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The Relation between Hot Flashes and Ambulatory Blood Pressure: The Hilo Women's Health Study

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Abstract

Objectives—Hot flashes (HFs) have been associated with elevated blood pressure, but studies have not examined the relationship between objectively measured HFs and blood pressure during normal daily activities. The objectives of this study are to examine ambulatory blood pressure (BP) differences between women who report HFs and those who do not, and to observe whether an objectively measured HF is associated with transient changes in BP.

Methods—A sample of 202 women in Hilo, Hawaii aged 45–55 years were asked to fill out a questionnaire that included demographic information and an inventory of symptoms. The women underwent simultaneous 24-hour monitoring of ambulatory BP and HFs, while keeping a diary that included mood and HF reports.

Results—No significant difference was present in mean BP between women who reported having a HF during the past 2 weeks and those who did not. When measurements controlled for negative mood reports and posture, there was a highly significant elevation in Z scores of systolic BP when a measured, objective HF occurred within 10 minutes preceding a BP reading, and a significant elevation of Z scores of diastolic BP when a subjectively reported HF occurred within 10 minutes after a BP reading.

Conclusions—These results suggest that objectively measured HFs precede transient elevations of systolic BP, but it is unclear if there is a causal relationship. These results also suggest that women experience subjective HFs within 10 minutes after a transient increase in diastolic BP. Again, the causal relationship is not understood.

INTRODUCTION

While risk of cardiovascular disease increases for women after menopause, there is no evidence for an increase in mean blood pressure (BP) due to the menopausal transition when results account for general age-related increases in BP (1,2). However, in a study of hypertensive women, Routledge et al. (3) noted that post-menopausal status was a significant predictor of which women had a nighttime decline in BP of less than 10% of waking values (“non-dippers”). Since non-dippers have a higher risk of cardiovascular morbidity (4), this suggests that changes in the diurnal pattern of BP after menopause may be an important health risk.

There is some evidence that BP is associated with vasomotor symptoms attributed to menopause. In a small sample (N=20) of women who underwent 24-hour ambulatory BP monitoring, James et al. (5) reported that women who had experienced a hot flash (HF) had a higher heart rate and tended to have higher sleep BP. Using a larger sample (N=154), Gerber et al. (6) found that women who reported HFs had significantly higher awake and sleep systolic BP, independent of menopausal status. In both of these studies, HF occurrence was based on responses to a questionnaire which asked if the respondent had experienced the symptom in the past two weeks and/or on subjective reports on the day of BP monitoring.

The advent of ambulatory HF monitoring by skin conductance has enabled observation of objective measures of HFs, and these studies have noted only low to moderate concordance between subjective reports and objective measures of HFs (7–10). Accordingly, this study was initiated with simultaneous objective ambulatory monitoring of BP and HFs, the latter through use of a skin conductance monitor, as well as questionnaire and diary assessments of HFs. This enables observation of (1) the association of HFs, measured subjectively through questionnaires and diaries and objectively through skin conductance, with mean BP, and (2) the association of subjective and objective HFs with transient variation in BP. Diary, laboratory and ambulatory studies have noted significantly fewer HFs during sleep than at other times of day, possibly due to lowered internal temperature (11–15). Since BP is usually considerably lower during sleep, studies must also account for this diurnal pattern when exploring associations between HFs and BP variability. The advantage of ambulatory, as opposed to laboratory-based, monitoring is the ability to observe the occurrence of the outcome variables, whether HFs or BP, during normal life. This study examined the hypothesis that ambulatory blood pressure is elevated in a ten minute period during or immediately following HFs, using both subjective and objective assessments of the HFs.

METHODS

Design

A “natural experimental” design was employed in which women from the general multi-ethnic population of Hilo, Hawaii were monitored over a single 24-hour period while doing normal activities. For the purposes of this study, the day was divided into “waking” and “sleep” periods. All of the women completed a questionnaire that included demographic information, health history, and symptom experience (described below) before the monitoring commenced. Following the 24-hour ambulatory monitoring period, women returned to the University where anthropometric measurements were taken. Monitoring took place from October 2005 to January 2008.

Sample

Previous to the current study, a postal survey had been undertaken in Hilo in which a random sample of the population, based on tax map key designations of properties in Hilo, was identified and mailed a questionnaire. Adult female members of the household were requested to complete and return the questionnaire. Of the 6401 survey packets delivered, 1824 questionnaires were completed and returned (16).

In the current study, eligibility was limited to women aged 45–55 who did not use blood pressure medications or exogenous hormones (hormone therapy or birth control), and had no history of hysterectomy, oophorectomy, or diabetes. All participants in the postal study who met the age eligibility criteria were invited to participate in the current study. Of those 572 eligible participants, 84 participated in ambulatory HF monitoring, with the 118 remaining participants recruited through word of mouth and through an advertisement placed in the

local paper. Table 1 summarizes characteristics of the participants (N=202), including the numbers who reported or demonstrated hot flashes. Figure 1 shows the frequency distribution of numbers of hot flashes either reported (subjective) or objectively measured during the ambulatory monitoring period. All participants provided written, informed consent, and the study was approved by the University of Hawaii Committee on Human Studies.

Procedures

All participants completed a questionnaire that elicited information about demographics (age, marital status, children), menopausal status, brief health history, symptom experience in the past two weeks, and other information including diet, attitudes toward menstruation and menopause, and HF experience during the two weeks prior to interview. Menopausal status was categorized as pre-menopausal (menses during the past 3 months), peri-menopausal (menses 3–12 months previous or menses becoming irregular by 7 or more days), or post-menopausal (no menses during the past 12 months). Women also were measured for height and weight, and body mass index (BMI) was computed as weight/height².

Women arrived at the laboratory at the University of Hawaii at Hilo at their convenience and received instructions about keeping diaries during the monitoring period and about the ambulatory BP and HF monitors. Monitors were then applied, and women were instructed to call project staff if there were any problems. The women were telephoned later in the day to ask if the monitors were working properly.

Participants wore a Biolog HF monitor (UFI, Morro Bay, CA) and ambulatory BP monitor (SpaceLabs 90217, Redmond, WA) for 24 hours, and were instructed to wear two-piece comfortable clothing, to avoid strenuous activity, and to forego showering or bathing while wearing the monitors. Ag/AgCl HF monitor electrodes (1081-HFD, UFI, Morro Bay, CA) filled with 0.05 potassium chloride Velvachol/glycol gel (Custom Med Apothecary, Indianapolis, IN), were placed about 4 inches apart on the upper chest between the second and third ribs to measure sternal skin conductance and about 4 inches apart on the back of the neck to measure nuchal skin conductance. Skin conductance measurements of HFs have most commonly utilized sternal sites, which have been shown to accurately denote hot flashes without interference from emotional sweating (17). Because research has shown that in some populations some women report HFs more commonly at nuchal sites (18), this site was also monitored. Each set of electrodes conducted a 0.5 volt constant circuit and was attached to a two-channel Biolog monitor where skin conductance levels were recorded. The criterion for an objective hot flash was a change in skin conductance level (SCL) of at least 2 μ mho within 30 seconds (17,19). This objective measure of the presence of HFs is not an accurate measure of HF intensity (20), and thus intensity of objective HFs is not addressed here. Women were asked to report intensity of subjective HFs intensity on a scale of 1 to 3 (1=mild, 3=severe), although only presence or absence of reported HFs are noted in this report.

Participants were also fitted with the Spacelabs 90217 BP monitors, which have previously been validated (21). Calibration readings were taken by simultaneously using a standard mercury sphygmomanometer and stethoscope with the participant in the seated position. The BP monitor was programmed to take measurements every 20 min during waking hours, and every 30 min during sleep, with these time periods determined by the woman's self report of her usual sleeping times. The measurements at these time intervals were of systolic and diastolic BP, and pulse.

While wearing the ambulatory monitors, women were asked to record subjective HFs by pushing buttons on the monitor and recording in a diary the start and end times of the HF, where it occurred on the body, and its intensity on a scale of 1 to 3 (1=mild, 3=severe); these recordings are referred to as “diary reports.” As noted by Sievert et al. (15), 40% of the time there was positive concordance between subjective HF experience and objective HF measurement. Additionally, participants filled out a diary entry after each waking BP measurement in which they noted their posture (standing, sitting or reclining), daily setting (work, home, other), and mood (negative: angry, anxious, or sad, or positive: happy, recorded as 0 “no,” 1 “mild,” 2 “moderate, or 3 “very”), and type of activity in which engaged. HFs were recorded as occurring within ten minutes *before* a BP measurement, or ten minutes *after* a BP reading; the total number of HFs for any individual, whether objective or subjective, was the sum of the number of HFs recorded as before and after a BP reading.

Analysis

The relationship between reported negative moods (anger, anxiety, and sadness) and ambulatory HF measurements was analyzed by χ^2 tests. BP measurements included mean ambulatory BP during waking times and during sleep. Comparisons of BP measurements between women who reported HFs and those who did not in questionnaires and in diaries were carried out using two-tailed t-tests. Similarly, t-tests were used to compare BP measurements between women who displayed an objective HF through skin conductance during monitoring and those who did not. Analyses of covariance (ANCOVAs) were then employed to control for menopausal status, age and BMI in the comparisons of mean ambulatory BP in women who experienced HFs or did not. Because the number of HFs reported or objectively measured per participant was not normally distributed, relationships between BP measurements and number of HFs during the study period were analyzed by means of Spearman correlations.

For analysis of nighttime BP dipping, an individual’s BP dipping percentage (whether systolic or diastolic) was computed as:

$$\text{BP dipping percentage} = [(\text{Mean waking BP} - \text{Mean sleep BP}) / (\text{Mean Sleep BP})] * 100$$

Individuals were characterized as either being “dippers” (BP dipping percentage > 10%) or non-dippers (BP dipping percentage ≤ 10%). Comparisons of BP dipping percentage between women who reported having HFs on questionnaires and those who did not were carried out with t-tests, followed by ANCOVAs that controlled for menopause status, age and BMI. In comparing dippers versus non-dippers for HF reporting, χ^2 tests were performed followed by binary logistic regressions that controlled for menopause status, age and BMI.

Analyses of the intra-individual relation between specific individual BPs and HFs were carried out using t-tests for times when the participant was awake. First, individual BP readings taken from times that the participant was awake were converted into Z-scores for each individual:

$$\text{Z score of given BP} = (\text{specific BP reading} - \text{individual's mean daytime BP}) / (\text{individual's standard deviation of daytime BP})$$

The Z scores serve to control for between-subject effects, permitting understanding of the individual’s BP variability relative to the individual’s mean BP. Since women were requested to only fill out diary entries, including reports of HFs, during waking hours,

nighttime BPs were excluded from the Z-score calculations. Also, for analyses of HFs only women who had subjectively reported at least one HF during the ambulatory period (N= 111) were included in analyses involving effects of subjective HFs. Similarly, only women who had at least one objectively measured HF during the monitoring period (N= 152) were included in analyses involving effects of objective HFs. Personal variables such as age, menopause status, BMI, and ethnicity are accounted for through the use of Z-scores, and therefore not included in analyses involving Z scores of BP as dependent variables. The Z-scores of BP were compared by means of t-tests for times when a HF had occurred within ten minutes *preceding* a blood pressure reading or not, and for times when a HF had occurred within ten minutes *following* a blood pressure reading or not. The analyses were repeated using analysis of variance (ANOVAs) with BP as the dependent variable, and presence of HF (within ten minutes, before or after), presence of a reported negative mood, and posture (standing versus sitting) as predictor variables. Posture serves as a proxy measure of physical activity level.

RESULTS

Women who reported HFs within the past two weeks on questionnaires were significantly more likely to report HFs in diaries during ambulatory monitoring compared to women who did not report HFs within the past two weeks (82.1 % versus 36.6 %; $\chi^2=40.4$, $P<.001$) but did not have a significantly higher frequency of objective HFs (83.3 % versus 72.3%; $\chi^2=3.3$, $P=.09$). Women who reported HFs in the past two weeks had a significantly higher mean number of reported subjective HFs in diaries during ambulatory monitoring (mean 9.8 versus 7.1, two tailed t-test $t=6.0$, $P<.001$) and had a non-significantly higher number of objectively recorded HFs (mean 4.8 versus 1.4, $t=1.8$, $P=.07$).

In the ten minutes following a subjective HF, the frequency of reported negative moods in diaries – regardless of noted severity - was significantly elevated compared with times when no HF was reported (for the 111 women who had reported a subjective HF during the monitoring period, $\chi^2=20.2$, $P<.001$). In the ten minutes following an objective HF, the frequency of reported negative moods was not significantly elevated (for the 152 women who had a measured objective HF during the monitoring period, $\chi^2=2.6$, $P=.12$) as illustrated in Figure 2. There was no significant difference in frequency of negative mood reports *preceding* either a subjective ($\chi^2=0.1$, $P=.74$) or objective HF ($\chi^2=0.0$, $P=.95$) compared with times when no HF was reported. Z scores of BP and pulse were significantly elevated when negative moods were reported (systolic BP: $t=9.9$, $P<.001$; diastolic BP: $t=9.7$, $P<.001$; pulse: $t=3.4$, $P<.001$).

There was no significant relationship between either age or menopausal status and mean ambulatory BP measures, but there was a significant negative correlation between age and mean pulse during waking hours ($r=-0.19$, $P=.008$). BMI was significantly correlated with mean waking systolic BP ($r=0.24$, $P=.001$), mean sleeping systolic BP ($r=0.26$, $P<.002$), mean waking pulse ($r=0.17$, $P=.014$) and mean sleeping pulse ($r=0.31$, $P<.001$), but was not significantly correlated with diastolic BP nor with BP dipping. As shown in Table 2, there were no significant differences in mean BP measures between women who experienced a HF and those who did not, whether the report was made on a questionnaire in reference to HFs during the past two weeks, in ambulatory diaries during the study period, or through objective ambulatory measures.

When ANCOVAs were carried out with BP measures as dependent variables, two predictor variables were utilized: menopausal status and whether or not HFs had been experienced, with age and BMI added as covariates. In all cases there was no significant difference in BP

measures between women who had at least one HF and those who did not have a HF (in questionnaire or diary reports, or in objective measures) (not shown).

Results of Spearman correlations between the number of subjective or objective HF reports and BP measures are shown in Table 3. None of the correlations are statistically significant. Also, women characterized as being “dippers” were not significantly more likely to report HFs on questionnaires or diaries, or to have objective HFs, than those who were not dippers (χ^2 tests, $P > .05$). For percentage of dipping, women who had experienced HFs (whether reported on diaries or questionnaires or measured objectively) did not have significantly lower BP dipping percentage than women who did not (t -tests, $P > .05$), and when analyses of covariance were carried out with BP dipping percentage as the dependent variable, HF experience and menopausal status as predictor variables, and age and BMI as covariates, HF experience was not a significant predictor of BP dipping percentage.

For women who had at least one reported subjective HF or at least one objective HF during the monitoring period, there were 444 instances (or 7.3 % of BP measurements) of objective HFs measured within 10 minutes before a BP reading and 441 instances (7.2 %) of objective HFs within 10 minutes after a BP reading. There were 215 (4.8 %) and 236 instances (5.3 %) of subjective HFs within 10 minutes before or after a BP reading, respectively. Among women with at least one objective HF during the monitoring period, Z-scores of waking BP and pulse were significantly elevated in the ten minutes immediately after an objectively measured HF than at times when an objective HF was not measured (t -tests, systolic BP: $t=4.6$, $P < 0.001$; diastolic BP $t=2.1$, $P = .04$; pulse $t=8.6$, $P < .001$). The difference in Z-scores of waking systolic BP within ten minutes after an objective HF averaged 0.22 units more than at times (± 10 minutes) when an objective HF was not measured, or an approximately 3 mm Hg difference. Z-scores of waking diastolic BP and pulse were significantly elevated in the ten minutes before an objectively measured HF than at times when no objective HF was measured (systolic BP: $t=0.9$, $P = .38$; diastolic BP $t=2.5$, $P = .01$; pulse $t=6.4$, $P < .001$), and thus elevations in BP are seen in the minutes both preceding and following an objective HF (see Figure 3A).

For women who reported at least one subjective HF during the monitoring period, Z-scores of BP within ten minutes either before or after a subjectively reported HF in diaries were not significantly different from BP at times when no subjective HF was reported (HF before BP measurement: systolic $t= 0.3$, $P = .74$; diastolic $t=1.5$, $P = .13$; HF after BP measurement: systolic $t=0.4$, $P = .72$; diastolic $t=0.7$, $P = .51$), as shown in Figure 3B. Z-scores of pulse within ten minutes before a subjectively reported HF were significantly elevated, but not within ten minutes after the BP measurement (Figure 3B; HF before pulse measurement: $t=3.5$, $P < .001$; HF after pulse measurement: $t=1.0$, $P = .31$).

Table 4 presents results of ANOVAs in which the Z-scores of waking BP and pulse were the dependent variables, and posture (standing versus sitting), presence or absence of a reported negative mood and occurrences of an objective or subjective HF within ten minutes preceding or after the BP measurement were predictor variables. These results pertain to women who had at least one reported subjective HF ($N=111$) or at least one measured objective HF ($N=152$) during the monitoring period; results are very similar when all women in the sample ($N=202$) are included in the analysis (not shown). The ANOVA results indicate that a BP reading within ten minutes after an objective HF is a significant predictor of elevated Z-scores of systolic BP (Table 4A), but there is no significant difference in Z-scores of systolic or diastolic BP when the BP reading occurs within ten minutes before an objective HF compared to times when no HF is measured (Table 4B). Z scores of diastolic BP are significantly elevated with the reporting of a subjective HF within 10 minutes after the BP recording (Table 4B). Pulse is significantly elevated in ten minute periods both

before and after objective HF measurements, and pulse is significantly elevated in the ten minutes after a subjective HF report (Table 4A and 4B).

DISCUSSION

Hot flashes involve an initial vasodilation of superficial blood vessels, an outcome seen in general responses to heat stress. In general responses to heat, this vasodilation is accompanied by a compensatory vasoconstriction in other areas that maintains BP levels (22). It is unclear if the same mechanism occurs during HFs. Over a somewhat longer time course, in this case within ten minutes of the start of an objectively measured HF, this study shows that there is a transient elevation of systolic BP.

HFs are thought to be initiated by a central nervous system (CNS) – but not peripheral – norepinephrine response (23). Peripheral release of norepinephrine leads to increases in BP through stimulation of vasoconstriction. Norepinephrine is thought to leak from the CNS into cerebrospinal fluid (CSF) (24), and higher levels of CSF norepinephrine have been found in hypertensives (25). Thus, there may be a physiological link between CNS elevations of norepinephrine and both HFs and elevated BP, with this study's results suggesting that if such a mechanism exists, the CNS norepinephrine apparently stimulates the HF before the pressor response occurs.

Alternately, one may posit that the aversive nature of a HF causes a general stress response that leads to elevated BP. The significant association between a rise in diastolic BP and a subsequent greater chance for reporting a HF in this study suggests that this hypothesis has merit. It appears that the link between HFs and transient increases in BP has both physiological and psychological components. The highly significant increase in frequency of reported negative moods within ten minutes after subjectively reported HFs suggests that there is an aversive nature to HFs. However, while less marked, there was also a significant increase in frequency of reported negative moods after an objective HF, including times when there was no concordant subjective report.

The strong relation between HFs and elevations in ambulatory pulse supports laboratory studies that have shown a strong association between HFs and concurrent pulse rate (17). In this study, elevated pulse rates were found in the ten minutes both before and after a HF, suggesting that both the HF and rise in pulse may be due to a common cause.

Although several studies suggest that women who report having HFs on questionnaires have higher mean BP than women who do not (5,6), this was not the case in the current sample. While this negative result may be attributed to the sample size in this study, there was sufficient power in the study to detect an effect size of 0.4 with a power of 0.80. There is a broad range of values across studies for the percentage of women who experience HFs, with these values varying due to different sampling methods, survey instruments, and ages of women sampled. The percentage of women who report HFs within the past two weeks in the current study (43.1 %) fits within the broader range of values that have been obtained. The warm, humid climate of Hilo therefore does not lead to an unusually high percentage of women who report HFs, and thus climate is unlikely to account for the difference in relations between HF reports and BP in this sample. There is consistency in the reporting of subjective HFs on questionnaires and in diaries, although the women who report hot flashes on questionnaires are not necessarily more likely to exhibit objectively measured HFs. The multiethnic sample in the current study, which contains a large number of Japanese American participants (N=44), may have affected the results, since Japanese Americans tend to report HFs less frequently than European Americans (26–28). However, when analyses

removed the Japanese Americans from the sample, similar, non-significant results were found between reported HFs on questionnaires and mean ambulatory BP (data not shown).

Limitations to the study include relatively small sample size; a possible bias in the sample because the intensive monitoring led to the loss of less motivated potential participants; and missing blood pressure values that occur commonly in ambulatory BP studies, some of which are due to arm movements during the measurements. Use of more sophisticated statistical procedures such as HLM or equivalent methods may be useful in further clarifying temporal associations between ambulatory BP and HF measurements.

In sum, the results presented here show that within a ten minute period, the onset of an objectively measured HF is associated with a transient elevation in systolic BP, but that an elevation in BP is not significantly associated with a subsequent objective HF. Diastolic BP is significantly elevated in the ten minutes following subjective hot flashes. On the other hand, we found that the presence of HFs in this sample of women has little effect on the individual's mean BP measured over longer time periods (in this case, of many hours).

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Glossary

BP	blood pressure
HF	hot flash

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Figure 1.
Frequency distribution of number of either subjective or objective hot flashes in participants.

Figure 2.
Percentage of time when negative moods are reported within ten minutes before, ten minutes after, or when no hot flash is noted.

Figure 3.

Z scores of blood pressure within ten minutes before, ten minutes after, or when no hot flash is noted. A. Objective measures of HF. B. Subjective reports of HF. t-test, difference from no HF: * $p < .05$; ** $p < .01$; *** $p < .001$.

Table 1

Selected characteristics of the participants

Characteristic	Mean (SD) or n (%)
N	202
Age (years)	50.6 (3.0)
Height (cm)	161.2 (7.7)
Weight (kg)	68.3 (16.5)
BMI (kg/m ²)	26.0 (5.3)
Ethnicity	
European American	78 (38%)
Japanese American	45 (22%)
Mixed	65 (32%)
Other	18 (9%)
Married	158 (78.3%)
With children	175 (86.6%)
Smokers	22 (10.8%)
Drink regularly:	
Alcohol	111 (55.0%)
Coffee	140 (69.2%)
Menopausal Status	
Pre-menopausal	59 (28.4%)
Peri-menopausal	83 (39.9%)
Post-menopausal	62 (29.8%)
Experienced Hot Flashes	
Reported, past two weeks	87 (43.1%)
Reported, during ambulatory monitoring	111 (55.0%)
Objective, during ambulatory monitoring	142 (70.3%)

Table 2

Comparison of BP and pulse measures between women who reported or demonstrated hot flashes (HFs) and those who did not. Means (standard deviations) and sample size.

	Subjective Reports: Questionnaire (Past two weeks)				Subjective Reports: Diary (24-hour study period)				Objective Measures	
	HF Report	No HF Report	t*		HF Report	No HF Report	t*		HF Measured	No HF Measured
Waking mean systolic BP	118.0 (12.0) N=87	117.3 (13.2) N=115	0.4		116.8 (13.7) N=111	118.5 (10.6) N=86	1.0		117.3 (11.8) N=142	118.6 (15.1) N=56
Waking mean diastolic BP	76.3 (13.2) N=87	75.5 (8.4) N=115	0.3		75.3 (8.2) N=111	76.3 (7.3) N=86	0.7		75.9 (7.7) N=142	75.8 (8.7) N=56
Sleeping mean systolic BP	103.0 (12.7) N=60	101.9 (10.2) N=83	0.6		102.1 (11.9) N=73	102.5 (10.7) N=66	0.2		101.6 (10.7) N=102	103.8 (12.5) N=42
Sleeping mean Diastolic BP	64.4 (9.0) N=60	63.3 (8.3) N=83	0.8		64.2 (9.0) N=73	63.1 (8.2) N=66	0.8		63.6 (8.1) N=102	64.0 (9.5) N=42
Systolic BP dipping pct.	16.2 (8.3) N=60	15.3 (8.2) N=83	0.6		14.9 (8.1) N=73	16.1 (8.0) N=66	0.9		15.0 (8.1) N=102	17.0 (7.7) N=42
Diastolic BP dipping pct.	19.7 (11.5) N=60	19.8 (11.5) N=83	0.1		17.8 (11.9) N=73	21.4 (10.7) N=66	1.8		18.8 (11.4) N=102	21.7 (11.5) N=42
Waking mean pulse	76.9 (8.4) N=87	75.8 (0.9) N=115	0.9		76.8 (8.6) N=111	75.7 (9.8) N=86	0.8		76.6 (9.0) N=142	75.5 (9.7) N=56
Sleeping mean pulse	62.7 (8.6) N=60	62.9 (9.5) N=83	0.1		62.0 (8.7) N=73	63.4 (9.8) N=66	0.2		62.8 (9.1) N=102	62.3 (9.9) N=42

* Two-tailed t-tests, all $p > .05$.

Table 3

Spearman correlations between number of hot flashes and BP and pulse measures. Spearman's rho.

	Number of reported hot flashes in diaries	Number of objectively measured hot flashes
Waking mean systolic BP	-0.12 N=198	-0.05 N=202
Waking mean diastolic BP	-0.08 N=198	0.01 N=202
Sleeping mean systolic BP	-0.09 N=144	-0.05 N=145
Sleeping mean diastolic BP	-0.05 N=144	0.00 N=145
Systolic BP dipping pct.	-0.06 N=144	-0.01 N=145
Diastolic BP dipping pct.	-0.10 N=144	-0.02 N=145
Waking mean pulse	0.05 N=198	0.06 N=202
Sleeping mean pulse	-0.12 N=144	-0.07 N=145

Spearman correlations all $P > 0.05$

Table 4

Analyses of variance of Z-scores of blood pressure and pulse with hot flash presence, posture (sitting versus standing) and negative mood reports as predictor variables.

A. Hot Flash Occurring Within 10 Minutes Before a BP Reading			
Dependent Variables:	Z-score of systolic BP	Z-score of diastolic BP	Z-score of pulse
Predictors:			
Objective HF 10 min before BP	F = 12.6***	F = 0.2	F = 29.5***
Standing vs. Sitting	F = 20.0***	F = 6.4**	F = 153.6***
Negative Mood Report	F = 25.7***	F = 12.0***	F = 0.0
Interaction: Neg. Mood and HF	F = 1.9	F = 0.0	F = 0.4
Predictor:			
Subjective HF 10 min before BP	F = 0.0	F = 3.7*	F = 6.8**
Standing vs. Sitting	F = 7.7**	F = 17.9***	F = 60.7***
Negative Mood Report	F = 10.1***	F = 9.9**	F = 0.1
Interaction: Neg. Mood and HF	F = 0.9	F = 1.2	F = 0.0

B. Hot Flash Occurring Within 10 Minutes After a BP Reading			
Dependent Variables:	Z-score of systolic BP	Z-score of diastolic BP	Z-score of pulse
Predictors:			
Objective HF 10 min after BP	F = 0.2	F = 0.2	F = 11.5***
Standing vs. Sitting	F = 3.8*	F = 6.7**	F = 109.4***
Negative Mood Report	F = 15.1***	F = 3.4 [†]	F = 0.1
Interaction: Neg. Mood and HF	F = 0.1	F = 2.4	F = 0.0
Predictor:			
Subjective HF 10 min after BP	F = 0.3	F = 7.1**	F = 1.9
Standing vs. Sitting	F = 7.9**	F = 1.9	F = 57.4***
Negative Mood Report	F = 12.8***	F = 0.0	F = 0.2
Interaction: Neg. Mood and HF	F = 2.5	F = 5.4*	F = 0.0

[†] p < .1;

* p < .05;

** p < .01;

*** p < .001