

Ethnicity, sex, trait anger, and nocturnal blood pressure decline

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Abstract

This study examined the relationship of trait anger to nocturnal blood pressure decline among Singaporean young adults. One hundred forty-nine participants (51 Chinese, 51 Malays, 47 Indians, 49.7% men) participated in 24-h ambulatory monitoring for blood pressure and hemodynamic measures. Significant interactions were obtained between ethnicity and trait anger for systolic blood pressure and mean arterial pressure such that trait anger was significantly and negatively related to nocturnal blood pressure decline for Indians whereas this was not true for Chinese or Malays. Significant sex \times trait anger interactions were obtained for systolic blood pressure, diastolic blood pressure, and mean arterial pressure in which trait anger was negatively related to blood pressure decline for men but not for women. Overall the results suggest that trait anger is a significant factor affecting nocturnal blood pressure decline particularly among Indians and men.

Descriptors: Trait anger, Nocturnal blood pressure decline, 24-h monitoring, Ambulatory impedance cardiography, Singapore, Chinese, Indians, Malays

It is well known that blood pressure and related functions show a diurnal cycle with blood pressure peaking for most people in mid-afternoon and reaching its minimum while the person sleeps at night, a phenomenon referred to as “dipping” (O’Brien, Sheridan, & O’Malley, 1988; Staessen et al., 1992). Evidence has accumulated over the past several years showing marked individual differences in the degree of day-to-night blood pressure fluctuation (Staessen et al., 1997) and demonstrating its relationship to cardiovascular risk. Of particular interest is evidence that “nondippers,” usually defined as individuals showing a day-to-night fall in systolic blood pressure (SBP) of less than 10%, are more likely to be or become hypertensive (Timio et al., 1995; Verdecchia et al., 1995) and are also at increased risk for left ventricular hypertrophy (Verdecchia et al., 1995), heart failure, stroke, myocardial infarction, and sudden death (Staessen et al., 1999) as well as cardiovascular mortality generally (Ohkubo et al., 1997; Palatini et al., 1992; Staessen et al., 1999).

It has also been established that racial differences in hypertension in the United States are paralleled by reduced blood pressure dipping, with African-Americans having higher rates of hypertension and also showing less blood pressure dipping (Fumo et al., 1992; Herbert et al., 1996; Ituarte, Kamarck, Thompson, & Bacanu, 1999). Further, it appears that psychosocial factors such as anger and hostility may be related to reduced dipping (KaMala, Nelesen, & Dimsdale, 2004).

The present study was undertaken to examine possible ethnic differences in blood pressure dipping in Asian populations in Singapore and to determine whether blood pressure dipping might be related to dispositional anger. Epidemiological data point to marked differences between ethnic groups in Singapore with respect to cardiovascular mortality. Indian Singaporeans have been found to be significantly more likely to die of ischemic heart disease than other ethnic groups in Singapore. Hughes, Lun, and Yeo (1990) have reported a relative risk ratio between Indians and Chinese of 3.8 for men aged 30 to 69 and a relative risk ratio between Indians and Malays of 1.9. For women the same ratios were 3.4 and 1.6, respectively. This finding of high rates of heart disease for individuals of South Asian origin has been obtained in other countries as well, including the United Kingdom (Marmot, Adelstein, & Bulusu, 1984), Canada (Anand et al., 2000), South Africa (Walker, 1980), and Trinidad (Miller, Beckles, Alexis, Byam, & Price, 1982).

To date most of the data on blood pressure dipping in Asian populations has come from studies done in China (Zhang et al., 1995), Taiwan (Chen et al., 1995), or Japan (Imai et al., 2004; Staessen et al., 1997), studies that have shown East Asians to exhibit less blood pressure dipping than Europeans or Ameri-

The write-up of these data was accomplished while the first author was a Visiting Scholar at the Duke University Medical School, Center for Behavioral Medicine Research. This research was supported by grant number RP-107-000-041-112 from the National University of Singapore Academic Research Fund.

Appreciation is expressed to Divjyot Kaur, Ai Ni Teoh, Wee Hong Tan, and Hwee Chong Tan for their assistance with data collection and to Jeannette Lee and Redford Williams for their comments on previous versions of the manuscript.

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cans. To date, the only published study done with South Asians is one in which Morar, Seedat, Naidoo, and Desai (1998) found less blood pressure dipping among black than Indian medical students in South Africa. In light of the marked differences in heart disease mortality between Indians and other groups in Singapore, it is of interest to examine blood pressure dipping among Indians in Singapore and to compare their dipping with that of other Singapore ethnic groups.

A second purpose of this study was to examine the relationship between dispositional anger and blood pressure dipping. Anger and hostility have been identified as significant psychosocial risk factors for coronary heart disease (CHD). Hostility refers to a personality disposition involving cynical attitudes about others along with increased propensity to anger and aggression, whereas anger refers to the experience of negative emotion ranging from mild irritation to rage. Individuals with high levels of hostility have been shown to be at significantly higher risk for cardiovascular disease (Barefoot, Dahlstrom, & Williams, 1983; Miller, Smith, Turner, Guijarro, & Hallet, 1996). Further, recent studies in Singapore have noted different patterns of cardiovascular reactivity to anger-related stress among Indians than among Chinese and Malays. In an experiment using a harassment protocol, Bishop and Robinson (2000) found that among Chinese men trait anger was not associated with SBP reactivity when they were not harassed but that higher levels of trait anger were associated with higher levels of reactivity when harassed. For Indian men, however, higher levels of trait anger were associated with higher reactivity regardless of harassment. In a study using impedance cardiography, Why et al. (2003) found that for Indian men hostility was positively related to cardiac output and negatively related to total peripheral resistance, whereas hostility was unrelated to either cardiac output or peripheral resistance for Chinese and Malay men. Further, using ambulatory blood pressure monitoring, Enkelmann et al. (2005) found that Indian men showed a stronger blood pressure response to situational anger and that diastolic blood pressure (DBP) was a positive function of social stress for Indians high in hostility but not for other groups. Data from these three studies have been interpreted as being consistent with the higher CHD mortality among Indians and as suggesting a role for anger and hostility in understanding cardiac risk among Indians.

In light of data showing different patterns of cardiovascular reactivity to stress as a function of anger and hostility for Indians, we wished to examine the extent to which dispositional anger might moderate the relationship between ethnicity and dipping. Research has demonstrated a relationship between racial differences in cardiovascular morbidity and mortality and blood pressure dipping in the United States, and KaMala et al. (2004) provide evidence that this relationship is mediated by hostility and anger. As such, we hypothesized that higher levels of trait anger would be significantly related to reduced blood pressure

dipping and that this relationship would be stronger for Indians than for Chinese or Malays, the other two main ethnic groups in Singapore.

Another purpose of this study was to explore the hemodynamics of blood pressure dipping. Impedance cardiography has been used for a number of years for exploring the hemodynamics of blood pressure changes in the laboratory (cf. Sherwood, 1993). Recently the technology for ambulatory impedance monitoring has become available, making 24-h impedance monitoring feasible (cf. Sherwood, McFetridge, & Hutcheson, 1998). Although this provides the opportunity for a better understanding of the hemodynamics behind blood pressure dipping, to date we know of no studies examining the hemodynamics of blood pressure dipping using 24-h impedance monitoring. As such, this study included 24-h impedance monitoring in an effort to explore these hemodynamics.

Methods

Participants

Participants in this research were 149 undergraduates at the National University of Singapore. Of these, 51 were Chinese (25 men, 26 women), 51 were Malays (25 men, 26 women), and 47 were Indians (24 men, 23 women). Ethnic classification was made on the basis of the parents' ethnic classification with the requirement that the participant's parents both be from the same ethnic group. Participants ranged in age from 18 to 29 years with an average of 21.5. Fifty-four participants (36.2%) reported a family history of hypertension or heart disease. Additional information on participants can be found in Table 1. Participants were recruited through advertisements around campus offering up to S\$80 (approximately US\$47) for participation in research on cardiovascular responses to stress.

Physiological Measures

Participants underwent 24-h monitoring for blood pressure using Spacelabs 90217 ambulatory blood pressure monitors (Spacelabs Medical, Redmond, WA). The Spacelabs 90217 is a lightweight ambulatory blood pressure monitor using the oscillometric method for blood pressure determination. SBP, DBP, and mean arterial pressure (MAP) were obtained every 20 min during waking hours and every 45 min while sleeping. When the monitor was unable to obtain a valid reading a second attempt was made 2 min later. Waking and sleeping hours were determined for each participant by asking him/her what time she/he usually retired for the night and got up in the morning. The Spacelabs 90217 was then programmed with those values for determining wake and sleep periods. Participants were told to avoid movement if possible during the time the blood pressure cuff was inflated so as to reduce movement artifact.

Table 1. Correlations among Measures of Percentage Nocturnal Dipping

	Heart rate	Systolic blood pressure	Diastolic blood pressure	Mean arterial pressure	Total peripheral resistance index
Systolic blood pressure	0.30***				
Diastolic blood pressure	0.18	0.80***			
Mean arterial pressure	0.23**	0.92***	0.97***		
Total peripheral resistance index	-0.11	0.24**	0.49***	0.42***	
Cardiac output index	0.21*	0.12	-0.11	-0.03	-0.85***

* $p < .05$, ** $p < .01$, *** $p < .001$.

Hemodynamic monitoring was accomplished simultaneously using the AIM-8F Ambulatory Impedance Monitor (Bio-Impedance Technology, Chapel Hill, NC). The AIM-8F is a light-weight impedance monitor that obtains electrocardiogram and impedance readings through the use of two band electrodes, one positioned at the base of the neck with the other around the chest at the xiphoid process, and three spot electrodes, one behind the right ear and the other two positioned on the left and right ribcage at least 3 cm below the band around the chest. Hemodynamic data obtained with the AIM-8 have shown good reliability and validity when compared against similar data obtained with the Minnesota 304B impedance cardiograph (Sherwood et al., 1998). Signals obtained by the AIM-8F are processed using ensemble averaging so as to remove the effects of respiration on the impedance readings. For this study ensemble averages were obtained over a 20-s period. Pretesting with the AIM-8F indicated that the 20-s ensemble average period produced the most stable data with the least movement artifact, as it ensured that readings were completed while the blood pressure cuff was inflated and participants had stopped or reduced movement. Coordination of blood pressure and impedance readings was achieved through the use of a connector that triggered readings of the AIM-8F each time the blood pressure cuff for the Spacelabs unit began inflation. The AIM 8-F was also used to obtain heart rate (HR) readings in addition to impedance cardiogram data.

Both the Spacelabs and AIM units along with a Palm Zire palmtop computer used for recording psychosocial data were placed in a fanny-pack that was worn around the participant's waist.

Psychological Measures—Trait Anger

Dispositional trait anger was measured using the Trait Anger scale of the State-Trait Anger Inventory (STAXI; Spielberger et al., 1985). The STAXI consists of three different scales, State Anger, Trait Anger, and Anger Expression. The primary focus of this study was on Trait Anger although exploratory analyses were done with Anger Expression. Anger Expression consists of three subscales: Anger-In, Anger-Out, and Anger-Control. Trait Anger measures the extent to which an individual is predisposed to experience anger or frustration in a range of situations, whereas Anger-In is concerned with the frequency of which an individual turns anger inwards, Anger-Out measures the extent to which an individual expresses anger or frustrations outwardly, and Anger Control measures the frequency with which an individual attempts to control and deal with anger in an appropriate manner. A high score on each of these scales represents a high tendency or frequency to experience or express that mode of anger. The STAXI has demonstrated good internal reliability and validity based on results from a variety of samples in the United States (Spielberger, 1988) and in Singapore (Bishop & Quah, 1998).

Procedures

Participants reported to a psychophysiology laboratory where they were briefed on the procedures for a laboratory study on cardiovascular responses to stress to be followed by ambulatory monitoring. After participating in the experiment participants were attached to the ambulatory monitors and given instruction on the use of a Palm Zire palmtop computer for filling out a questionnaire containing various control variables (location, physical posture, physical activity, consumption of a meal, consumption of alcohol, and so on) along with various psychosocial

measures (emotions experienced, interactions engaged in, and so on). Included among the measures were questions asking participants to rate physical activity at the time of the blood pressure measurement as well as the amount of stress they were experiencing at the time. Physical activity was rated on a 4-point scale from 1 (*inactive*) to 4 (*strenuous activity*), whereas the question on stress asked the participant to rate whether they felt stressed at the time of the blood pressure reading using a 4-point scale from 1 (*definitely not*) to 4 (*definitely*). Also the last question asked the participant whether she/he would be going to bed in the next 20 min. This question was used to verify the time when the participant actually retired for the night.

As part of their orientation to the ambulatory monitoring participants were instructed that when the blood pressure cuff began to inflate they should try to move as little as possible until the blood pressure cuff was completely deflated. They were also instructed to begin filling out the questionnaire on the palmtop computer only once the blood pressure cuff had completely deflated. This was done to reduce arm movements that might interfere with the blood pressure readings. Participants were instructed not to get the equipment wet and were provided with written instructions to remind them on the use of the palmtop computer along with the researcher's contact number should there be any problems. Finally, the participant was given an appointment for returning approximately 24 h later.

To encourage participants to fill out the questionnaires they were paid on a graduated scale according to their cooperation in filling out the questionnaires. For the experiment, for wearing the monitors and completing up to 50% of the questionnaires they were paid S\$30 (US\$17.65). They were then paid S\$1.00 (US\$0.59) for each percentage above 50% of questionnaires completed up to a maximum payment of S\$80 (US\$47).

Results

Data Screening and Reduction

The Spacelabs 90217 automatically checks readings for possible artifacts and eliminates those determined to be erroneous. To further test for possible artifacts the criteria proposed by Marler, Jacob, Lehoczky, and Shapiro (1988) were used to eliminate likely artifactual blood pressure and HR readings. Both SBP and DBP values were excluded from analyses if SBP > 250 mmHg or < 70 mmHg, DBP > 150 mmHg or < 45 mmHg, or SBP/DBP > 3 or < [1.065 + (0.00125 × DBP)]. Heart rates above 200 beats per minute (bpm) or below 40 bpm were also excluded from analyses. MAP was computed as (SBP + 2 × DBP)/3 for each reading for which both valid SBP and DBP readings were available.

To control for the quality of hemodynamic measures the impedance cardiograms generated by the AIM-8 were rated for quality on a 3-point scale (1 = *good*, 2 = *fair*, and 3 = *poor*) by two raters. Impedance cardiograms rated good were those in which the *q*, *b*, and *x* points were all easily distinguishable and there was no more than a small amount of ambiguity in the exact positioning of the points. Those rated fair were ones in which there was a moderate or greater degree of ambiguity as to positioning one or more of the points, and those rated poor were those for which one or more of the points could not be located. Comparison of the ratings showed 96.7% agreement. Cases of disagreement were then resolved between the two raters. Only impedance cardiograms rated as 1 were used and those rated 2 or

3 were eliminated from further analyses. After resolution of differences between raters, 6,470 (92.3%) of the 7011 impedance cardiograms obtained in conjunction with blood pressure readings were deemed to be usable. To control for differences in body size, as they might influence cardiac output and peripheral resistance, a cardiac output index and a total peripheral resistance index were computed by dividing cardiac output and total peripheral resistance by body surface area using Mosteller's (1987) formula for body surface area.

Data for all observations and all variables were then grouped by ethnicity and sex and screened for outliers. This screening identified 29 values for HR, 11 for SBP, 4 for DBP, 3 for MAP, 28 for the cardiac output index, and 41 for the total peripheral resistance index as outliers based on the criterion of being more than 3.29 standard deviations from the group mean for the variable and also disconnected from the group distribution. These represented less than 1% of available data for each variable and were deleted from the data set.

Altogether 9,816 attempts were made to obtain blood pressure and impedance measurements for a total of 8,309 time periods with valid blood pressure readings obtained in 7,768 cases and usable impedance cardiograms obtained in 6,478 cases. In 6,018 cases both valid blood pressure and usable impedance cardiograms were obtained. The number of valid blood pressure readings during the day for each participant ranged from 0 to 57 with an average of 36.6. For nighttime readings the range was 0 to 25 with an average of 7.0. To be included in the analyses each participant needed to have at least 3 valid blood pressure readings each during day and night. The number of valid impedance cardiograms during the day ranged from 0 to 59, $M = 36.4$, with the number of valid impedance cardiograms at night ranging from 0 to 23, $M = 7.1$. As with blood pressure, inclusion in analyses involving hemodynamic data required that the participant have at least 3 valid impedance cardiograms both during the day and during the night. Based on these criteria usable dipping data was obtained for 122 participants.

Daytime averages for each participant were then obtained for all measures by taking the average of readings taken from the beginning of the monitoring period until the time the person retired for the night and then those taken from the time the person got up the next morning until the end of the monitoring period. Sleeping averages were obtained by taking the average of all readings taken from the time the person went to bed until getting up the next morning. Percentage of dipping was then computed by subtracting the sleeping average from the daytime average, dividing by the daytime average, and then multiplying by 100. Participants who showed a drop in SBP of 10% or more were defined as dippers whereas those exhibiting a drop of less than 10% were categorized as nondippers. By this definition 86 participants were classified as dippers with 36 classified as nondippers. All averages and dipping percentages were grouped by dipping status and screened for outliers. Based on the criterion of more than 3.29 standard deviations from the group variable mean and a clear disconnection from the variable distribution, one value each for sleeping HR, daytime cardiac output index, sleeping cardiac output index, and percentage cardiac output dipping were deleted.

Correlations among the outcome measures are given in Table 1. As expected, blood pressure measures were highly correlated. In addition, percentage HR dipping was significantly correlated with dipping for SBP and MAP as well as cardiac output dipping. Percentage peripheral resistance dipping was positively correlat-

ed with blood pressure dipping and negatively correlated with cardiac output dipping.

Comparison of Dippers and Nondippers

As nondipper status has been associated with increased cardiovascular morbidity, it is of interest to examine the characteristics of dippers and nondippers. These are shown in Table 2. As can be seen in this table, no differences were found between dippers and nondippers with respect to ethnicity, age, weight, BMI, measures of anger, posture, daytime activity level, hours slept, or self-rated stress. A near significant difference was obtained for height, $p < .06$, with dippers being slightly taller, $M = 1.69$ m, than nondippers, $M = 1.65$ m.

Turning to cardiovascular parameters, awake and sleeping HR along with awake and sleeping cardiac output index and awake total peripheral resistance index were found to be comparable for dippers and nondippers, but significant differences were obtained for daytime SBP, DBP, and MAP, as well as for sleeping SBP, DBP, MAP, and total peripheral resistance index. Dippers had higher awake values for SBP, DBP, and MAP, but lower values for sleeping total peripheral resistance index as well as sleeping SBP, DBP, and MAP. This indicates that blood pressure for dippers was higher than nondippers during the day but lower at night. With respect to hemodynamics, cardiac output tended to be equal for dippers during both the day and while sleeping, whereas peripheral resistance was lower while sleeping.

Relationship of Ethnicity, Sex, and Trait Anger to Percentage Dipping

Our next analyses examined the extent to which ethnicity, sex, and trait anger were related to the percentage of dipping in different cardiovascular parameters. These analyses utilized moderated regressions, performed using SAS Proc GLM version 8.2 (SAS Institute Inc., Cary, NC) using Type III sums of squares, with ethnicity and sex as categorical variables and trait anger entered as a continuous variable. Correlations between daytime averages and percentage dipping ranged from $r = .18-.37$ and were statistically significant for all measures. Thus to control for differences in daytime cardiovascular values as well as potential effects related to BMI or family history, daytime average for the respective cardiovascular variable as well as BMI and family history were entered as covariates.

No effects for ethnicity were found for any of the outcome variables. Two significant effects were obtained for sex, which indicated that women showed a significantly lower percentage of dipping for DBP, $F(1,104) = 4.50$, $p = .0363$, $\eta_p^2 = .04$, $M = 16.58$ versus 19.28, women and men, respectively, and total peripheral resistance index, $F(1,104) = 10.04$, $p = .002$, $\eta_p^2 = .09$, $M = 1.58$ versus 10.59. By contrast, a significant trait anger effect was obtained for SBP, $F(1,104) = 4.91$, $p = .0288$, $\eta_p^2 = .05$, $b = -0.18$, along with a near significant effect for percentage MAP dipping, $F(1,104) = 3.13$, $p = .0799$, $\eta_p^2 = .03$, $b = -0.17$.

The effects for trait anger, however, must be considered in the context of interactions of trait anger with ethnicity and sex. Significant ethnicity \times trait anger interactions were obtained for percentage dipping of SBP, $F(2,104) = 5.92$, $p = .0037$, $\eta_p^2 = .10$, and MAP, $F(2,104) = 3.59$, $p = .031$, $\eta_p^2 = .06$, in which higher trait anger scores were related to a lower percentage of dipping among Indians whereas this was not true for Chinese and Malays. The pattern of this interaction for percentage SBP dipping is shown in Figure 1. The pattern for MAP was the same. Simple

Table 2. Characteristics of Dippers versus Nondippers

Variable	Dippers (<i>n</i> = 86; ≥ 10% drop in SBP)	Nondippers (<i>n</i> = 36; < 10% drop in SBP)	<i>p</i>
Demographics			
% Chinese	31.4	38.9	n.s.
% Malay	38.4	33.3	
% Indian	30.2	27.8	
% Female	45.3	61.1	n.s.
Age	21.4 ± 0.16	21.7 ± 0.32	n.s.
% with family history of CHD or hypertension	42.4	27.8	n.s.
Anthropometric			
Height (m)	1.69 ± 0.01	1.65 ± 0.01	< .06
Weight (kg)	63.2 ± 1.61	60.1 ± 2.26	n.s.
BMI	22.0 ± 0.40	21.9 ± 0.71	n.s.
Ambulatory cardiovascular values^a			
Awake heart rate (bpm)	77.3 ± 1.05	76.6 ± 1.62	n.s.
Awake systolic blood pressure (mmHg)	119.1 ± 1.18	112.1 ± 1.50	< .001
Awake diastolic blood pressure (mmHg)	73.8 ± 0.60	70.7 ± 0.93	< .01
Awake mean arterial pressure (mmHg)	88.9 ± 0.78	84.5 ± 1.01	< .001
Awake cardiac index (L/min/BSA)	4.20 ± 0.11	3.86 ± 0.17	n.s.
Awake total peripheral resistance index (dyne × s × cm ⁻⁵ /BSA)	656.5 ± 22.46	718.27 ± 32.20	n.s.
Sleep heart rate (bpm)	58.6 ± 0.91	61.5 ± 1.49	n.s.
Sleep systolic blood pressure (mmHg)	101.2 ± 1.00	104.9 ± 1.60	< .05
Sleep diastolic blood pressure (mmHg)	58.2 ± 0.58	62.7 ± 0.82	< .001
Sleep mean arterial pressure (mmHg)	72.6 ± 0.64	76.7 ± 0.97	< .001
Sleep cardiac index (L/min/BSA)	3.64 ± 0.09	3.54 ± 0.15	n.s.
Sleep total peripheral resistance index (dyne × s × cm ⁵ /BSA)	601.2 ± 20.78	686.5 ± 32.04	< .05
Waking posture			
Standing (%)	22.3 ± 1.08	21.2 ± 1.52	n.s.
Sitting (%)	65.9 ± 1.43	63.0 ± 2.38	n.s.
Lying down (%)	11.9 ± 1.07	15.9 ± 2.28	n.s.
Average daytime activity (1–4)	1.53 ± 0.03	1.54 ± 0.05	n.s.
Hours slept	6.72 ± 0.16	7.05 ± 0.33	n.s.
Self-rated stress (1–4)	1.60 ± 0.07	1.66 ± 0.10	n.s.
STAXI			
Trait Anger	20.8 ± 0.54	21.40 ± 0.77	n.s.
Anger-In	16.8 ± 0.45	16.4 ± 0.61	n.s.
Anger-Out	14.9 ± 0.40	15.1 ± 0.61	n.s.
Anger-Control	24.1 ± 0.49	23.9 ± 0.70	n.s.
Anger-Expression	23.6 ± 1.00	23.6 ± 1.24	n.s.

Note: Numbers in table are means and standard errors for all variables except ethnicity and sex, which are percentages.

^aAdjusted for BMI and family history of heart disease or hypertension.

effects analysis indicated that whereas the relationship between trait anger and percentage dipping was significant for Indians, $F(1,29) = 13.09$, $p = .0011$, $\eta_p^2 = .31$, $b = -0.57$, for SBP, and $F(1,29) = 10.34$, $p = .0032$, $\eta_p^2 = .26$, $b = -0.52$, for MAP, the relationships for Chinese and Malays were nonsignificant, all $ps > .19$. Further examination by ethnicity and sex showed that for SBP the relationship between trait anger and dipping was

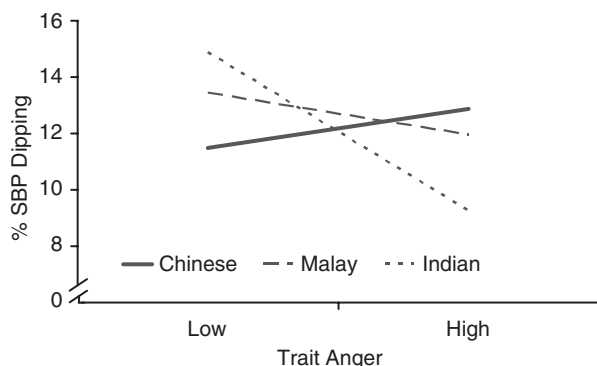


Figure 1. Ethnicity × trait anger interaction for percentage SBP dipping.

significant only for Indian men, $F(1,13) = 12.08$, $p = .0041$, $\eta_p^2 = .48$, $b = -0.83$, and Indian women, $F(1,13) = 5.31$, $p = .0384$, $\eta_p^2 = .29$, $b = -0.34$, but not for other groups, all $ps > .29$. For MAP the relationship between trait anger and percentage dipping was significant only for Indian men, $F(1,13) = 11.88$, $p = .0044$, $\eta_p^2 = .48$, $b = -0.84$, but not other groups, all $ps > .30$.

A near significant ethnicity × trait anger interaction was also obtained for percent dipping in the total peripheral resistance index. Whereas percent dipping for total peripheral resistance index was a positive function of trait anger for Chinese and Malays, it was a negative function for Indians. Simple effects analysis, however, showed that none of these relationships achieved statistical significance, all $ps > .14$. Examination of the relationship of trait anger to percentage dipping by ethnicity and sex showed that this relationship was significant only for Indian men, $F(1,13) = 14.81$, $p = .0023$, $\eta_p^2 = .55$, $b = 1.91$, with the relationship nonsignificant for all other groups, all $ps > .17$.

Turning to sex, significant sex × trait anger interactions were obtained for SBP, $F(1,104) = 3.94$, $p = .0498$, $\eta_p^2 = .04$, DBP, $F(1,104) = 5.50$, $p = .0209$, $\eta_p^2 = .05$, and MAP, $F(1,104) = 5.61$, $p = .0197$, $\eta_p^2 = .05$. Figure 2 shows this interaction for SBP. The same pattern was obtained for DBP and MAP. Simple effects

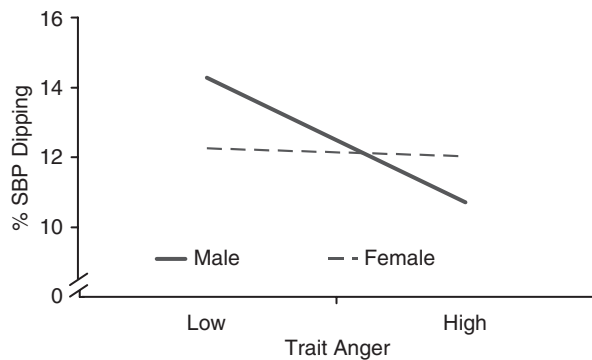


Figure 2. Sex \times trait anger interaction for percentage SBP dipping.

analyses showed that the relationship between trait anger and percentage dipping was significant or near significant for men, $F(1,50) = 5.12$, $p = .0280$, $\eta_p^2 = .09$, $b = -0.35$, for SBP, $F(1,50) = 4.01$, $p = .0506$, $\eta_p^2 = .07$, $b = -0.44$, for DBP, and $F(1,50) = 5.06$, $p = .0290$, $\eta_p^2 = .09$, $b = -0.40$, for MAP, whereas it was not significant for women, all $ps > .48$.

Peripheral Resistance Dipping as a Mediator of Blood Pressure Dipping

The significant sex effect for percentage dipping in total peripheral resistance along with the near significant interaction of ethnicity and trait anger suggest the possibility that the sex effects for percentage DBP dipping as well as the ethnicity \times trait anger effects for percentage SBP and MAP dipping may be mediated by dipping in peripheral resistance. To test this idea the analyses for percentage of SBP, DBP, and MAP dipping were repeated with the inclusion of percentage of total peripheral resistance dipping as a covariate. Results of these analyses showed that the sex effect for percentage DBP dipping was reduced to nonsignificance with the inclusion of total peripheral resistance dipping as a covariate, $F(1,99) = 1.32$, $p = .2537$, $\eta_p^2 = .01$. The ethnicity \times trait anger effect for percentage SBP dipping remained significant with the inclusion of total peripheral resistance dipping as a covariate, $F(2,99) = 3.90$, $p = .0234$, although the size of the effect was reduced, $\eta_p^2 = .07$ versus $.10$. For percentage MAP dipping inclusion of total peripheral resistance dipping as a covariate reduced the ethnicity \times trait anger effect to nonsignificance, $F(2,99) = 1.69$, $p = .1894$, $\eta_p^2 = .03$. Interestingly, even though the sex \times trait anger interaction for percentage of total peripheral resistance dipping did not approach significance, inclusion of total peripheral resistance dipping as a covariate reduced the sex \times trait anger interaction to nonsignificance for SBP, $F(1,99) = 2.59$, $p = .1107$, $\eta_p^2 = .03$, DBP, $F(1,99) = 2.21$, $p = .1406$, $\eta_p^2 = .02$, and MAP, $F(1,99) = 2.70$, $p = .1034$, $\eta_p^2 = .03$. Similar analyses controlling for cardiac output index produced no substantive change in the pattern of results for any of the blood pressure variables.

Analyses Using Other Components of the STAXI

Exploratory analyses were also done of potential relationships of other STAXI components (Anger-In, Anger-Out, Anger-Control, and Anger-Expression) and their potential interactions with race and sex as related to nocturnal dipping. All effects involving other STAXI components were nonsignificant with the exception of an ethnicity \times anger-in interaction for percentage dipping in the cardiac output index, $F(2,102) = 4.25$, $p = .0168$, $\eta_p^2 = .08$, an ethnicity \times anger-in interaction for percentage dipping in the

total peripheral resistance index, $F(2,100) = 5.45$, $p = .0057$, $\eta_p^2 = .10$, and a race \times sex \times anger-out interaction for percentage dipping in HR, $F(2,104) = 3.41$, $p = .0367$, $\eta_p^2 = .06$. Given the small number of significant effects out of the total number of effects tested, these results are almost certainly chance findings deriving from the number of effects tested.

Discussion

As expected, blood pressure dipping was a negative function of trait anger. As trait anger increased the percentage of day-to-night dipping decreased for SBP and MAP. However, further examination showed that this decrease was found primarily among Indian men. Examination by ethnicity and sex of the regression coefficients linking trait anger and dipping showed that the relationship between trait anger and SBP dipping was significantly negative for Indian men and Indian women but not for other groups. For MAP dipping, which is a composite of dipping for SBP and DBP, the relationship was significant only for Indian men. These latter results must be interpreted cautiously, however, because none of the three-way interactions between ethnicity, sex, and trait anger were statistically significant. With respect to hemodynamics, a near significant interaction was found between ethnicity and trait anger showing that percentage dipping in peripheral resistance increased with trait anger for Chinese and Malays but decreased for Indians. Inspection of the regression coefficients linking trait anger with percentage dipping in total peripheral resistance broken out by ethnicity and sex showed that whereas this coefficient was significantly negative for Indian men it was nonsignificant for other groups. Again, in the absence of a three-way interaction this finding needs to be interpreted cautiously.

On the whole, these findings are in line with other findings concerning ethnic differences in the relationship of anger and hostility to cardiovascular responses in Singapore. As noted earlier, studies of cardiovascular reactivity in Singapore have consistently found that cardiovascular reactivity in Indians as a function of anger or hostility shows a different pattern than that found among Chinese or Malays. In previous studies all participants have been male, limiting generalizability of those findings to men. The current study is the first of this series of studies that has included women, which represents an important advance in this work. In this regard it is interesting to note that the strongest effects for trait anger were found with Indian men. Although a significant relationship was obtained between trait anger and percentage SBP dipping for Indian women, the relationship was stronger among the men. Further, the relationship between trait anger and percentage MAP dipping as well as between trait anger and percentage dipping in peripheral resistance were only significant for Indian men. This suggests the presence of important gender differences among Indians that need to be examined in future research.

With respect to the hemodynamics of blood pressure dipping, it is interesting to note that differences between dippers and nondippers included lower total peripheral resistance among dippers at night. These results are consistent with the findings of Sherwood, Steffen, Blumenthal, Kuhn, and Hinderliter (2002), suggesting a dominant role of systemic vascular resistance in nondippers. In particular, Sherwood et al. noted an attenuated diurnal pattern of sympathetic nervous system activation coupled with heightened sensitivity of α_1 adrenergic receptors, lead-

ing to continued vasoconstriction among nondippers during the night. The fact that effects for blood pressure dipping were attenuated or reduced to nonsignificance when percentage total peripheral resistance dipping was controlled adds further evidence for the central role of continued nocturnal vasoconstriction in understanding the phenomenon of nondipping.

The pattern of results with respect to the relationship of trait anger to dipping suggests that trait anger has particular importance for Indian men. Blood pressure dipping was consistently and negatively associated with trait anger with high trait anger Indian men showing an average 9.2% reduction in nighttime SBP as compared with 14.9% for those low in trait anger. Further, this appears to be primarily a result of decreased dipping in total peripheral resistance. This indicates that vasoconstriction for Indian men high in trait anger shows little variation between day and night, which is in line with the suggestion of Sherwood et al. (2002) about the dominant role of systemic resistance in nondippers.

Despite these intriguing findings it is important to note the limitations of this study. One of the key limitations is the age of the participants. These findings were obtained with young adults with a mean age of 21.5 years. Nocturnal decline in blood pressure has been found to be related to age with the amount of these declines decreasing with advancing age (Staessen et al., 1997). As such, the results obtained here may be limited to young adults. Further research is needed with participants from across the lifespan to establish the extent to which these findings generalize across age ranges. Second, these results do not take into consideration the possible effects of frequency of getting out of bed and other movement during the night, which may affect nighttime values. Also, monitoring in this study was limited to 24 h. Although measurement of dipping is commonly done on the basis of one 24-h period, monitoring over several days would provide more stable estimates of dipping and could also be used to examine individual fluctuations in dipping over time.

At present the reasons for the ethnic differences in cardiovascular reactivity and nocturnal blood pressure decline as a function of anger and hostility are unclear. The experience and expression of emotion is known to show significant cultural variation (Kitayama & Markus, 1994; Scherer, Wallbott, Matsu-moto, & Kudoh, 1988) and one possibility is that the observed differences in reactivity result from differences between ethnic groups in the experience and expression of emotion. It is also possible that these differences reflect genetic differences. Chinese, Malays, and Indians represent different genetic pools and, as such, observed differences may reflect genetic differences between the groups. Recent research has shown the relevance of specific genes for personality and cardiovascular reactivity. For example, polymorphisms in the promoter region of the serotonin transporter gene (5-HTT) have been linked with the personality traits of neuroticism and agreeableness (Lesch et al., 1996), which are closely associated with anger and hostility, as well as with cardiovascular reactivity (Williams et al., 2001). It may well be possible that ethnic differences in the distribution of these polymorphisms may play a role in ethnic differences in reactivity and nighttime blood pressure decline as a function of anger and hostility. At this point both of these possible explanations remain highly speculative because no evidence is currently available for either. They do, however, suggest potentially fruitful avenues for future research.

On the whole, these results along with those of previous studies of ethnic differences in cardiovascular reactivity as a function of anger and hostility are consistent with the higher CHD rates among Indians in Singapore. The reduced dipping among Indians high in trait anger is indicative of increased cardiovascular risk, as is the greater reactivity to both harassed and nonharassed tasks as a function of hostility and the greater responsiveness of ambulatory blood pressure to situational anger and social stress among Indian men.

REFERENCES

- Anand, S. S., Yusuf, S., Vuksan, V., Devanesen, S., Teo, K. K., Montague, P. A., et al. (2000). Differences in risk factors, atherosclerosis and cardiovascular disease among ethnic groups in Canada: The study of health assessment and risk in ethnic groups (SHARE). *Indian Heart Journal*, *52*, S35–S43.
- Barefoot, J. C., Dahlstrom, W. G., & Williams, R. B. (1983). Hostility, CHD incidence and total mortality: A 25-year follow-up study of 255 physicians. *Psychosomatic Medicine*, *45*, 59–64.
- Bishop, G. D., & Quah, S. H. (1998). Reliability and validity of measures of anger/hostility in Singapore: Cook & Medley Ho Scale, STAXI and Buss-Durkee Hostility Inventory. *Personality and Individual Differences*, *24*, 867–878.
- Bishop, G. D., & Robinson, G. (2000). Anger, harassment and cardiovascular reactivity among Chinese and Indian men in Singapore. *Psychosomatic Medicine*, *62*, 684–692.
- Chen, C. H., Ting, C. T., Lin, S. J., Hsu, T. L., Chou, P., Kuo, H. S., et al. (1995). Relation between diurnal variation of blood pressure and left ventricular mass in a Chinese population. *American Journal of Cardiology*, *75*, 1239–1243.
- Enkelmann, H. C., Bishop, G. D., Tong, E. M. W., Diong, S. M., Why, Y. P., Khader, M., et al. (2005). The roles of hostility, affect and ethnicity in cardiovascular responses: An ambulatory study in Singapore. *International Journal of Psychophysiology*, *56*, 185–197.
- Fumo, M. T., Teeter, S., Lang, R. M., Bednarz, J., Sareli, P., & Murphy, M. B. (1992). Diurnal blood pressure variation and cardiac mass in American Blacks and Whites and South African Blacks. *American Journal of Hypertension*, *5*, 111–116.
- Herbert, L. A., Agarwal, G., Ladson-Wofford, S. E., Reif, M., Hiremath, L., Carlton, S. G., et al. (1996). Nocturnal blood pressure in treated hypertensive African Americans compared to treated hypertensive European Americans. *Journal of the American Society of Nephrology*, *7*, 2130–2134.
- Hughes, K., Lun, K. C., & Yeo, P. P. B. (1990). Cardiovascular diseases in Chinese, Malays, and Indians in Singapore. I Differences in mortality. *Journal of Epidemiology and Community Health*, *44*, 24–28.
- Imai, Y., Nagai, K., Sakuma, M., Nakatsuka, H., Satoh, H., Minami, N., et al. (2004). Ambulatory blood pressure of adults on Ohasama, Japan. *Hypertension*, *22*, 900–912.
- Ituarte, P. H. G., Kamarck, T. W., Thompson, H. S., & Bacanu, S. (1999). Psychosocial mediators of racial differences in nighttime blood pressure dipping among normotensive adults. *Health Psychology*, *18*, 393–402.
- KaMala, S. T., Nelesen, R. A., & Dimsdale, J. E. (2004). Relationships between hostility, anger expression, and blood pressure dipping in an ethnically diverse sample. *Psychosomatic Medicine*, *66*, 298–304.
- Kitayama, S., & Markus, H. R. (1994). *Emotion and culture: Empirical studies of mutual influence*. Washington, DC: American Psychological Association.
- Lesch, K. P., Bengel, D., Heils, A., Sabol, S. Z., Greenberg, B. D., Petri, S., et al. (1996). Association of anxiety-related traits with a polymorphism in the serotonin transporter gene regulatory region. *Science*, *274*, 1527–1531.
- Marler, M. R., Jacob, R. G., Lehoczky, J. P., & Shapiro, A. P. (1988). The statistical analysis of treatment effects in 24-hour ambulatory blood pressure recordings. *Statistics in Medicine*, *6*, 697–716.
- Marmot, M. G., Adelstein, A. M., & Bulusu, L. (1984). Lessons from the study of immigrant mortality. *Lancet*, *i*, 1455–1458.

- Miller, G. J., Beckles, G. L. A., Alexis, S. D., Byam, N. T. A., & Price, S. G. L. (1982). Serum lipoproteins and susceptibility of men of Indian descent to coronary heart disease: The St. James survey, Trinidad. *Lancet*, *ii*, 200–203.
- Miller, T. Q., Smith, T. W., Turner, C. W., Guijarro, M. L., & Hallet, A. J. (1996). A meta-analytic review of research on hostility and physical health. *Psychological Bulletin*, *119*, 322–348.
- Morar, N., Seedat, Y. K., Naidoo, D. P., & Desai, D. K. (1998). Ambulatory blood pressure and risk factors for coronary heart disease in black and Indian medical students. *Journal of Cardiovascular Risk*, *5*, 313–318.
- Mosteller, R. D. (1987). Simplified calculation of body-surface area. *New England Journal of Medicine*, *317*, 1098.
- O'Brien, E., Sheridan, J., & O'Malley, K. (1988). Dippers and non-dippers. *Lancet*, *2*, 397.
- Ohkubo, T., Imai, Y., Tsuji, I., Nagai, K., Watanabe, N., Minamai, N., et al. (1997). Relations between nocturnal decline in blood pressure and mortality: The Ohasama Study. *American Journal of Hypertension*, *10*, 1201–1207.
- Palatini, P., Penzo, M., Racioppa, A., Zugno, E., Guzzardi, G., Anacletio, M., et al. (1992). Clinical relevance of nighttime blood pressure and of daytime blood pressure variability. *Archives of Internal Medicine*, *152*, 1855–1860.
- Scherer, K. R., Wallbott, H. G., Matsumoto, D., & Kudoh, T. (1988). Emotional experience in cultural context: A comparison between Europe, Japan, and the United States. In K. R. Scherer (Ed.), *Facets of emotion: Recent research* (pp. 5–30). Hillsdale, NJ: Erlbaum.
- Sherwood, A. (1993). Use of impedance cardiography in cardiovascular reactivity research. In J. Blascovich & E. S. Katkin (Eds.), *Cardiovascular reactivity to psychological stress & disease* (pp. 157–199). Washington, DC: American Psychological Association.
- Sherwood, A., McFetridge, J., & Hutcheson, J. S. (1998). Ambulatory impedance cardiography: A feasibility study. *Journal of Applied Physiology*, *85*, 2365–2369.
- Sherwood, A., Steffen, P. R., Blumenthal, J. A., Kuhn, C., & Hinderliter, A. L. (2002). Nighttime blood pressure dipping: The role of the sympathetic nervous system. *American Journal of Hypertension*, *15*, 111–118.
- Spielberger, C. D. (1988). *State-Trait Anger Expression Inventory (revised research edition): STAXI professional manual*. Odessa, FL: Psychological Assessment Resources.
- Spielberger, C. D., Johnson, E. H., Russell, S. F., Crane, R. J., Jacobs, G. A., & Worden, T. J. (1985). The experience and expression of anger: Construction and validation of an anger expression scale. In M. A. Chesney & R. H. Rosenman (Eds.), *Anger and hostility in cardiovascular and behavioral disorders* (pp. 5–28). Washington, DC: Hemisphere Publishing Corporation.
- Staessen, J., Bulpitt, C. J., O'Brien, E., Cox, J., Fagard, R., Stanton, A., et al. (1992). The diurnal blood pressure profile: A population study. *American Journal of Hypertension*, *5*, 386–392.
- Staessen, J. A., Bieniaszewski, L., O'Brien, E., Gosse, P., Hayashi, H., Imai, Y., et al. (1997). Nocturnal blood pressure fall on ambulatory monitoring in a large international database. *Hypertension*, *29*, 30–39.
- Staessen, J. A., Thijs, L., Fagard, R., O'Brien, E. T., Clement, D., de Leeuw, P. W., et al. (1999). Predicting cardiovascular risk using conventional vs ambulatory blood pressure in older patients with systolic hypertension. Systolic Hypertension in Europe Trial Investigators. *Journal of the American Medical Association*, *282*, 539–546.
- Timio, M., Venanzi, S., Lolli, S., Lippi, G., Verdura, C., Monarca, C., et al. (1995). "Non-dipper" hypertensive patients and progressive renal insufficiency: A 3-year longitudinal study. *Clinical Nephrology*, *43*, 382–387.
- Verdecchia, P., Schillaci, G., Borgioni, C., Ciucci, A., Sacchi, M., Battistelli, M., et al. (1995). Gender, day-night blood pressure changes, and left ventricular mass in essential hypertension: Dippers and peakers. *American Journal of Hypertension*, *8*, 193–196.
- Walker, A. R. P. (1980). The epidemiology of ischemic heart disease in the different ethnic populations in Johannesburg. *South African Medical Journal*, *57*, 748–752.
- Why, Y. P., Bishop, G. D., Tong, E. M. W., Enkelmann, H. C., Diong, S. M., Ang, J. C. H., et al. (2003). Cardiovascular reactivity of Singaporean male police officers as a function of task, ethnicity and hostility. *International Journal of Psychophysiology*, *49*, 99–110.
- Williams, R. B., Marchuk, D. A., Gadde-Kishore, M., Barefoot, J. C., Grichnick, K., Helms, M. J., et al. (2001). Central nervous system serotonin function and cardiovascular responses to stress. *Psychosomatic Medicine*, *63*, 300–305.
- Zhang, W., Shi, H., Wang, R., Yu, Y., Wang, Z., Zhang, L., et al. (1995). Reference values for the ambulatory blood pressure: Results from a collaborative study. *Chinese Journal of Cardiology*, *10*, 325–328.

(RECEIVED November 1, 2004; ACCEPTED March 9, 2005)