n = 2 \); cIMT: \( n = 0 \)), leaving 3454 participants in the sample. The excluded group did not differ significantly from the included group on any of the, in total, 24 variables used in the analyses, with the exception of the excluded group having higher prevalence of hypertension.

Among the 3454 participants, 884 (25.6%) constituted the quartile with the lowest score on emotional support (≤0.83), and thus constituted the low emotional support group, and the remaining 2570 constituted a reference group. Corresponding sample sizes were 530 (32.6%) and 1095 for men, and 354 (19.4%) and 1475 for women, respectively. Mean ± SD score on emotional support was 0.89 ± 0.21 for men, 0.94 ± 0.16 for women, and 0.92 ± 0.19 for the total sample. The groups are described in Table 2. In general, the low support groups, compared to their reference group, were slightly younger, had lower education, were less likely to live with a partner and to be involved in social leisure activities, were more likely to be unemployed/early retiree, had poorer self-rated health and higher body mass index, and were more likely to have reported diabetes.

Associations with low emotional support

Percentages of the participants in the low emotional support group who meet criteria for the various CVD risk factors are presented in Figure 1. Depending on sex, the prevalence rates varied between 6.0 and 39.6% for lifestyle CVD risk factors, between 13.4 and 60.9% for biomedical CVD risk factors, between 18.6 and 78.0% for 10-year risk of CVD morbidity and mortality, and between 23.5 and 50.8% for measures of atherosclerosis. After adjustment, all ORs for the lifestyle risk factors were significantly larger than unity (OR: 1.29–2.23), except for risky alcohol consumption in women. In
contrast, none of the ORs for the biomedical risk factors differed significantly from unity, except for fasting hyperglycemia in men (OR: 1.36). The ORs were significantly larger than unity for 10-year risk of morbidity and mortality for the total sample (OR: 1.56–1.68), but not for the sexes separately. Regarding the measures of atherosclerosis, the OR was significantly larger than unity for carotid plaque in the total sample and in men (OR: 1.35–1.39), but not in women, and not for cIMT in any group.

Figure 2 shows results from the cubic spline analyses. Smoking, alcohol consumption, physical inactivity, CVD morbidity and mortality risk, and carotid plaque were all significantly associated with emotional support. In contrast, abdominal obesity, hypertension, hypercholesterolemia, fasting hyperglycemia, and cIMT were not statistically associated with emotional support.

Due to the significant association between emotional support and CVD morbidity and mortality risk, post-hoc ANCOVAs were conducted to investigate which specific aspects of emotional support that were associated with risk of CVD morbidity and mortality (FRS score) in the total sample. The ANCOVAs showed that the AVAT items ‘Is there someone special who feels close to you?’ (F = 13.13, p < 0.001), ‘Is there someone special with whom you share feelings of happiness?’ (F = 27.23, p < 0.001), ‘Is there someone with whom you can share your inner thoughts?’ (F = 26.85, p < 0.001), ‘Does anyone ever hold or embrace you to give comfort and support?’ (F = 106.75, p < 0.001), and ‘Do you think people, those at home or others, really appreciate what you do for them?’ (F = 7.28, p = 0.007) were significantly associated with FRS score.

Table 2. Description of the participants with low emotional support and corresponding reference groups.

<table>
<thead>
<tr>
<th></th>
<th>Total sample</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low support</strong></td>
<td>55.2 (6.7)*</td>
<td>55.2 (6.8)**</td>
<td>55.2 (6.4)**</td>
</tr>
<tr>
<td><strong>Referents</strong></td>
<td>55.8 (6.3)</td>
<td>55.7 (6.3)</td>
<td>55.9 (6.3)</td>
</tr>
<tr>
<td><strong>Age in years, mean (SD)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Highest education</strong>, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>95 (10.8)***</td>
<td>62 (11.7)**</td>
<td>33 (9.4)***</td>
</tr>
<tr>
<td>Medium</td>
<td>542 (61.5)</td>
<td>336 (63.5)</td>
<td>206 (58.5)</td>
</tr>
<tr>
<td>High</td>
<td>244 (27.7)</td>
<td>131 (24.8)</td>
<td>113 (32.1)</td>
</tr>
<tr>
<td><strong>Living with partner</strong>, n (%)</td>
<td>548 (62.0)***</td>
<td>325 (61.8)***</td>
<td>223 (63.5)***</td>
</tr>
<tr>
<td>≤ 2 times/year</td>
<td>528 (59.7)***</td>
<td>318 (60.0)***</td>
<td>210 (59.3)***</td>
</tr>
<tr>
<td>Unemployed or early retiree</td>
<td>98 (11.1)**</td>
<td>60 (11.3)**</td>
<td>38 (10.7)**</td>
</tr>
<tr>
<td><strong>Self-rated health</strong>, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good or very good</td>
<td>547 (61.9)***</td>
<td>1959 (76.3)</td>
<td>197 (55.8)***</td>
</tr>
<tr>
<td>Fairly good</td>
<td>255 (28.9)</td>
<td>145 (27.4)</td>
<td>110 (31.2)</td>
</tr>
<tr>
<td>Poor or rather poor</td>
<td>81 (9.2)</td>
<td>35 (6.6)</td>
<td>46 (13.0)</td>
</tr>
<tr>
<td><strong>Body mass index, mean (SD)</strong></td>
<td>28.1 (5.2)*</td>
<td>28.4 (4.8)**</td>
<td>27.6 (5.8)**</td>
</tr>
<tr>
<td><strong>Self-reported diabetes</strong>, n (%)</td>
<td>42 (4.8)**</td>
<td>37 (7.0)***</td>
<td>5 (1.4)**</td>
</tr>
</tbody>
</table>

Note: *Low = compulsory 9 years of schooling, medium = senior high school (≤ 12 years), high = 13 years or more of schooling. **p < 0.05, ***p < 0.01, ***p < 0.001, ns non-significant.
In contrast, the item ‘Is there someone special from whom you really can feel support?’ was not significantly associated with FRS score ($F = 2.30, p = 0.129$).

**Discussion**

The results supported to a large extent the hypothesis of associations between low emotional support, on the one hand, and separate measures of conventional CVD risk factors and subclinical atherosclerosis, on the other. Thus, low emotional support was associated with (i) each of the lifestyle CVD risk factors (although not alcohol consumption in women), (ii) 10-year risk of CVD morbidity and mortality (although not in men or women separately), and (iii) presence of carotid plaque (although not in women). However, low emotional support was not found to be associated with neither biomedical CVD risk factors (except for fasting hyperglycemia in men) nor cIMT. The lack of an association with biomedical factors may be explained by emotional support predominantly promoting health-related lifestyle factors or habits (e.g. Cohen & Wills, 1985), which, in turn, may affect biomedical factors. The results from the cubic spline analyses correspond very well with the results from the logistic regression analyses; the CVD risk factors were found to be associated with emotional
Figure 2. Results from logistic regression using cubic splines, with emotional support as a statistical predictor of various risk factors for cardiovascular disease, adjusted for age and education, showing 95% confidence interval bands. The horizontal dashed line represents an or of 1, i.e. a null effect. LDL = low-density lipoprotein; FRS = Framingham Risk Score; SCORE = European Systematic Coronary Risk Evaluation; cIMT = carotid intima-media thickness.
support, both when dichotomising it and when treating it as a continuous variable. This strengthens the conclusions of the results.

It has been shown that the relationship between emotional support and high-density lipoprotein cholesterol is significantly attenuated by physical inactivity and alcohol consumption in persons at risk for CVD (Aggarwal et al., 2008). However, whether lifestyle CVD risk is mediating an association between low emotional support and biomedical CVD risk requires longitudinal analysis.

Comparable with our result, Wolff et al. (2005) found psychological strain to be associated with plaque formation, but not with cIMT. They explain their findings in terms of plaque formation and intima media thickening (IMT) being pathologically distinct processes, acting on different initiators. This may also explain the present findings of emotional support being associated with plaque formation, but not cIMT.

Turning from a relative to an absolute perspective, the prevalence of CVD risk factors in low emotional support differed within the groups of risk factors. Based on the presently used criteria, physical inactivity was most common among the lifestyle risk factors, and abdominal obesity and hypertension among the biomedical factors. This implies that a relatively large proportion of the population can benefit from interventions aiming at increasing physical activity and contributing to better control of abdominal obesity and hypertension. Accordingly, 14% of the general Swedish population report sedentary leisure time, and 51% report overweight or obesity (Public Health Agency of Sweden, 2020). The presently found association between physical activity and emotional support suggests that strengthening emotional support may enhance the interventions.

Certain comparisons between men and women are worthwhile making. A considerably larger proportion of men (32.6%) compared to women (19.4%) met the criterion for low emotional support, which is in accordance with prior findings (Antonucci & Akiyama, 1987). Although there are several exceptions, the associations between low emotional support and individual CVD risk factors tended to be generally stronger in men than in women. An example is risky alcohol consumption/alcohol dependency for which the increased risk, if perceiving low support, was 2–3-fold in men, whereas no significantly increased risk was observed in women. This lack of association between emotional support and alcohol consumption in women may be due to hazardous alcohol consumption still being more limited among women (Ceylan-Isik et al., 2010). Worthwhile noting, the AUDIT does not provide a direct assessment of alcohol consumption, but rather its negative impact. The tendency of low emotional support being more strongly associated with individual CVD risk factors in men than in women is interesting from a preventive perspective. Early studies suggest that married men, more than married women, profit in terms of health from their marriage, as women provide more effective support than men (Glynn et al., 1999). Taken together, this implies that emotional support in men may be a particular target in future interventions for CVD prevention.

Notably, the ORs for some of the risk factors for the entire group did not fall in size between that for men and women. In contrast to proportions, odds ratios have the property of non-collapsibility, in which a measurement on a group does not equal a designated average of the same measurement over its constituents (Greenland, 2021).
Five of the six items on emotional support were found to be associated with risk of CVD morbidity and mortality as assessed with the FRS. Among these, having someone to hold or embrace to give comfort and support was particularly strongly associated, followed by having someone special with whom to share feelings of happiness, and having someone with whom to share inner thoughts. These aspects of emotional support may therefore be particularly important to consider in CVD preventive work, but it calls for further analyses, preferably with longitudinal data, for a causal link.

The present study has strengths and limitations. Regarding strengths, the present sample size is very large, the VIPVIZA is integrated in ordinary healthcare through the VIP, which has high participation rate (~70%) and shows little evidence of selection bias (Norberg et al., 2012). In addition, the present sample constituted a large proportion (82.7%) of those 4177 persons invited to participate in the VIPVIZA. Taken together, this suggests that the results to a large extent can be generalised to a population with low to intermediate risk for CVD. There is also support for validity of the categorisation of participants into groups of low emotional support and referents, based on AVAT score. This lies in the features of the low support groups which are likely to contribute to social isolation, such as relatively low prevalence of partnership and involvement in society leisure activities, and high prevalence of being unemployed/early retiree. Features in these groups that support the validity of the biomedical CVD risk factors are relatively poor self-rated health, high body mass index, and high prevalence of reported diabetes.

A limitation of the study is that some of the variables used were assessed as self-reports, which may induce, for example, social desirability bias and recall bias (Althubaiti, 2016). This calls for interpreting the results with certain caution. Another note of caution is that the group low in emotional support is low in comparison to the reference group, but not necessarily low in an absolute sense. The participants in the quartile among the total sample with the lowest score were considered as relatively low in emotional support, referred here to as low emotional support, and the remaining participants were considered as relatively high in emotional support, referred to as referents. It is also important to keep in mind that the cross-sectional nature of this study does not enable test of causal direction. The statistical strength of the presently studied associations are likely to have increased if the sample had been older, with more advanced atherosclerosis disease, and if participants with high risk of CVD events had been included. On the other hand, persons at low to intermediate risk constitute an important target group since there still is time for preventive measures, and since they constitute about 70% of cases of CVD morbidity and mortality (Polonsky & Greenland, 2012; Rose, 2001).

In conclusion, the results from the present study suggest that low emotional support is associated with lifestyle CVD risk factors, estimation of 10-year risk of CVD morbidity and mortality, and presence of carotid plaque in a middle-aged, population with low or intermediate risk for CVD. Aspects of emotional support that were associated with risk of CVD morbidity and mortality were having someone close to oneself to share feelings of happiness and inner thoughts and to hold for comfort and support, and perceiving that others appreciate what one is doing for them. The findings
encourage causal evaluation with longitudinal data investigating an impact of emotional support on mechanisms underlying CVD.

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**Disclosure statement**

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**Data availability statement**

The data is available upon request.

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