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Authors

Salmoirago-Blotcher, Elena
Hovey, Kathleen
Andrews, Cristopher
et al.

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Psychological traits, heart rate variability, and risk of coronary heart disease in healthy aging women – the Women's Health Initiative

Elena Salmoirago-Blotcher, MD, PhD[1], **Kathleen M. Hovey, MS**[2], **Cristopher A. Andrews, PhD**[3], **Matthew Allison, MD, MPH**[4], **Robert L. Brunner, PhD**[5], **Nathalie L. Denburg, PhD**[6], **Charles Eaton, MD, MPH**[1], **Lorena Garcia, MPH, DrPH**[7], **Shawnita M. Sealy-Jefferson, PhD, MPH**[8], **Oleg Zaslavsky, PhD**[9], **Joseph Kang, PhD**[10], **Lenny López, MD, MPH**[11], **Stephen G. Post, PhD**[12], **Hilary Tindle, MD, MPH**[13], and **Sylvia Wassertheil-Smoller, PhD**[14]

[1]Brown University School of Medicine;

[2]University at Buffalo;

[3]University of Michigan;

[4]UC San Diego;

[5]University of Nevada;

[6]University of Iowa;

[7]UC Davis;

[8]Virginia Commonwealth University;

[9]University of Washington;

[10]formerly of Northwestern University; currently with the US Centers for Disease Control

[11]UC San Francisco;

[12]Stony Brook University;

[13]Vanderbilt University;

[14]Albert Einstein College of Medicine

Abstract

Corresponding author: Elena Salmoirago-Blotcher, PhD, MD, Brown University School of Medicine & School of Public Health, Centers for Behavioral and Preventive Medicine, The Miriam Hospital, Coro Building, suite 309, One Hoppin Street, Providence RI 02903, tel: 401-793-8325; fax: 401-793-8059, Elena_Salmoirago-Blotcher@brown.edu.

WHI investigators

For a list of WHI investigators, please refer to the Appendix in Supplemental Digital Content 2.

Disclosures

None.

The authors have no conflict of interest to disclose.

Objective.—Psychological traits such as optimism and hostility affect coronary heart disease (CHD) risk, but mechanisms for this association are unclear. We hypothesized that optimism and hostility may affect CHD risk via changes in heart rate variability (HRV).

Methods.—We conducted a longitudinal analysis using data from the Women's Health Initiative Myocardial Ischemia and Migraine Study. Participants underwent 24-hour ambulatory ECG monitoring 3 years after enrollment. Optimism (Life Orientation Test-Revised), cynical hostility (Cook-Medley), demographics, and coronary risk factors were assessed at baseline. HRV measures included standard deviation of average N-N intervals (SDNN); standard deviation of average N-N intervals over 5 min (SDANN); and average heart rate (HR). CHD - was defined as the first occurrence of myocardial infarction, angina, coronary angioplasty, and bypass grafting. Linear and Cox regression models adjusted for CHD risk factors were used to examine, respectively, associations between optimism, hostility and HRV and between HRV and CHD risk.

Results.—Final analyses included 2655 women. While optimism was not associated with HRV, hostility was inversely associated with HRV 3 years later (SDANN: adjusted β= −0.54; 95% CI −0.97, −0.11; SDNN: −0.49; 95% CI −0.93, −0.05). HRV was inversely associated with CHD risk; for each 10 milliseconds increase in SDNN or SDANN there was a decrease in CHD risk of 9% (p=0.023) and 12% (p=0.006), respectively.

Conclusions.—HRV did not play a major role in explaining why more optimistic women appear to be somewhat protected from CHD risk. Although hostility was inversely associated with HRV, its role in explaining the association between hostility and CHD risk remains to be established.

Keywords

Coronary heart disease; heart rate variability; optimism; hostility; women's health

Introduction

Over the past few decades there has been increasing interest in the link between psychological traits and cardiovascular health. (1, 2) Optimism, a psychological attitude characterized by positive expectations about the future, has been associated with a reduction in the risk of heart failure, cardiovascular morbidity, and all-cause and cause-specific mortality (in particular, cardiovascular mortality). (3–7)

Other studies have focused on the role of cynical hostility, a trait characterized by cynical attitude and mistrust of others in interpersonal relationships. Higher hostility has been associated with higher risk of developing hypertension(8) and subclinical atherosclerosis,(9) and in the WHI-OS cohort, most (vs. least) cynical hostile women showed a trend toward increased CHD risk over eight years of follow up.(10) In addition, a comprehensive meta-analysis has shown that higher hostility was associated with 19% increased risk of incident CHD among healthy subjects and 24% increased risk of recurrent events among patients with existing CHD. The association with incident CHD persisted after adjustment for baseline disease status and treatment. (11, 12)

Despite the compelling evidence described above, the pathophysiological mechanisms by which less optimistic and more hostile individuals are more prone to develop CHD are

unclear. Researchers have hypothesized that unhealthy behaviors (which in turn could lead to the development of CHD risk factors), poor adherence to medical treatment, and maladaptive response to stress could play a role in increasing CHD risk in these individuals. (13–15) Less optimistic individuals cope less effectively with adversity,(16) while greater hostility has been associated with greater reactivity to stressors.(17) These processes could result in a more sustained or frequent activation of the sympathetic nervous system with release of catecholamine from nerve terminals and the adrenals.(15) Thus, a possible mechanism linking these psychological traits and CHD outcomes is dysregulation of the autonomic nervous system (ANS) with increased sympathetic nervous system activity and decreased parasympathetic activity.

The ANS modulates beat-to-beat heart rate variability predominantly via parasympathetic (vagal) innervation of the sinus node. A commonly used method to evaluate the ANS modulation of cardiac function is the assessment of heart rate variability (HRV). HRV can be assessed non-invasively and provides a measure of changes in cardiac autonomic tone. (18) (19)

A study conducted by Tindle et al. in a large cohort of women from the Women's Health Initiative Observational Study (WHI-OS) has shown that over 8 years of follow up, most (vs. least) optimistic women had 9% lower risk of coronary heart disease (CHD) and 14% lower risk of mortality independent of important confounders such as traditional coronary risk factors and depressive symptoms.10 With this analysis, we were interested in studying the role of HRV in explaining the association between psychological traits (optimism and hostility) and cardiovascular outcomes observed in the above noted study in a sub-group of women who underwent assessments of HRV three years after enrollment, followed by prospective assessments of CV outcomes. We hypothesized that a more optimistic attitude would be associated with higher HRV, while a more hostile attitude would be associated with lower HRV. We also expected that, consistent with studies conducted in survivors of acute myocardial infarction (MI), lower HRV would be associated with higher CHD risk. (20–25)

Establishing whether optimism and hostility are associated with HRV would support the biological plausibility of the findings of previous epidemiological studies. (3–6) Furthermore, the literature indicates that psychological traits are amenable to interventions, (26, 27) thus providing further justification for the design of behavioral approaches to promote positive psychological traits or to improve negative ones among individuals at risk of CHD.

Methods

The WHI-OS was a prospective study of risk factors for heart disease, cancer, fractures, and other causes of morbidity and mortality among 93,676 community-dwelling postmenopausal women. After providing written informed consent, all WHI-OS participants underwent a baseline physical examination, collection of blood specimens, and completion of a medication/supplement inventory and medical history, family history, reproductive history, lifestyle/behavioral factors, and quality of life questionnaires. Follow-up included an on-site

clinic visit three years after enrollment and annual mailings (a medical history update and questionnaires about lifestyle and dietary habits, demographics, hormone therapy, and psychosocial variables). (28, 29)

The present study sample included women who participated in the Myocardial Ischemia and Migraine Study (MIMS), an ancillary study to the WHI-OS in 10 of the 40 WHI centers. MIMS methods have been described in detail elsewhere. (30) Briefly, the objective of MIMS was to investigate relationships among migraine, coronary ischemia (as measured on a 24-hour ambulatory ECG (AECG) monitor), and panic symptoms. Participants could join the MIMS at the WHI-OS baseline visit (performed between 1993 and 1998), at the 3-year visit, or between the baseline and 3-year visit. MIMS data were collected between December 1, 1997, and November 30, 2000.

Inclusion criteria for this analysis were absence of self-reported cardiovascular disease (defined as a history of stroke, MI, angina, congestive heart failure, peripheral arterial disease, percutaneous coronary angioplasty, or coronary artery bypass graft) at baseline through the AECG assessment, no missing data on optimism or hostility, and complete 24-hour AECG recordings.

Measures

Heart rate variability

After completing questionnaires inquiring about the occurrence of panic attacks and migraine headaches during the previous 6 months, MIMS participants were fitted with an AECG recorder (model 3100–001; Zymed Laboratories Inc, South San Francisco, CA) worn for 24 hours during usual daily activities. Three bipolar leads (modified leads MCL1, MCL2, and CC6) were recorded. Recordings were analyzed in the AECG Core Laboratory at the University of Florida using a replay system (Zymed 0210, model 108005–003; Zymed Laboratories Inc).(19)

The following time-domain measures of HRV were considered: SDNN (standard deviation of all analyzed N-N intervals in milliseconds); SDANN (standard deviation of the average NN interval over 5 minutes in milliseconds); and average heart rate (mean cycle length of N-N complexes). Although these measures are influenced by a number of factors and, in general, HRV measures do not directly reflect ANS activity, for the purpose of this analysis and interpretation of study findings lower SDNN and SDANN were used as HRV indices reflecting lower parasympathetic activity.

Optimism and hostility

Optimism and hostility were both assessed at the WHI-OS baseline visit. The Life Orientation Test-Revised, a 6-item measure with good internal consistency (0.78), was used to measure optimism (31). Scores range from 6 to 30 and higher scores indicate greater optimism.

Hostility was measured using the cynical hostility subscale from the Cook & Medley hostility scale, a measure with good internal consistency (0.86). (32) Scores range from 0 to

13, with higher scores indicating greater cynical hostility. Scores for both measures were calculated consistent with the computation done in the study by Tindle and colleagues. (10)

Incident CHD events

CHD events in the WHI studies were self-reported annually and then centrally adjudicated by trained physicians after obtaining medical records and/or death certificates. (33) All incident CHD events since AECG recording were included. Consistent with Tindle et al., CHD was defined as the first occurrence of fatal or non-fatal MI, angina, percutaneous transluminal coronary angioplasty, and coronary artery bypass grafting.[10]

Descriptive variables

Demographic characteristics included age, race/ethnicity (White, Black, Hispanic, American Indian or Alaskan Native, Asian/Pacific Islander, Other/Unknown), education (< high school, college or some college, post-graduate), marital status (Never married, divorced or separated, widowed, presently married, marriage-like relationship), and income (Less than $10,000, $10,000 to $19,999, $20,000 to $34,999, $35,000 to $49,999, $50,000 to $74,999, $75,000 to $99,999, $100,000 to $149,999, $150,000 or more, Don't know). Age, history of hypertension (never, treated, untreated), history of diabetes mellitus (yes/no), history of high cholesterol requiring pills (yes/no), smoking status (current, past, never), and depressive symptoms (assessed using an 8-item screening tool including 6 items from the Center for Epidemiological Studies Depression Scale and 2 items from the Diagnostic Interview Schedule)(34) were self-reported at baseline. Body mass index (BMI - kg/m^2, categorized as normal, overweight, and obese, was calculated from baseline measurements of height and weight. All WHI studies, including the WHIMS, were approved by research ethics committees at each participating center.

Statistical analysis

Baseline characteristics were summarized by counts and percentages or means and standard deviations overall, by categories of optimism and hostility scores and by high/low HRV. For descriptive analyses, SDNN and SDANN were categorized as > 100 or <=100 milliseconds based on normative values reported in the literature;(35) optimism scores were categorized as high (scores 26–30); mid-high (24–25); mid-low (22–23); and low (< 22); and hostility scores were categorized as high (>=6), mid-high (4–5), mid-low (2–3) and low (0–1) consistent with the study conducted by Tindle et al. in the larger WHI-OS cohort. (3) Crude associations were tested with Pearson's chi-square tests and ANOVA F-tests.

To examine associations of optimism and hostility with HRV we used Pearson's correlation and linear regression models. Three models were generated for both predictors: model 1 (unadjusted); model 2 (age-adjusted); and model 3 (adjusted for traditional CHD risk factors - age, smoking, hypertension, high cholesterol requiring medication, and diabetes). To examine associations between HRV measures and incident CHD events we used multivariable Cox proportional hazard regression models adjusted for traditional CHD risk factors. Confounders were chosen consistent with previous analyses conducted in the same MIMS cohort (19) Other factors – such as BMI, and physical activity, have been omitted

because they may be mediating factors (rather than confounders) of the association between psychological traits and HRV.

Results are presented as β coefficients or Hazard Ratios (HR) with 95% confidence intervals. P-values <0.05 were considered statistically significant. All analyses were conducted using SAS version 9.3 (SAS Institute, Cary, NC).

Results

Between December 1997 and November 2000, 3372 women enrolled in MIMS. The average time from baseline assessments of hostility and optimism to the performance of the AECG was 2.8 (SD 0.9) years. After excluding women with a history of cardiovascular disease at enrollment, missing data on predictors, no follow-up data, or incomplete AECG recordings, 2655 women (79% of the original sample) were available for final analyses (Figure 1).

Optimism, cynical hostility, and HRV

More optimistic, vs. less optimistic, women (table 1A) were younger, more likely to be white, and more educated. More optimistic women also had a more favorable CHD risk factors profile (i.e., they were less likely to be smokers, physically inactive, diabetic, hypertensive, and to report a history of treated high cholesterol).

More hostile, vs. less hostile women were significantly older, more likely to be Hispanic or African American, and less educated. They also had a less favorable CHD risk profile, with higher prevalence of diabetes, obesity, high cholesterol, and hypertension at baseline (Table 1B).

Correlation coefficients between traits (continuous scores) and continuous HRV measures are shown in Table S1, Supplemental Digital Content 1 (r values between −0.057 and 0.030). In unadjusted linear regression models, baseline *optimism* was not associated with HRV measures 3 years later, while we found an inverse association between *hostility* scores and HRV measures (SDANN, SDNN) (Table 2, model 1), which persisted after adjustment for traditional CHD risk factors (Table 2, models 2 and 3). Further adjustment for depression scores did not change this association (data not shown). Although the association between hostility and HRV was statistically significant, effect sizes were small. No association was observed between either optimism or hostility and average 24 hours HR.

HRV and CHD risk

Women with low (< 100 msec) HRV were significantly older than those with higher HRV (Table 3). With the exception of high cholesterol, the prevalence of CHD risk factors was significantly greater in the low HRV group. HRV was also modestly associated with education and ethnicity (p = 0.01). Over an average follow-up duration of 12 years, crude incidence rates of CHD events were 3.7% (29/779) in the low HRV group and 1.9% (35/1876) in the high HRV group (p=0.005). We found significant linear associations between HRV (SDNN and SDANN) and CHD events, such that per each 10 milliseconds increase in these measures, we found 12% (p=0.003) and 14% (p<0.001) reductions in risk of CHD outcomes, respectively (Table 4). Associations remained significant after adjusting

for CHD risk factors (age, smoking, hypertension, high cholesterol, and diabetes). We found no association between average 24-hours heart rate and CHD risk.

Exploratory analyses

To examine the possible role of HRV in explaining associations between either optimism or hostility and CHD risk, we added HRV measures to multivariate Cox proportional hazards regression models of optimism and hostility and CHD risk adjusted for risk factors. If HRV were a mediator of this association (i.e., it was on the causal pathway linking optimism and hostility with CHD risk), we expected to see changes in the magnitude of point estimates for CHD risk upon including HRV measures in the model. Given the small number of CHD events, we did not expect associations to be significant. Consistent with the results reported by Tindle et al. in the larger WHI-OS cohort, (10) women in top quartiles of optimism and hostility scores had, respectively, a lower and a higher risk of CHD events compared to the bottom quartiles, but associations were non-significant due to the smaller sample size. For both optimism and hostility, including HRV in the model did not modify the magnitude of the association (Table 5).

Discussion

In this community-based cohort of healthy aging women free of cardiovascular disease at baseline, we did not find any association between optimism and HRV indices (SDNN and SDANN). Cynical hostility was inversely associated with HRV indices three years later, but effect sizes were small. While SDNN and SDANN were inversely associated with CHD risk, exploratory analyses suggest that these HRV indices likely do not play a major role in explaining associations with CHD risk.

The mechanisms underlying associations between optimism, hostility and cardiovascular risk are yet to be fully explored. A common explanation is that optimism and hostility affect CHD outcomes via behavioral risk factors. For example, more optimistic people are more prone to exercise regularly, to quit smoking, to follow a healthy diet, and to take their medications regularly. (13–15) Hostility has been associated with poor health behaviors such as physical inactivity, poor dietary habits, and smoking. (36–38)

The role of the autonomic nervous system as a potential mechanism explaining associations between optimism and hostility and CHD events has yet to be defined. While reduced parasympathetic activity may be a mechanism explaining why individuals with a hostile attitude are at higher risk of CHD, it is yet to be clarified whether autonomic dysregulation plays a causal, independent role. Our exploratory analyses (although limited by the small number of events and selected HRV indices) suggest that this may not be the case. Our findings are consistent with those of a recent randomized controlled trial (RCT) that assigned 158 hostile volunteers to a 12-week cognitive behavior therapy program or to a waitlist control condition. This study showed expected reductions in hostility and anger but did not result in changes in HRV indices. (39) Similar results were reported in a smaller study conducted among patients with cardiac defibrillators. (40) These findings call into question the role of autonomic dysregulation (as measured by HRV indices) as an

independent pathophysiological mechanism explaining the association between hostility and CHD risk.

In regard to our finding of an inverse association between HRV indices and CHD risk, the available evidence is largely based on studies conducted in MI survivors. (18) The Multicenter Post Infarction Group study found that low SDNN was a strong predictor of cardiac mortality over an average follow-up period of 2.5 years even after adjustment for multiple demographic and clinical factors. Another prospective study involving more than 800 MI survivors documented similar findings after adjusting for clinical and demographic characteristics. (24) Furthermore, in the thrombolytic era, two prospective studies (the GISSI-2 group and the large ATRAMI study) consistently found that post-acute MI patients with SDNN < 70 msec had an adjusted 3-fold increase in mortality after adjustment for clinical characteristics. (23, 25) Inverse associations between HRV and CHD risk were found also in patients with stable angina, independent of traditional coronary risk factors and Framingham risk. (22) Among populations without cardiovascular disease at enrollment, large prospective studies involving both men and women (20, 21, 41, 42) have shown inverse associations between HRV and CHD risk, independent of demographic characteristics and coronary risk factors. None of these studies, however, involved exclusively women; to date, ours is the largest study of HRV and CHD risk conducted in a healthy female sample.

In contrast with findings from a large meta-analysis of prospective cohort studies, (43) we did not find an association between heart rate and CHD risk. This could be explained by the fact that such studies included participants with CHD and other co-morbidities at baseline, while in our study women with prevalent cardiovascular disease were excluded from the analysis.

Strengths of this study include its longitudinal design, the use of validated measures of HRV, and a large sample of women with 24 hours AECG data. This study also has some weaknesses. First, given the demographic characteristics of the WHI population, findings are not generalizable to males, younger age groups, and non-white minorities. A second possible limitation is the lack of frequency-domain measures of HRV, which were not assessed in the MIMS study. However, according to Task Force Recommendations, findings from time domain measures are equivalent to those of frequency domain, and time domain assessments have been used in large studies of HRV in post-MI patients. (35) Finally, while it is relatively well established that SDNN is an index of vagally mediated HRV, the interpretation of SDANN is less clear. Some researchers have noted, for instance, that SDANN assessed over a 24-hour period might not reflect exclusively ANS activity, but also capture characteristics related to movement and functional capacity. (44, 45)

In sum, in this sample of older women free of cardiovascular disease, HRV indices (SDNN and SDANN) did not explain why more optimistic women appear to be somewhat protected from CHD risk. Although hostility was inversely associated with SDNN and SDANN, the magnitude of the association was small, and the role of autonomic dysregulation as a possible mechanism underlying the association between hostility and CHD risk remains to be established.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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List of acronyms

ANS	Autonomic nervous system
HRV	Heart rate variability
MI	Myocardial infarction
WHI-OS	Women's Health Initiative Observational Study
CHD	Coronary heart disease
MIMS	Myocardial Ischemia and Migraine Study
AECG	Ambulatory electrocardiogram
SDNN	standard deviation of N-N intervals
SDANN	standard deviation of the average NN interval
MET	Metabolic equivalent of task
BMI	Body mass index
ANOVA	analysis of variance
HR	hazard ratio

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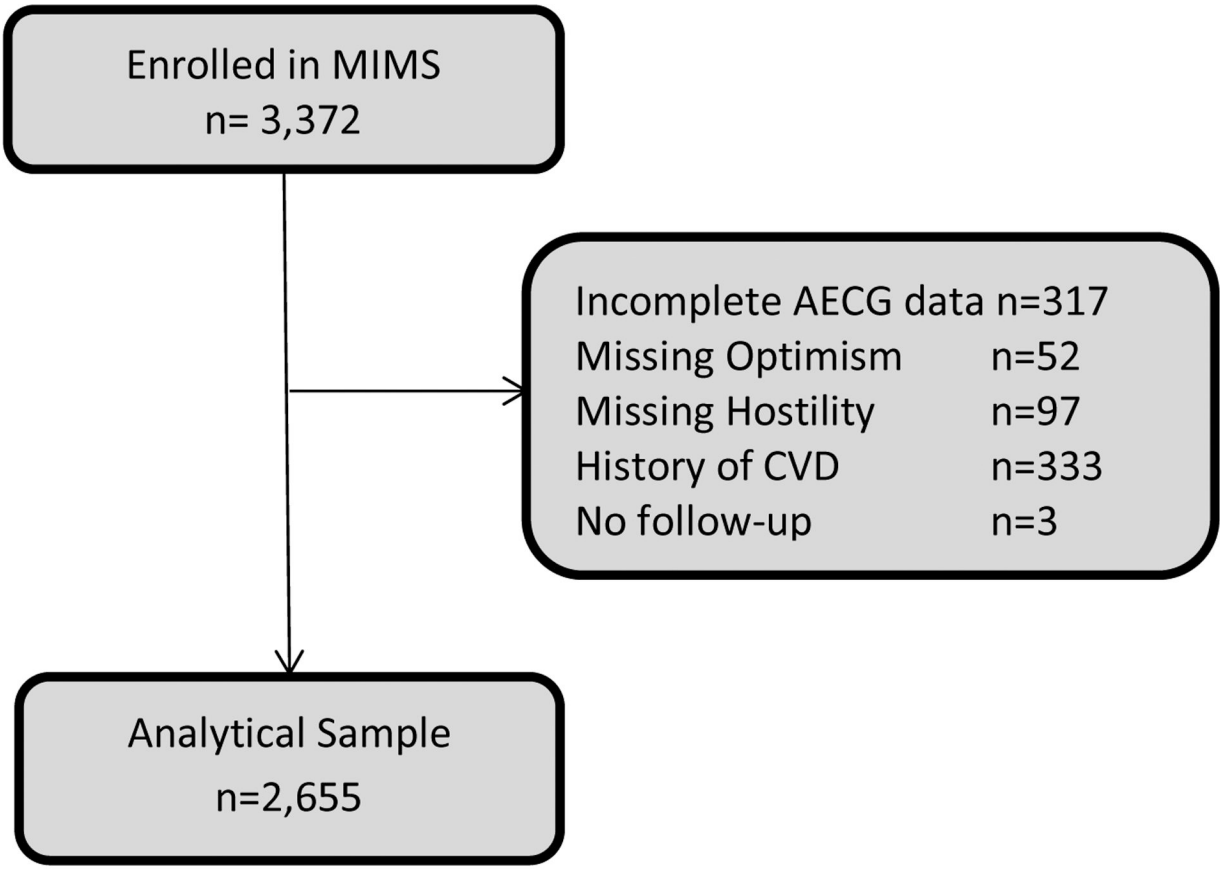

Figure 1 –. STROBE diagram

Table 1a.

Participant characteristics by optimism scores

	Optimism				
	Q1 (6–21)	Q2 (22–23)	Q3 (24–25)	Q4 (26–30)	p[1]
N	706	603	584	762	
Age (mean ± s.d.: years)	63.0 ± 7.3	62.4 ± 7.3	62.6 ± 7.2	61.9 ± 7.0	0.024
American Indian/Alaskan	6 (0.9)	0 (0.0)	0 (0.0)	2 (0.3)	
Asian/Pacific Islander	200 (28.4)	115 (19.1)	77 (13.2)	65 (8.6)	
Black	34 (4.8)	34 (5.6)	28 (4.8)	28 (3.7)	<.001
Hispanic/Latino	28 (4.0)	9 (1.5)	11 (1.9)	11 (1.5)	
White	423 (60.0)	434 (72.0)	456 (78.4)	638 (84.4)	
Other	14 (2.0)	11 (1.8)	10 (1.7)	12 (1.6)	
≤ High school diploma	204 (29.0)	116 (19.3)	95 (16.4)	90 (11.9)	
College or some college	320 (45.5)	303 (50.3)	263 (45.3)	340 (44.9)	<.001
Post-graduate	179 (25.5)	183 (30.4)	223 (38.4)	327 (43.2)	
Never smoked	403 (57.2)	370 (62.0)	331 (56.9)	400 (52.7)	
Past smoker	253 (35.9)	200 (33.5)	228 (39.2)	324 (42.7)	0.003
Current smoker	48 (6.8)	27 (4.5)	23 (4.0)	35 (4.6)	
Physical activity (mean ± s.d.)*	12.8 ± 13.7	13.1 ± 12.6	14.9 ± 14.1	16.3 ± 15.2	<.001
Normal weight (BMI < 25 kg/m^2)	321 (45.9)	285 (47.6)	275 (47.2)	379 (50.0)	
Overweight (BMI 25-<30 kg/m^2)	234 (33.4)	209 (34.9)	201 (34.5)	234 (30.9)	0.50
Obese (BMI ≥30 kg/m^2)	145 (20.7)	105 (17.5)	107 (18.4)	145 (19.1)	
Diabetes mellitus	22 (3.1)	21 (3.5)	11 (1.9)	10 (1.3)	0.029
Never hypertensive	459 (65.0)	412 (68.8)	431 (73.9)	586 (77.4)	
Untreated hypertensive	65 (9.2)	53 (8.8)	33 (5.7)	49 (6.5)	<.001
Treated hypertensive	182 (25.8)	134 (22.4)	119 (20.4)	122 (16.1)	
High cholesterol	109 (15.5)	74 (12.4)	68 (11.8)	84 (11.1)	0.061
Depressive symptoms[3]	136 (19.3)	59 (9.9)	35 (6.1)	22 (2.9)	<.001

Values are n (%) unless otherwise noted.

[1] P-values are chi-square for categorical variables and ANOVA for continuous variables.

[2] MET hours/week

[3] Scores > 0.06(34)

Table 1b.

Participant characteristics by hostility scores

	Hostility				
	Q1 (0–1)	**Q2 (2–3)**	**Q3 (4–5)**	**Q4 (6–13)**	**p[1]**
N	**778**	**695**	**616**	**566**	
Age (mean ± s.d.: years)	62.2 ± 7.1	62.2 ± 7.3	62.5 ± 7.2	63.0 ± 7.3	0.14
American Indian/Alaskan Native	3 (0.4)	1 (0.1)	0 (0.0)	4 (0.7)	<.001
Asian/Pacific Islander	156 (20.1)	103 (14.9)	96 (15.6)	102 (18.1)	
Black/African-American	17 (2.2)	28 (4.0)	32 (5.2)	47 (8.3)	
Hispanic/Latino	8 (1.0)	7 (1.0)	18 (2.9)	26 (4.6)	
White	576 (74.2)	544 (78.6)	456 (74.3)	375 (66.5)	
Other	16 (2.1)	9 (1.3)	12 (2.0)	10 (1.8)	
≤ High school diploma	122 (15.7)	116 (16.8)	105 (17.1)	162 (28.8)	<.001
College or some college	355 (45.8)	313 (45.2)	308 (50.2)	250 (44.5)	
Post-graduate	298 (38.5)	263 (38.0)	201 (32.7)	150 (26.7)	
Never smoked	443 (57.1)	379 (55.2)	358 (58.1)	324 (57.5)	0.46
Past smoker	298 (38.4)	279 (40.6)	222 (36.0)	206 (36.6)	
Current smoker	35 (4.5)	29 (4.2)	36 (5.8)	33 (5.9)	
Physical activity (mean ± s.d.)	15.2 ± 14.2	14.4 ± 13.6	14.2 ± 14.5	13.1 ± 13.8	0.051
Normal weight (BMI < 25)	418 (54.0)	325 (47.0)	277 (45.4)	240 (42.5)	<.001
Overweight (BMI 25-<30)	242 (31.3)	237 (34.3)	206 (33.8)	193 (34.2)	
Obese (BMI ≥30)	114 (14.7)	129 (18.7)	127 (20.8)	132 (23.4)	
Diabetes	20 (2.6)	5 (0.7)	17 (2.8)	22 (3.9)	0.003
Never hypertensive	567 (73.3)	512 (74.0)	441 (71.8)	368 (65.1)	0.007
Untreated hypertensive	50 (6.5)	53 (7.7)	51 (8.3)	46 (8.1)	
Treated hypertensive	157 (20.3)	127 (18.4)	122 (19.9)	151 (26.7)	
High cholesterol	100 (13.0)	83 (12.0)	62 (10.2)	90 (16.0)	0.025
Depressive symptoms[3]	43 (5.6)	64 (9.3)	51 (8.3)	94 (16.7)	<.001

Values are n (%) unless otherwise noted.

[1] Chi-square for categorical variables and ANOVA for continuous variables

[2] MET hours/week

[3] Scores > 0.06 (34)

Table 2.

Associations between Optimism, Hostility and HRV measures

	Optimism β (95% CI)	p	Hostility β (95% CI)	p
SDNN				
Model 1	0.158 (−0.191, 0.507)	0.374	−0.613 (−1.051, −0.176)	0.006
Model 2	0.134 (−0.214, 0.482)	0.451	−0.578 (−1.015, −0.141)	0.010
Model 3	0.034 (−0.318, 0.385)	0.851	−0.487 (−0.926, −0.049)	0.029
SDANN[1]				
Model 1	0.201 (−0.141, 0.543)	0.250	−0.648 (−1.077, −0.218)	0.003
Model 2	0.180 (−0.162, 0.522)	0.303	−0.616 (−1.045, −0.187)	0.005
Model 3	0.099 (−0.247, 0.444)	0.575	−0.542 (−0.973, −0.111)	0.014
HR				
Model 1	−0.042 (−0.137, 0.052)	0.380	0.095 (−0.024, 0.213)	0.12
Model 2	−0.051 (−0.145, 0.043)	0.284	0.109 (−0.009, 0.227)	0.071
Model 3	−0.043 (−0.138, 0.052)	0.374	0.099 (−0.020, 0.218)	0.10

Model 1: Unadjusted

Model 2: Age-adjusted

Model 3: Adjusted for age, smoking, hypertension, high cholesterol requiring medication, and diabetes (n=2,612)

[1]Outlier >1000 was excluded

HR = average 24-hour heart rate

Table 3.

Participants' characteristics by low/high heart rate variability

		SDNN		
	Total	**<100**	**≥100**	**p[1]**
N	**2,655**	**779**	**1,876**	
Age at baseline (mean ± s.d.: years)	62.5 ± 7.2	63.1 ± 7.1	62.2 ± 7.2	0.003
American Indian or Alaskan Native	8 (0.3)	5 (0.6)	3 (0.2)	0.011
Asian or Pacific Islander	457 (17.3)	131 (16.8)	326 (17.5)	
Black or African-American	124 (4.7)	49 (6.3)	75 (4.0)	
Hispanic/Latino	59 (2.2)	22 (2.8)	37 (2.0)	
White (not of Hispanic origin)	1,951 (73.7)	563 (72.3)	1,388 (74.3)	
Other	47 (1.8)	9 (1.2)	38 (2.0)	
≤ High school diploma	505 (19.1)	150 (19.3)	355 (19.0)	0.012
College or some college	1,226 (46.4)	390 (50.3)	836 (44.8)	
Post-graduate	912 (34.5)	236 (30.4)	676 (36.2)	
Never Smoked	1,504 (56.9)	427 (55.2)	1,077 (57.7)	0.012
Past Smoker	1,005 (38.0)	293 (37.9)	712 (38.1)	
Current Smoker	133 (5.0)	54 (7.0)	79 (4.2)	
Diabetes mellitus	64 (2.4)	34 (4.4)	30 (1.6)	<.001
Never hypertensive	1,888 (71.4)	498 (64.2)	1,390 (74.4)	<.001
Untreated hypertensive	200 (7.6)	72 (9.3)	128 (6.8)	
Treated hypertensive	557 (21.1)	206 (26.5)	351 (18.8)	
High cholesterol	335 (12.7)	111 (14.3)	224 (12.0)	0.11

Values are n (%) unless otherwise noted.

[1] P-values are chi-square for categorical variables and ANOVA for continuous variables.

Table 4.

Associations between HRV measures and risk of incident CHD

		Crude		p	Adjusted[a]		P
HRV measures	N events	HR[b]	95% CI		HR[b]	95% CI	
SDNN	64	0.88	(0.81–0.96)	0.003	0.91	(0.83–0.99)	0.023
SDANN[c]	64	0.86	(0.78–0.94)	<0.001	0.88	(0.80–0.96)	0.006
Average heart rate	64	0.95	(0.71–1.26)	0.711	0.97	(0.73–1.28)	0.81

[a] Adjusted for age, smoking, hypertension, high cholesterol requiring medication, and diabetes (n=2,612)

[b] HR are per 10 milliseconds for SDNN and SDANN, and 10 beats/min for average HR

[c] Outlier >1000 was excluded

Table 5.

Risk of CHD by quartiles of optimism and hostility, adjusting for risk factors and HRV measures

		Crude	Adjusted[1]	SDNN[2]
	N events	HR (95% CI)	HR (95% CI)	HR (95% CI)
Optimism (quartiles)				
Q1 (0–21)	20	1.0 (ref)	1.0 (ref)	1.0 (ref)
Q2 (22–23)	14	0.82 (0.41–1.61)	0.96 (0.48–1.91)	0.95 (0.48–1.90)
Q3 (24–25)	19	1.12 (0.60–2.11)	1.41 (0.74–2.70)	1.39 (0.73–2.65)
Q4 (26–30)	11	0.49 (0.24–1.03)	0.66 (0.31–1.41)	0.64 (0.30–1.37)
Optimism (continuous)	64	0.94 (0.88–1.01)	0.97 (0.90–1.04)	0.97 (0.90–1.04)
Hostility (quartiles)				
Q1 (0–1)	18	1.0 (ref)	1.0 (ref)	1.0 (ref)
Q2 (2–3)	17	1.06 (0.55–2.05)	1.16 (0.59–2.26)	1.13 (0.58–2.20)
Q3 (4–5)	9	0.63 (0.28–1.41)	0.62 (0.28–1.39)	0.58 (0.26–1.30)
Q4 (6–13)	20	1.54 (0.82–2.92)	1.23 (0.64–2.35)	1.20 (0.63–2.29)
Hostility (continuous)	64	1.03 (0.95–1.13)	1.00 (0.92–1.09)	1.00 (0.92–1.09)

[1]Adjusted for CHD risk factors (age, smoking status, hypertension, high cholesterol, and diabetes)

[2]SDNN added to the model