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Ambulatory Cardiovascular Activity and Hostility Ratings in Women with Chronic Posttraumatic Stress Disorder

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Abstract

Background—The objective of the current study is to evaluate the relationship between hostility and ambulatory cardiovascular activity in women with and without PTSD.

Methods—One hundred and one women completed 24 hours of ambulatory monitoring and standardized diagnostic and hostility measures. Generalized estimating equations analysis was used to examine the effects of group and hostility factor scores (hostile beliefs, overt hostility, and covert hostility) on ambulatory heart rate (AHR), systolic (ASBP), and diastolic (ADBP) blood pressure.

Results—After controlling for covariates, there was an interaction between PTSD and both hostile beliefs and overt hostility for AHR. Increases in hostility were associated with greater increases in heart rate among women with PTSD relative to those without PTSD. There was a similar interaction between hostile beliefs and group for ADBP.

Conclusions—Increased ambulatory heart rate and blood pressure have been linked to poor cardiovascular outcomes in nonpsychiatric populations. Individuals with PTSD display increased hostility, a construct that has also been linked to poorer cardiovascular outcomes. Increases in hostile beliefs were associated with a greater increase in ADBP among women with PTSD as compared to controls. This data suggests that PTSD may in part moderate the relationship between hostility and cardiovascular outcomes.

Keywords

ambulatory monitoring; hostility; cardiovascular health; PTSD; women

Posttraumatic stress disorder (PTSD) is a psychiatric condition that affects approximately 6-8% of the adult population (1), and women are twice as likely to develop PTSD than men (2). Women with chronic PTSD are of particular interest in the current study because of the extensive literature linking this psychiatric diagnosis to adverse health outcomes (3). Studies have consistently found that individuals with PTSD report increased somatic complaints, health care utilization, functional impairment, and morbidity due to physical health problems (3-7).

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Further, PTSD has been linked to cardiovascular health problems such as hypertension, increased incidence of cardiac events, and sudden death from cardiac-related problems (4;5).

Although the majority of studies examining PTSD and health have been conducted in male samples, there is increasing evidence that PTSD is associated with poor health in women (6; 7). It is unclear, however, if PTSD is associated with cardiovascular health and functioning among women with PTSD. Cardiovascular health is the leading cause of death among women of all races and is a significant public health concern (8). Knowledge that PTSD may place women at even greater risk for cardiovascular health problems is important in managing the global health needs of this vulnerable population.

Cardiovascular ambulatory monitoring studies provide a unique opportunity to examine physiological reactivity and its relationship to affect. Studies including nonpsychiatric populations have demonstrated that increased ambulatory heart rate and blood pressure are significantly related to poorer cardiovascular health including both intermittent and long-term outcomes such as arterial stiffness (9;10), target organ damage (11;12), and mortality (13; 14). Ambulatory studies have shown that male PTSD participants demonstrate higher ambulatory heart rate than those without PTSD (e.g., 15; 16), but there have been such no studies in women with PTSD.

A separate line of research has shown a link between other negative affective states including anger and hostility with cardiovascular parameters and health risk (17;18). Hostility has been linked to adverse health outcomes including cardiac death (e.g., (19;20). Anger and hostility are common symptoms reported in the aftermath of trauma exposure. In fact, meta-analysis of the extant 39 studies indicates that anger and hostility are significantly elevated in individuals with PTSD (21). Additionally, studies have found that compared to individuals without PTSD, individuals with PTSD have greater cardiovascular responsivity when reliving an anger-provoking event from their past (22). Although hostility has been strongly linked to PTSD, relatively few of the studies documenting this link have been conducted in female samples.

The interconnections between PTSD, hostility, and health outcomes are significant, and a plausible model for understanding these interrelationships have been presented elsewhere in more detail (e.g., 23). Recent evidence suggests that the relationship between hostility and health outcomes may be moderated by PTSD (61; 33). The relationships between PTSD, hostility and cardiovascular parameters, however, have not been well examined in women.

Thus, the current study had two aims: 1) evaluate ambulatory cardiovascular activity among women with and without PTSD and 2) determine whether the association between hostility and cardiovascular parameters is moderated by PTSD. It was expected that women with PTSD would demonstrate increased physiological arousal (e.g., higher HR, BP) than women without PTSD, and that women with PTSD would demonstrate a stronger association between hostility and ambulatory cardiovascular parameters than women without PTSD.

Methods and Materials

Participants

A total of 193 women were screened for this study between 2001-2005. Participants were recruited *via* advertising at two local medical centers for a study on trauma and health, and all participants gave informed consent based on a protocol that was in compliance with local institutional review boards. The Clinician Administered PTSD Scale was used to determine PTSD diagnostic status (CAPS; 24), and the Structured Clinical Interview for DSM-IV (SCID; 25)) was used to diagnose other Axis I disorders. Any potential participants meeting criteria for current alcohol or other substance dependence/abuse (n = 7), or psychotic disorders

(including schizophrenia and bipolar with active manic symptoms; $n = 4$) were excluded. Two additional participants were excluded during the screening process due to medication usage (amitriptyline and methadone). Participants recruited for the comparison group were excluded if they met criteria for lifetime PTSD ($n = 27$) or if they met criteria for current or lifetime major depressive disorder ($n = 18$). Finally, two participants were excluded from these analyses due to missing log data as described in further detail below. Based on the structured clinical interviews, the remaining 117 study participants were classified into the following two groups: PTSD ($n=67$) and non-PTSD comparison ($n=50$). Eight diagnostic raters were utilized, and interrater reliability for diagnoses based on videotapes of patient interviews was $\kappa = .94$. Participants were compensated \$250.00 (\$50 for screening interview and \$200 at study completion).

This sample reported a wide range of index trauma exposures. For participants not diagnosed with PTSD, 40 (80%) reported a criterion A trauma in their history. The following were endorsed as the index trauma: childhood physical or sexual assault (12% in non-PTSD; 22% in PTSD); adult physical or sexual assault (5% in non-PTSD; 17% in PTSD); domestic violence (8% in non-PTSD; 20% in PTSD); witnessing violence as an adult (3% in non-PTSD; 4% in PTSD); witnessing violence as a child (10% in non-PTSD; 4% in PTSD); death of someone close to them (32% in non-PTSD; 21% in PTSD); accident (3% in non-PTSD; 3% in PTSD); natural disaster (5% in non-PTSD; 0% in PTSD); and other traumatic event (22% in non-PTSD; 9% in PTSD).

Medications were recorded, and anyone taking a medication with cardiovascular effects (e.g., beta-blocker, diuretic) were classified as taking a cardiac affecting medication. This included psychiatric medications that could affect cardiac function (e.g., beta blockers, alpha adrenergic blockade medication and anticholinergic) were also counted as a cardiac affecting medication. Statistical comparisons for demographic, diagnostic characteristics, and cardiac medication use between PTSD and comparison group are reported in Table 1.

Measures

A series of self-report measures were also administered. These questionnaires included the short form of the Cook-Medley Hostility Scale (26); the Buss-Durkee Hostility Inventory (27); the Spielberger Anger Expression Scale (28); and the Rotter Interpersonal Trust Scale (29).

Procedure

Participants were screened for eligibility using the CAPS, the SCID (and a urine sample was utilized to corroborate alcohol/drug use reports on the SCID). Eligible participants returned for a second visit (arriving at the laboratory between 8 and 9 am) during which time they were instructed in the use of their ambulatory blood pressure/heart rate monitor. Monitors and a log of readings and activity level were returned during a third and final study visit.

Ambulatory Monitoring

Participants were fitted with an ambulatory recorder: the Accutacker II (Suntech Medical Instruments, Raleigh, NC), or the Spacelabs 90207. Reliability and validity of these recorders have been demonstrated previously (30;31). There was some difficulty in obtaining valid readings with the Accutacker, particularly in women with greater arm circumference. Thus, once invalid measurements were obtained for participants using the Accutacker II, a Spacelabs 90207 ambulatory monitor was purchased and instead utilized for these participants (14%). Participants were instructed to carry on with their usual daily activities, to keep their nondominant arm (where the cuff was attached) at their side whenever the recorder operated, and to wear the monitor for 24 hours.

The recorder was programmed to operate every 30 minutes $\pm$ 5 minutes during waking hours based on self-reported sleep/wake times. On each measurement occasion, single readings were obtained of AHR, ASBP and ADBP. Both monitors were programmed to retake any blood pressure readings that appeared out of range. Criteria for detection and elimination of final values in the dataset included the following: ADBP less than 40 mmHg or greater than 140 mmHg; ASBP less than 50 mmHg or greater than 245 mmHg; and ASBP/ADBP ratio of greater than 3. Whenever the ASBP or ADBP was removed, the corresponding ABP and AHR were also removed (resulting in 16 exclusions). Participants completed a log each time the recorder operated while they were awake; one question of interest to the current study was for participants to rate their current level of physical activity from the following levels: Level 1 (Inactive: Sitting, Reclining, Sleeping); Level 2 (Light: Slow walk, some movement); Level 3 (Medium: rapid walking, moving a lot); and Level 4 (Heavy: strenuous movement). Analyses of AHR and ABP only included readings taken at physical activity level 1 or level 2 as there were very few readings (11%) taken at levels 3 or 4. Each measurement occasion was rated as asleep or awake based on report of sleep and wake times completed during the 24-hour monitoring period.

Results

Hostility Factors

Four self-report hostility measures were used to conduct a principal component analysis with varimax rotation as a means of identifying common factors related to hostility, and factors were based on an eigenvalue of > 1 . The post-rotation analysis revealed three factors that accounted for 100% of the variance. The first factor, 'hostile beliefs-cognitive dimensions of hostility such as suspiciousness and cynicism,' explained 37.6% of the variance (eigenvalue = 5.78). The second factor, 'overt hostility – expression of anger outwardly,' accounted for 33.5% of the variance (eigenvalue = 1.69). The third factor, 'covert hostility – indirect anger such as irritability,' explained 28.9% of the variance (eigenvalue = 1.01). This factor structure replicated previous community and men samples using the same measures (32;22). Table 2 displays the means, standard deviations, and group differences for the self-report hostility measures and factors.

Cardiovascular Readings

The AHR and ABP data were participant-specific, time series/repeated measurement data and the unit of analysis was the individual observation. Primary analyses of these variables were performed using generalized estimating equations (GEE; 33) in SAS Proc GENMOD (2001; Version 8.2; SAS Institute, Cary, NC) in order to account for multiple observations within subjects and differing numbers of observations for each participant. This analytic approach allows the inclusion of variables at different levels of analysis (i.e., individual characteristics and time-dependent variables) and is not dependent on each individual having the same number of data points. The effective sample size is the number of participants $\times$ the number of observations which was 1312 in this sample. These analyses treated the cardiovascular variables (AHR, ASBP and ADBP) as dependent variables and modeled each separately as a function of selected covariates. Covariates included in each model were age, body mass, race, current smoking status, cardiac medication status, and physical activity level as reported on the recording log. Psychiatric covariates were selected as follows: lifetime criteria for substance or alcohol abuse or dependence, current criteria for other anxiety disorder (i.e., social phobia, specific phobia, obsessive compulsive disorder, or generalized anxiety disorder) and group assignment (PTSD versus control). Finally, the three hostility factors (hostile beliefs, overt hostility, covert hostility) were entered into the models to examine main and interaction effects of hostility with PTSD status for each cardiovascular parameter. Tables 3-5 depicts the comprehensive findings from the GEE analysis.

In the AHR model (see Table 3), higher body mass, current smoking, an anxiety disorder diagnosis, higher physical activity, PTSD and the covert hostility factor were associated with higher AHR. There was a main effect for group [adjusted mean: PTSD $M = 80.79$ ($SE = 2.31$) and non-PTSD $M = 76.02$ ($SE = 3.02$)]. There were also significant group $\times$ hostility factor interactions. Both hostile beliefs ($\beta = 4.697$, $SE = 0.989$, $p < .0001$) and overt hostility ($\beta = 3.668$, $SE = 0.880$, $p < .0001$) significantly interacted with group, such that increases in hostile beliefs and overt hostility were associated with higher AHR readings in the PTSD group relative to the comparison group.

In the ASBP, higher body mass, current smoking, not being on cardiac medication, an anxiety disorder diagnosis, higher physical activity, and the covert hostility factor predicted higher systolic blood pressure. In contrast to the other GEE models conducted, there were no group $\times$ hostility factor interactions.

In the ADBP, older age, higher body mass, current smoking, an anxiety disorder diagnosis, and higher physical activity predicted higher diastolic blood pressure. There were also significant group $\times$ hostility factor interactions. Both hostile beliefs ($\beta = 3.651$, $SE = 0.809$, $p < .0001$) and covert hostility ($\beta = 1.415$, $SE = 0.668$, $p < .05$) significantly interacted with group, where increases in hostile beliefs and covert hostility were associated with higher ADBP in the PTSD group relative to the control group. In contrast, the interaction between overt hostility $\times$ group was in the opposite direction ($\beta = -2.145$, $SE = 0.720$, $p < .01$), where increases in overt hostility was associated with higher ADBP readings in the control group relative to the PTSD group; however, the mean difference in score was relatively small in comparison to the other significant interactions.

Discussion

The current study found evidence linking PTSD, hostility, and cardiovascular functioning. Overall, women with PTSD demonstrated significantly higher heart rate readings over time in comparison to the non-PTSD group. The study demonstrated interactions between group membership and the three hostility factors (hostile beliefs, overt hostility, covert hostility). For the heart rate and diastolic blood pressure models, there was a significant interaction between hostile beliefs and overt hostility by group. While there is ample empirical support for the association between hostility and cardiovascular outcomes (17), our data suggests that PTSD may in part moderate this relationship. Increases in hostile beliefs and overt hostility resulted in higher heart rate and higher diastolic blood pressure only in those participants with PTSD. These data are consistent with other studies suggesting that individuals with PTSD may have increased autonomic arousal (33;24;20), and with a study of men in which PTSD moderated the effect of hostility on cardiovascular parameters (22;34).

There are study limitations. Cardiovascular functioning was only tracked over a 24-hour period during a weekday. This timeframe may not have been sufficient to yield other group differences in blood pressure as initially hypothesized nor may it generalize to weekend readings. There may also have been unidentified differences across the two ambulatory monitors, but baseline values for each had been verified with manual blood pressure readings. Results are cross-sectional, limiting any interpretation of causality among PTSD diagnosis, hostility and cardiovascular function. Finally, these results can only be generalized to women. Gender differences may be present in the associations between cardiovascular function and PTSD, as there are documented gender differences in PTSD (35). For example, we have detected lower BRS in women with PTSD only (36-37), and in a sample without PTSD, hostility and indices of glucose metabolism were present in women only (38). However, there have been few studies of PTSD and cardiovascular health that include both men and women.

This is the first study to our knowledge of a large women sample examining PTSD and hostility and ambulatory cardiovascular function. Additional strengths of the study included standardized diagnostic assessment and analysis that controlled for a wide range of covariates. The need remains to conduct more comprehensive longitudinal designs to evaluate temporal relationships among PTSD status, cardiovascular risk factors (psychological, behavioral and physiological), and cardiovascular outcomes in an effort to develop effective preventive interventions for these patients.

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Table 1

Participant Characteristics

	PTSD (n=67)	Control (n=50)	Test Statistic
	M (SD)	M (SD)	
Age	41.45 (11.44)	34.30 (11.30)	$F(1,116) = 11.29, p = 0.001^{***}$
Education	14.43 (2.64)	16.76 (2.73)	$F(1,116) = 21.60, p < .0001^{***}$
Hollingshead Rating	45.55 (17.87)	31.80 (14.53)	$F(1,116) = 19.82, p < .0001^{***}$
% Minority	58	52	$\chi^2_{1df} = 0.45, p = 0.504$
% Married	46	30	$\chi^2_{1df} = 3.17, p = 0.075$
% Veteran	24	6	$\chi^2_{1df} = 6.73, p = 0.010^*$
% Employed	61	94	$\chi^2_{1df} = 16.53, p < .0001^{***}$
% Current Smokers	36	14	$\chi^2_{1df} = 7.00, p < .01^{**}$
% Current Other Anxiety Disorder	46	12	$\chi^2_{1df} = 15.55, p < .0001^{***}$
% Lifetime Substance Abuse/Dependence	45	10	$\chi^2_{1df} = 16.52, p < .0001^{***}$
% Lifetime Major Depressive Disorder	76	0	$\chi^2_{1df} = 67.47, p < .0001^{***}$
% On Cardiac Effecting Medication	30	4	$\chi^2_{1df} = 12.53, p < 0.001^{**}$

*
<.05,**
<.01,***
<.001

Table 2

Means, Standard Deviations, and Associated Probability Statistics for Hostility Questionnaire Measures and Hostility Factors by Group

	PTSD (n=67)	Control (n=50)	Test Statistic
	M (SD)	M (SD)	
Cook-Medley Total	12.68 (5.60)	7.70 (4.82)	F(1,116) = 25.42, p < .001**
Rotter Trust Scale Total	4.60 (3.04)	7.18 (4.00)	F(1,115) = 15.51, p < .001**
Buss-Durkee Total	28.65 (10.42)	20.61 (9.22)	F(1,113) = 18.37, p < .001**
Speilberger Anger Exp Total	46.38 (7.84)	46.90 (5.80)	F (1,116) = 0.16, p = .690
Factor 1: Hostile Beliefs	0.23 (0.95)	-0.09 (1.02)	F (1,112) = 25.54, p < .0001***
Factor 2: Overt Hostility	0.26 (0.90)	-0.63 (0.94)	F (1,112) = 0.05, p = 0.824
Factor 3: Covert Hostility	-0.02 (1.01)	-0.06 (0.91)	F (1, 112) = 7.96, p = .006**

Table 3

Summary of GEE Analyses for Heart Rate

Dependent Variable	Heart Rate			
	Estimate	Standard error	Z	p
Age	0.047	0.040	1.17	0.242
Body Mass	-0.222	0.069	-3.24	0.001
Minority Status	-0.613	0.923	-0.66	0.507
Smoking Status	-3.349	1.026	-3.27	0.001
Physical Activity	-3.938	0.786	-5.01	<0.0001
Cardiac Medication	2.265	1.359	1.67	0.096
Anxiety Diagnosis	-4.905	0.975	-5.03	<0.0001
MDD Diagnosis	0.807	1.177	0.69	0.493
PTSD Diagnosis	6.378	1.228	5.20	<0.0001
Hostile Beliefs	-3.615	0.797	-4.53	<0.0001
Overt Hostility	-0.261	0.692	-0.38	<0.706
Hostile Beliefs $\times$ PTSD	4.697	.989	4.75	<0.0001
Overt Hostility $\times$ PTSD	3.668	.880	4.17	<0.0001

Table 4

Summary of GEE Analyses for Systolic Blood Pressure

Dependent Variable	Estimate	Standard error	Z	P
Age	-0.057	0.037	-1.52	0.129
Body Mass	0.414	0.067	6.14	<0.0001***
Minority Status	0.894	0.860	1.04	0.299
Smoking Status	-4.439	0.987	-4.50	<0.0001***
Physical Activity	-1.738	0.771	-2.25	0.024*
Cardiac Medication	-9.791	1.271	-7.71	<0.0001***
Anxiety Diagnosis	-3.020	0.931	-3.24	0.001**
MDD Diagnosis	0.726	1.127	0.64	0.519
PTSD Diagnosis	-1.089	1.144	-0.95	0.341
Hostile Beliefs	.0814	0.497	1.64	0.101
Overt Hostility	0.289	0.458	0.63	0.527
Covert Hostility	1.241	0.408	3.04	.002

Table 5

Summary of GEE Analyses for Diastolic Blood Pressure

Dependent Variable	Estimate	Standard error	Z	p
Age	-0.070	0.033	-2.11	0.035*
Body Mass	0.348	0.057	6.16	<0.0001***
Minority Status	-0.764	0.754	-1.01	0.311
Smoking Status	-6.466	0.838	-7.72	<0.0001***
Physical Activity	-1.280	0.644	-1.99	0.047*
Cardiac Medication	-0.101	1.115	-0.09	0.928
Anxiety Diagnosis	-1.992	0.800	-2.49	0.013*
MDD Diagnosis	0.750	0.960	0.78	0.435
PTSD Diagnosis	0.358	1.002	0.36	0.721
Hostile Beliefs	-1.776	0.655	-2.71	.0067
Overt Hostility	0.921	0.570	1.62	0.11
Covert Hostility	-0.534	0.476	-1.12	0.26
Hostile Beliefs × PTSD	3.651	0.809	4.51	.0001
Overt Hostility × PTSD	-2.145	0.720	-2.98	.0029
Covert Hostility × PTSD	1.415	0.668	2.12	0.034