Psychosocial Factors and Heart Rate Variability in Healthy Women

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Objective: This study was conducted to investigate associations between psychosocial risk factors, including social isolation, anger and depressive symptoms, and heart rate variability in healthy women. **Methods:** The study group consisted of 300 healthy women (median age 57.5 years) who were representative of women living in the greater Stockholm area. For the measurement of social isolation, a condensed version of the Interpersonal Support Evaluation List was used and household size assessed. Anger was measured by the anger scales previously used in the Framingham study and depressive symptoms by a questionnaire derived from Pearlin. Health behaviors were measured by means of standard questionnaires. From 24-hour ambulatory electrocardiographic monitoring, both time and frequency domain measures were obtained: SDNN index (mean of the SDs of all normal to normal intervals for all 5-minute segments of the entire recording), VLF power (very low frequency power), LF power (low frequency power), HF power (high frequency power), and the LF/HF ratio (low frequency by high frequency ratio) were computed. **Results:** Social isolation and inability to relieve anger by talking to others were associated with decreased heart rate variability. Depressive symptoms were related only to the LF/HF ratio. Adjusting for age, menopausal status, exercise and smoking habits, history of hypertension, and BMI did not substantially change the results. **Conclusions:** These findings suggest heart rate variability to be a mediating mechanism that could explain at least part of the reported associations between social isolation, suppressed anger, and health outcomes. **Key words:** psychosocial factors, social support, heart rate variability, women.

BMI = body mass index (kg/m^2); SBP = systolic blood pressure (mm Hg); DBP = diastolic blood pressure (mm Hg); HRT = hormone replacement therapy; CHD = coronary heart disease; JMP = John's Macintosh program; HRV = heart rate variability; SDNN = SD of the normal to normal intervals (ms); SDNN index = average of the SDs of all normal to normal intervals for each 5-minute interval of the entire recording (ms); LF power = low frequency power (ms^2); HF power = high frequency power (ms^2); VLF power = very low frequency power (ms^2); LF/HF ratio = ratio of low-frequency to high-frequency power (none).

INTRODUCTION

Psychosocial factors, including social isolation, depressive symptoms, and anger, have been associated with increased risk of all-cause mortality, CHD incidence, and mortality after myocardial infarction (1–10).

The mechanisms through which psychosocial factors exert their effects are unclear. Associations between psychosocial factors and standard risk factors for atherosclerosis, including smoking, lack of exercise, and unhealthy dietary habits, have been proposed as causal pathways. Furthermore, neuroendocrine and psychophysiological mechanisms have been suggested to mediate the effects between psychosocial factors and CHD. Among these mechanisms, a decreased HRV or disturbed autonomic balance, operating through altered autonomic nervous system function, seems to be one of the most plausible pathways (11). HRV is widely recognized as an important index of autonomic function in normal individuals and in those recovering from acute myocardial infarction (12, 13). Decreased HRV measured over a 24-hour period has been shown repeatedly to be a strong predictor of fatal outcome after a myocardial infarction (14–17). Furthermore, decreased HRV has been associated with increased risk of all-cause mortality in community studies of male and female populations such as the Framingham study (18) and the recent Zutphen study from Holland by Dekker et al. (19). In addition, results of the Atherosclerosis Risk in Communities (ARIC) study recently showed that a decreased HRV is associated with the risk of developing nonfatal and fatal CHD (20). These results extend the previous literature to newly occurring CHD and to the general population.

The concept of allostasis (21) emphasizes that the physiological systems within the body fluctuate to meet demands from external forces. This ability can be diminished by chronic activation of the sympathetic branch or chronic suppression of the parasympathetic branch of the autonomic nervous system caused by chronic stress or harmful social conditions. It is possible, that it is this phenomenon that is captured by the

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measurement of HRV. Decreased HRV could then be conceptualized as a lack of ability to respond by physiological variability and complexity, making the individual physiologically rigid and, therefore, more vulnerable. This is consistent with Porges' proposal that a chronically depressed vagal tone would reflect poor homeostasis and a neurophysiological vulnerability to the deleterious effects of stress (22).

Decreased HRV has been demonstrated in both depressed psychiatric patients and in depressed cardiac patients (23–27). Among other psychosocial factors that have been associated with HRV are anger (28), Type A behavior pattern (29), and mental stress (30, 31). We have found no studies directly examining social isolation or support in relation to HRV. However, an association can be hypothesized on the basis of earlier studies showing associations between low social support and increased catecholamine levels (32, 33), and low social support and sustained increased heart rates (34), which in turn are related to low HRV and autonomic dysfunction (14). Furthermore, poor emotional and social support has been related frequently to depressive symptoms (35, 36). Therefore, the present study examines associations between social isolation, depressive symptoms, anger, and HRV.

Besides the paucity of studies investigating relations between psychosocial risk factors and HRV, even less attention has been given to female subjects. When women were included in such studies, the number was usually too small to analyze the data by gender. In addition, as described above, both decreased HRV and psychosocial strain (eg, depression, social isolation) have been related to CHD incidence and all-cause mortality justifying the hypothesis that psychosocial strain may be associated with a decreased HRV in a healthy population.

Therefore, the aim of the present study was to investigate associations between psychosocial risk factors and HRV indices in healthy women.

METHODS

Subjects

The study group consisted of 300 healthy women aged between 30 and 65 years. The subjects were obtained randomly from the census register of the greater Stockholm area. They constituted the control group of the Female Coronary Risk Study, a population-based case-control study of all female cases of acute CHD events in Stockholm within a 3-year period. All subjects were free of symptoms of heart disease and without hospitalization for any illness during the past 5 years. All women were examined for clinical signs or symptoms of chronic diseases. Three women were on medication for hypertension, but otherwise were healthy. None of the women had diabetes mellitus. The standard cardiovascular risk factors of the study group were compared with those of a random sample of 2500 women of the same age from the general population of Stockholm. No differences in health behaviors (smoking, exercise, and dietary habits) or educational level were found (37). The study group thus can be regarded as representative of healthy women aged 30 to 65 years in the normal Stockholm population.

A letter was sent to prospective subjects that explained the objectives and the focus of the study and invited them to participate. Those who did not call the clinic spontaneously were contacted by phone from the research clinic. When a subject refused to participate, a new subject was selected to obtain a final number of 300 healthy women. Of those eligible, 17% declined to participate, mainly because of difficulties in arranging time off from work for the study.

Procedure

The first day of the study included a physical examination and placement of a 24-hour Holter EKG monitor. During the second day, anthropometric measures were obtained, blood pressure was measured, and the Holter EKG monitor was detached. Questionnaires on psychosocial and life style factors, including depressive symptoms (38), social support (39), and anger (40), were sent to the subjects 1 week before their visit to the research clinic. Subjects completed the questionnaires at home and brought them to the clinic. The research nurse reviewed the questionnaires with the subjects and completed any answers that were missing. Internal nonresponse was less than 10%.

Psychosocial Factors

Depressive symptoms were measured by means of a 10-item questionnaire derived from Pearlin et al. (38). One question, about sexual activity, was excluded in an effort to avoid potentially threatening items. The present version thus included 9 questions with yes/no alternatives. The yes answers were summed, with a low score indicating a low degree of depressive feelings. The scale includes questions on mood, sleeping problems, appetite, energy, interest in normal activities, crying, and feelings about the future. Some examples of questions are: Do you feel bored or do you have little interest in doing things? Do you feel downhearted or blue? Do you feel hopeless about the future? The scale had an adequate internal consistency (Cronbach's $\alpha = .85$) and was significantly correlated ($r = .71$) with the Beck Depression Inventory in a subsample of the study population ($N = 30$).

For the measurement of social support, a condensed version of the Interpersonal Support Evaluation List (ISEL) was used (39). Social support functions included belongingness (5 items), tangible support (3 items), and appraisal support (5 items). Examples of items were: There are several different people with whom I enjoy spending time; When I feel lonely, there are several people I could call and talk to; I regularly meet or talk with members of my family or friends (belongingness); When I need suggestions for how to deal with a personal problem, I know there is someone I can turn to (appraisal support); If I needed some help in moving to a new home, I would have a hard time finding someone to help me (tangible support). Items were scored on a scale from 1 (is very true) to 4 (is not at all true). The total scale thus comprised 13 items with scores ranging from 13 to 52, a high score indicating more social support.

Anger was measured by a 12-item scale previously used in the Framingham study (40). The scale consisted of four subscales: anger-symptoms (5 items), anger-in (3 items), anger-out (2 items), and anger-discuss (2 items). Examples of items included: How do you react when you are really angry or annoyed? Get tense or worried (anger-symptoms); Keep it to yourself (anger-in); Take it out on others (anger-out); Talk to a friend or relative (anger-discuss). The items were scored on a scale from 0 to 1 (1 indicating presence of the trait characteristic). Responses to each item were summed and the sum was divided by the number of items per subscale.

Demographic and Lifestyle Factors

Age at examination was obtained from the date of birth given in the person number of the census register. The number of persons in the household, marital status, educational level, history of hypertension, physical exercise, and smoking behavior were assessed by means of questionnaires and interview procedures. Educational level was classified as follows: (I) mandatory only (corresponding to 9 years of school education); (II) high school or college. Physical exercise was assessed according to the World Health Organization criteria and graded into: (I) reading, watching TV, or other sedentary leisure activities; (II) walking, cycling, or other forms of physical activity; (III) exercises to keep fit, heavy gardening, etc., for at least 4 hours a week; and (IV) hard training or participation in competitive sports several times a week. In the analyses, physical exercise in leisure time was dichotomized into; sedentary lifestyle (I) and nonsedentary lifestyle (II-IV). Blood pressure, weight, and height were measured by the research nurse during examination. BMI was calculated as weight (kg)/height (m^2). In univariate analyses, obesity was defined as BMI > 28.6 kg/m^2 (41). In the analyses, a cutoff for high systolic blood pressure was taken at > 140 mm Hg and for high diastolic blood pressure at > 90 mm Hg, defining hypertension as systolic blood pressure >140 mm Hg or diastolic blood pressure $>$ 90 mm Hg.

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

Ambulatory EKG Monitoring and Analysis of Heart Rate Variability

A two-channel EKG recording was performed for 24-hour periods during normal daily activities. A Spacelabs model 90205 recorder (Spacelab Inc., Redmond, WA) was used to obtain the EKG data. Electrodes were attached at the positions of CM-V5 (left anterior axillary line sixth rib) and CS-V1 (fourth rib at the sternal border). Subjects were encouraged to continue their normal daily activities during the period of monitoring. There were 264 complete 24-hour Holter EKG recordings available. Recordings were excluded if they showed more than 10% nonsinus rhythm ($N = 4$), extreme outliers on total power ($N = 2$), medication for hypertension ($N = 3$), or less than 50% original material ($N = 6$), resulting in 249 recordings available for the analyses.

The 24-hour tape recordings were digitized and QRS-labeled using a commercially available PC-based system (Aspect Holter System, Daltek, Borlänge, Sweden). An automatic analysis of arrhythmias was first made and the QRS complexes classified. The consecutive R-R intervals were expressed in centiseconds and their corresponding classification codes were exported to an ASCII text file. The text file was additionally analyzed using our own custom-made software on a personal computer. Additional analysis was made in units of 5-minute epochs. To be accepted for additional analysis, we required an interval to have at least 96% of the QRS-complexes classified as normal by the Daltek system (42).

Five-minute (300 s) epochs of data were analyzed by custom-made software. The time series of R-R intervals were resampled at a sampling frequency of two samples per second. Gaps in the time series due to nonnormal R-R intervals (QRS-labeled by the Aspect System classification as noise or ectopic beats) were filled with values calculated by linear interpolation between adjacent normal R-R intervals. The computer also automatically checked for misclassified dropped beat deviating more than 3.0 SD from the normal R-R interval of each epoch.

After editing was computed, the time domain measures mean of normal RR intervals and mean of the SDs of all normal to normal intervals for all 5-minute segments of the entire recording (SDNN index, in msec) (43) were obtained from the time series of normal R-R intervals. SDNN index has also been referred to as SDNNIDX in the literature (44).

The frequency domain of the time series of R-R intervals was analyzed with an autoregressive method described by Kay and Marple (45). The model order and number of coefficients in the polynomial describing the time series was constantly set to 18. The mean R-R interval of each time series was subtracted and then detrended by applying linear regression. Frequency domain measures of R-R variability were computed by integrating over their frequency intervals in three frequency bands as described by Bigger et al. (46) and later recommended by the Task Force (43) 0.003 to $<$ 0.04 Hz (VLF, in msec^2), 0.04 to < 0.15 Hz (LF, in msec^2), and 0.15 to 0.4 Hz (HF, in msec^2). In addition, the LF/HF ratio was calculated.

Vagal activity is the major contributor to the HF component. Disagreement exists in respect to the LF component, which is considered by some as a marker of sympathetic modulation (especially when expressed in normalized units) and by others as a parameter that includes both sympathetic and vagal influences. Consequently, the LF/HF ratio is considered by some investigators to mirror sympathovagal balance. In results from 24-hour periods, the interpretation of the LF/HF ratio is more complicated because physiological mechanisms of heart period modulations responsible for LF and HF power components cannot be considered stationary during the 24-hour period. The physiological interpretation of VLF power is yet unclear (although the major component of the spectral density is located there) (43).

Statistical Analyses

We used JMP Statistics for the Apple Macintosh Version 3.1 (47) and STATA 3.1 (48) for the statistical analyses. All HRV variables were nonnormally distributed and, therefore, log transformed in the analyses. All correlation's reported are Spearman ρ correlations. Multivariate linear regression analyses were performed to test associations between the risk factors and the HRV variables, the HRV variables always being the dependent variable. The anti-logs of the least squares mean (LSM) were reported after controlling for other risk factors. For variables with more than two categories, the linear trend was assessed by computing the p value for trend (49). When the linear trend was nonsignificant but the LSM suggested a difference between one of the groups versus the rest, this was tested and reported when significant.

RESULTS

Table 1 shows the distribution of the study variables in the sample. Mean age in the HRV group was 56.3 years (SD = 7.0), ranging from 31 to 65. Age was

TABLE 1. Distribution of the Study Variables (N = 249)

Factor	*N*	%	Range	Median	Mean	SD
Age (yr)						
31–45	19	8				
46–50	37	15				
51–55	53	21				
56–60	55	22				
61–65	85	34				
Educational attainment						
Mandatory	131	53				
High school + college/university	114	47				
Menopausal status						
Premenopausal	73	29				
Postmenopausal with HRT	34	14				
Postmenopausal without HRT	141	57				
Smoking	73	29				
Sedentary lifestyle	46	18				
History of hypertension	19	8				
Age (yr)			31–65	57.5	56.3	7.0
SBP (mm Hg)			86–177	117.0	120.2	16.8
DBP (mm Hg)			53–119	76.0	77.1	10.4
BMI (kg/m^2)			17.6–48.6	24.2	25.4	4.8
Social support (score)			24–52	46.0	44.3	6.6
Depressive symptoms (no.)			0–9	1.0	1.9	2.2
Anger-symptoms (score)			0–1	0.27	0.29	0.20
Anger-in (score)			0–1	0.22	0.21	0.19
Anger-out (score)			0–0.83	0	0.11	0.16
Anger-discuss (score)			0–1	0.67	0.58	0.28
SDNN index (msec)			18–80	42.0	43.6	11.2
VLF power (msec^2)			69–1850	471.0	565.2	310.0
LF power (msec^2)			39–2032	372.0	451.6	313.9
HF power (msec^2)			36–2626	185.0	229.2	218.0
LF/HF (none)			1.1–6.1	2.65	2.78	0.92

significantly associated with SDNN index, VLF power, LF power, and HF power ($r = -.18$, $p = .003$; $r = -.14$, $p = .02$; $r = -.28$, $p < .0001$; $r = -.19$, $p = .002$, respectively), but not with the LF/HF ratio ($r = -.09$, $p = .15$). The HRV measures were all statistically significantly associated with each other (correlations ranging from $r = -.17$, $p = .006$ between the LF/HF ratio and HF power to $r = .97$, $p < .0001$ between the SDNN index and VLF power). All of these associations were positive except for the one between the LF/HF ratio and HF power.

Table 2 shows the age-adjusted associations between standard risk factors and HRV parameters. Smoking, sedentary lifestyle, high BMI, and high systolic blood pressure were statistically significantly associated with lower values of one or more HRV measures. Table 3 shows the age-adjusted associations between psychosocial factors and HRV parameters. Being single, living alone, reporting low social support, depressive symptoms, and not discussing anger (anger-discuss subscale) were statistically significantly associated with lower values of one or more HRV measures. When the depressive symptoms scale was divided into three groups, no differences in HRV were found between the upper quartile and the intermediate group. Therefore, comparisons between women without versus women with at least one depressive symptom were reported. The group without depressive symptoms had a statistically significant higher LF/HF ratio than the group with at least one depressive symptom. Of the four anger scales, only anger-discuss showed statistically significant associations with HRV. Table 4 shows the associations between psychosocial factors and HRV variables, after adjusting for age, menopausal status, sedentary lifestyle, smoking, history of hypertension, and BMI. Results are shown in italics if the association was not statistically significant in the age-adjusted analyses. The multivariate adjustment did not substantially alter the results (Table 4). The anger scales, anger-symptoms, anger-in, and anger-out, did not show any statistically significant association with HRV in the age-adjusted analyses and were, therefore, not tested with subsequent multivariate adjustment.

TABLE 2. Differences in Heart Rate Variability Between Standard Risk Factor Groups; Adjusted for Age (N = 249)

Standard Risk Factors	SDNN Index			VLF Power			LF Power			HF Power			LF/HF		
	LSM[a]	SEM	*p*	LSM	SEM	*p*	LSM	SEM	*p*	LSM	SEM	*p*	LSM	SEM	*p*
Smoking															
No	42.9	0.83		510.8	20.9		382.6	18.7		179.9	9.0		2.77	0.07	
Yes	40.0	1.21	.05	439.7	28.1	.05	315.9	24.1	.036	179.4	14.0	.98	2.31	0.09	.0001
Sedentary lifestyle															
No	42.7	0.77		506.8	19.3		382.4	17.3		185.7	8.6		2.70	0.06	
Yes	39.4	1.48	.05	416.8	33.0	.03	286.3	27.1	.006	156.4	15.1	.11	2.34	0.12	.01
Menopausal status															
Premenopausal	42.5	1.67		491.9	41.0		380.4	38.0		171.9	17.4		2.69	0.14	
Postmenopausal with HRT	42.5	1.88		506.8	47.5		359.5	40.4		183.4	20.9		2.57	0.15	
Postmenopausal without HRT	41.7	1.03	.65*	481.7	25.2	.76*	351.5	22.0	.56*	183.0	11.6	.68*	2.59	0.09	.68*
Obesity (kg/m^2)															
BMI ≤ 28.6	43.2	0.76		517.5	19.1		388.6	17.2		188.3	8.6		2.68	0.06	
BMI > 28.6	37.6	1.43	.001	383.0	30.9	.001	262.2	25.3	.000	148.8	14.8	.033	2.37	0.12	.04
Blood pressure (mm Hg)															
SBP ≤ 140 and DBP ≤ 90	43.0	0.74		509.0	18.6		380.7	16.7		188.9	8.4		2.62	0.06	
SBP > 140 or DBP > 90	37.4	1.62	.003	392.4	36.1	.009	268.7	29.7	.004	136.8	15.4	.008	2.61	0.15	.96
History of hypertension															
No	42.3	0.72		493.1	17.8		366.5	15.8		181.7	7.9		2.62	0.06	
Yes	40.6	2.39	.52	458.4	57.2	0.58	335.0	49.8	.56	162.7	24.6	.48	2.73	0.21	.62

[a] LSM = least squares mean.
* *p* value for trend.

To test whether associations were due to differences in socioeconomic status, all multivariate analyses were repeated with educational level as an additional confounder but results remained essentially the same.

As expected, a statistically significant correlation existed between marital status and household size (r = .68, $p < .0001$). The correlation between social support and household size was not statistically significant (r = .10, p = .13). The effects of household size were also tested while controlling for social support. Although the associations between household size and HRV parameters were weakened, they remained statistically significant (all p values > .01 and < =.05).

DISCUSSION

We found social isolation, low social support, and not discussing ones anger to be related to decreased HRV in a normal population of women. A smaller household, not discussing anger and lower appraisal, belonging, and tangible support were associated with lower SDNN index, LF power, and VLF power. A smaller household was also associated with lower HF power. These associations remained statistically significant after adjustment for age, menopausal status, educational level, exercise and smoking habits, history of hypertension, and BMI. These findings may reflect one of the mechanisms that could explain at least part of the reported associations between social isolation, living alone, suppressed anger, and CHD incidence as well as mortality (1–3, 5, 6).

The strongest and most consistent results were found for small household size, a proxy measure for social isolation, and for lack of social support. The associations between household size and HRV remained statistically significant after controlling for educational level, indicating that they were not due to a confounding effect of low socioeconomic status, which has been found to be related both to smaller households and to cardiac mortality (9). When the effects of household size on HRV were tested while controlling for social support, the associations were weakened, but remained statistically significant. A tentative explanation for this could be that household size is an indicator of support from close family (spouse, children) that is not totally covered by the social support measure.

The social support scale describes three functions that are usually provided by the more extended social network. These include appraisal support, which provides help to orient oneself in life, to adequately perceive and estimate stressors, and to find ways to cope with them. The second function, belongingness, describes the basic human need for a sense of belonging to groups of people and to share interests and values with

TABLE 3. Associations of Psychosocial Factors With Heart Rate Variability; Adjusted for Age ($N = 249$)

Psychosocial Factors	SDNN Index			VLF Power			LF Power			HF Power			LF/HF		
	LSM[a]	SEM	*p*	LSM	SEM	*p*	LSM	SEM	*p*	LSM	SEM	*p*	LSM	SEM	*p*
Education															
Mandatory	41.7	0.95		477.5	23.1		358.2	20.7		184.4	10.8		2.56	0.08	
High school/university	42.7	1.04	.48	508.6	26.3	.38	374.8	23.2	.60	176.5	11.1	.61	2.74	0.09	.12
Marital status															
Single	39.9	2.01		439.3	46.7		323.0	41.0		142.4	18.3		2.81	0.19	
Widow/divorced	40.4	1.37		449.7	32.2		328.1	28.0		170.7	14.8		2.47	0.11	
Cohabiting	43.2	0.88	.06*	516.5	22.2	.06*	386.6	19.9	.07*	191.1	10.0	.03*	2.68	0.07	.88*
No. persons in the household															
1	39.3	1.24		420.3	28.8		305.5	24.5		152.5	12.5		2.54	0.11	
2	42.8	0.95		507.5	23.8		376.1	21.1		185.2	10.6		2.69	0.08	
≥3 (3–5)	45.1	1.86	.005*	562.8	49.2	.005*	435.6	45.5	.006*	216.5	23.2	.008*	2.61	0.14	.51*
Social support															
Low (lower quartile)	40.5	1.27		453.3	30.2		325.4	25.7		168.7	13.7		2.54	0.10	
Intermediate	42.1	0.99		486.7	24.2		354.6	20.9		185.0	11.2		2.54	0.08	
High (upper quartile)	44.4	1.44	.046*	547.1	37.8	.05*	436.7	35.8	.01*	185.0	15.6	.43*	2.94	0.12	.01*
Depressive symptoms															
0	42.5	1.14		508.7	28.9		384.4	26.2		177.3	12.3		2.80	0.10	
1–9	42.0	0.86	.69	480.8	20.9	.43	352.2	18.4	.31	181.9	9.63	.77	2.54	0.07	.03
Anger-symptoms															
Low (≤ median)	41.3	1.04		473.9	25.2		344.7	21.9		166.3	10.7		2.71	0.09	
High	42.9	0.99	.26	500.4	24.5	.45	377.2	22.1	.33	191.8	11.3	.10	2.56	0.08	.21
Anger-in															
Low (≤ median)	42.3	1.02		494.9	25.4		374.9	23.0		178.2	11.0		2.71	0.09	
High	41.9	0.97	.79	486.0	23.8	.80	353.5	20.7	.49	179.6	10.6	.93	2.58	0.08	.27
Anger-out															
Low (≤ median)	42.1	0.91		488.7	22.5		365.1	20.2		179.4	10.0		2.67	0.08	
High	42.4	1.10	.82	500.1	27.4	.75	366.6	24.1	.96	182.0	12.1	.87	2.59	0.09	.51
Anger-discuss															
Low (≤ median)	40.7	0.98		461.0	23.6		334.4	20.4		175.2	10.9		2.54	0.08	
High	43.6	0.96	.03	520.9	24.4	.08	393.7	22.1	.05	185.2	10.6	.51	2.72	0.08	.12

[a] LSM = least squares mean.
* *p* value for trend.

them. The third function, tangible support, assesses the availability of concrete, practical help (39, 50).

As far as we know, no other study has investigated relations between social support, household size, and HRV in women. However, Undén et al. (34) reported persons with low social support at work to have sustained increased heart rates, using 24-hour ambulatory EKG monitoring. Sustained increased heart rates have been associated with lower HRV (14), thereby supporting the results of the present study. Both measures have been viewed as measures of cardiac autonomic dysfunction.

Depressive symptoms were only statistically significantly associated with the LF/HF ratio. Women with depressive symptoms had a lower LF/HF ratio than women without depressive symptoms. This finding may suggest less sympathetic modulation in the women with depressive symptoms. However, interpretation of the LF/HF ratio in spectral analyses performed on the entire 24-hour period is difficult, inasmuch as averages of the modulations attributable to the LF and HF components are provided. Such averages obscure the detailed information about autonomic modulation of R-R intervals, that is available in shorter recordings (43).

In the present study, depressive symptoms were not statistically significantly associated with the other HRV measures, including the SDNN index, VLF power, LF power, and HF power. In previous studies, decreased HRV in both depressed psychiatric patients and in depressed cardiac patients has been reported (23–27). In these studies, significant associations with various time domain HRV measures were reported. The one study that reported frequency domain measures of HRV in relation to depression did not base these on 24-hour EKG recordings (26), complicating comparison with our results. Furthermore, they all used patient study groups. It is possible that associations between depressive symptoms and HRV measures in patient populations are different from those in normal populations (as used in the present study).

TABLE 4. Associations of Psychosocial Factors With Heart Rate Variability; Adjusted for Age, Menopausal Status, Exercise, Smoking, History of Hypertension, and BMI (N = 249)

Psychosocial Factors	SDNN Index			VLF Power			LF Power			HF Power			LF/HF		
	LSM[a]	SEM	*p*	LSM	SEM	*p*	LSM	SEM	*p*	LSM	SEM	*p*	LSM	SEM	*p*
Marital status															
Single	38.5	2.72		393.9	58.7		290.6	51.4		118.9	22.0		*2.77*[b]	*0.25*	
Widow/divorced	40.2	2.48		426.6	55.7		322.1	49.9		147.1	23.8		*2.53*	*0.20*	
Cohabiting	42.1	2.38	.07*	470.1	56.1	.08*	360.1	51.0	.08*	165.0	24.4	.02*	*2.61*	*0.19*	*.64**
No. persons in the household															
1	39.0	2.33		401.6	50.6		295.6	44.1		128.7	20.2		*2.61*	*0.20*	
2	42.0	2.33		471.9	55.2		353.7	49.0		157.9	23.0		*2.66*	*0.19*	
≥3 (3–5)	44.3	2.87	.01*	520.6	71.4	.02*	404.8	65.7	.02*	188.1	32.2	.006*	*2.51*	*0.21*	*.71**
Social support															
Low (lower quartile)	39.0	2.36		402.4	51.5		289.9	43.8		*139.3*	*22.4*		2.45	0.19	
Intermediate	40.9	2.26		440.5	51.6		320.1	44.3		*155.2*	*22.8*		2.47	0.18	
High (upper quartile)	42.9	2.54	.04*	491.4	61.6	.04*	391.1	57.9	.009*	*154.0*	*24.2*	*.40**	2.86	0.22	.009*
Depressive symptoms															
0	*41.2*	*2.41*		*458.2*	*56.7*		*345.5*	*50.8*		*146.5*	*22.6*		2.73	0.21	
1–9	*41.0*	*2.22*	*.91*	*441.6*	*50.6*	*.61*	*327.3*	*44.5*	*.52*	*153.5*	*21.9*	*.60*	2.51	0.18	.05
Anger-discuss															
Low (≤ median)	39.5	2.22		418.7	49.9		305.2	43.2		*146.8*	*21.9*		*2.48*	*0.18*	
High	42.5	2.32	.03	474.5	54.9	.07	358.1	49.2	.05	*156.8*	*22.7*	*.45*	*2.64*	*0.19*	*.14*

[a] LSM = least squares mean.
[b] Results are shown in italics if the association was already nonsignificant in the age-adjusted analyses.
* *p* value for trend.

Interestingly, of the anger scales only the scale "anger-discuss" was statistically significantly associated with HRV. Not being able to relieve anger by talking to a friend or relative was associated with lower HRV. An association with HRV has not been previously reported, but in the Framingham study the same scale was an independent predictor of the incidence of CHD and angina pectoris in women under 65 years of age (6).

As discussed earlier, the physiological meaning of the HRV measures, especially of the VLF power component, is not very well established. We know that decreased HRV is related to both cardiac and all-cause mortality (14–19) and that vagal activity is the major contributor to the HF component (43). In the present study, the time domain measure SDNN index was used. The rationale for using the SDNN index was that only the normal R-R intervals included in the 5-minute epochs used for spectral analysis should be included in the time domain measures, so that time and frequency domain measures are based on the same 5-minute epochs. Consequently, normal beats adjacent to periods of, eg, ectopic activity, were not included in the analysis. VLF power and LF power have been suggested as the frequency domain equivalents for the SDNN index because they are highly correlated ($r \cong .90$) (44, 51). Furthermore, in a study by Bigger et al. (51), the correlation between the SDNN and the SDNN index was .81, and both measures had an equally strong association with death after myocardial infarction.

We would like to see decreased HRV in the light of the statement by Porges (22) that "clinically, stasis or lack of endogenous variability in neurally mediated peripheral systems, such as gastric motility and heart rate, is a sign of severe physiological compromise." The decreased HRV in the socially isolated women and those not being able to relieve their anger by talking to others, could then be conceptualized as a lack of ability to respond by physiological variation and complexity, making them physiologically rigid and, therefore, more vulnerable.

In conclusion, women who lived alone, who reported lack of social support, and who reported not to relieve their anger by talking to others showed evidence of lower HRV during daily life compared with women with larger households, higher social support, and women that could discuss their anger. Of all HRV measures, low SDNN, its frequency domain equivalent low ultra LF power (44, 51) and low VLF power have been most consistently and strongly related to mortality after myocardial infarction and to all-cause mortality (14, 15, 19, 51). In addition, social isolation has also been related to all-cause mortality, to CHD incidence, and to prognosis after myocardial infarction (1, 2, 5, 8–10, 52). Furthermore, suppressed anger has been related to all-cause mortality (3), to the progression of atherosclerosis (53), and in the Framingham study—

using the same scale as the present study—to CHD incidence (6). Our results suggest that HRV may be one of the possible mechanisms that explain these reported associations.

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