Ambulatory Blood Pressure, Heart Rate, and Neuroendocrine Responses in Women Nurses During Work and Off Work Days

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Objective: This study examined women's cardiovascular and neuroendocrine responsiveness to work. **Methods:** Ambulatory blood pressure (BP) and heart rate (HR) were recorded over 24-hour periods on 2 work and 2 off days during the luteal and follicular phases of the menstrual cycle in 138 registered nurses, aged 25 to 50 years. Urinary catecholamines and cortisol were measured for day and night periods. **Results:** During waking hours systolic BP (SBP), HR, and epinephrine were higher on work than off days. Diastolic BP (DBP) and HR were highest at work. Nurses scoring high on job demands had elevations in daytime SBP, daytime HR only on work days, and nighttime epinephrine on work days. Compared with those with short work histories, nurses employed longer had consistently higher norepinephrine levels during days and nights, and higher nighttime DBP during off days. In unmarried nurses compared with married nurses, nighttime cortisol was lower during all 4 days and norepinephrine was lower during days off. All findings were independent of actigraph-recorded activity. **Conclusions:** Although the work environment leads to increased activity of the cardiovascular and sympathoadrenal medullary system in healthy women, the effects are modified by the woman's domestic role, by the length of her employment, and by the demands of her job. **Key words:** ambulatory blood pressure, catecholamines, cortisol, women, work.

BP = blood pressure; DBP = diastolic blood pressure; SBP = systolic blood pressure; HR = heart rate; ANOVA = analysis of variance; RN = registered nurse.

INTRODUCTION

This study focuses on 24-hour ambulatory BP and HR responses and urinary catecholamine and cortisol levels during work and off work days in a relatively homogeneous group of 138 healthy, premenopausal, female nurses. Elevations in BP during the work day were found in diverse populations including British male firefighters (1) and Swedish male and female white collar workers (2). When normotensive and hypertensive men and women of varying occupations were studied during the total 24-hour work day, daytime BP (including the evening) was higher on the work day than on the off day, but there were no sleep differences (3). Physicians had higher DBP and HR during waking and sleeping hours when they were on call compared with days off (4). For male paramedics, there were no overall cardiovascular differences between a 24-hour day spent at the work site and a comparable day at home, although work day BP was higher during specific work situations in the daytime (5). We predicted that women in a stressful occupation such as nursing would exhibit higher BP and HR during a work day than during an off day, particularly during the waking portion of the work day spent at the work site.

We focused on the following factors that we felt could modify a woman's physiological responses to work: menstrual cycle effects, marital status, presence or absence of children in the home, length of employment, and job strain. Prominent among these factors was the issue of whether BP and HR during work and off work days would vary as a function of menstrual cycle phase. Because increased cardiovascular activity is associated with greater sympathetic activation, any situation that further stimulates the sympathetic nervous system should lead to even greater BP and HR increases. Although findings vary considerably, increased sympathetic activity has been reported during the luteal phase of the menstrual cycle (6). One group of investigators (7–9) found higher BP and HR in the luteal phase than in the follicular phase, although others reported no changes in BP as a result of menstrual cycle phase (10, 11). Although there might be some increase in cardiovascular activity because of sympathetic activation during the luteal phase, prior findings would lead one to expect these effects to be small (12).

Concerning a woman's role at home, the literature has shown that working full time may lead to some reduction in housework time, but the woman still retains primary responsibility for housework and child care (13–15). The added household responsibilities that accompany marriage and children could contribute to a working woman's feelings of stress eliciting a sympathetic response and an increase in BP that could extend to the work situation. In support of this, some investigators found that compared with single women, those who were married had higher ambulatory BP at work (16) and during the work day (17). In addition, women who had children had higher BP at work and at

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home than those without children (17). We expected to find cardiovascular increases to be associated with having children and with being married. We expected that women with a long work history in nursing would exhibit lower cardiovascular levels because they would have learned skills enabling them to cope with problems at work.

Whether BP is elevated at work may be a function of the level of job strain, which is a ratio of job demands to job decision latitude (18). When compared with low-strain workers, high-strain university male and female normotensive employees had higher SBP at home in the evening and at work and higher DBP at work (19). For people with borderline hypertension, job strain was related only to DBP at night and during work, but not during leisure time (20). Schnall et al. (21) reported that high job strain in men with and without hypertension was associated with generalized elevations in BP extending not only to home but to sleep as well. Similarly, among normotensive and mild hypertensive male workers in Italy, high-strain subjects had elevations in BP throughout the work day, although there were smaller effects during leisure time and at night (22). Not only are most studies of BP and job strain confined to men, but most of the evidence gathered by Karasek and Theorell (18) on the concept of job strain has been derived from men. Some investigators have questioned whether job strain is associated with BP in women (23), with conflicting findings in this area (16, 24, 25). This may be because compared with men, women perceive working as being less stressful and actually associate work with enhanced well-being (26–28). The present study seeks to determine whether job strain in nurses is associated with increased activity of the cardiovascular and sympathoadrenal medullary systems.

To understand the meaning of cardiovascular responses during work days and off days, catecholamines and cortisol were also measured throughout the day and night. Fluctuations in these urinary stress hormones have been associated with increases in self-reported negative mood states (29, 30). According to Frankenhaeuser (31), elevations in catecholamines on a given day could be interpreted as being related to increased effort, whereas increases in cortisol reflect more negative affect or distress. By assessing urinary catecholamine and cortisol levels along with cardiovascular responses, we hoped to determine the impact of work and off work days on our sample of women nurses. To the extent that work has primarily positive benefits for women, we expected there to be very little difference in cortisol between work and off days.

METHODS

Subjects

The study included 138 RNs, aged 25 to 50 years [mean (SD) = 37.8 (6.3)], from the Los Angeles area. Racial composition was as follows: 92 whites, 19 African Americans, 14 Latinos, 13 Asian Americans. All of the women worked daytime shifts, with 42% having 8-hour shifts and 58% 12-hour shifts. Most of the women (77%) were employed in hospital settings, the remainder working in outpatient clinics. Mean length of employment was 12.5 (7.2) years; education was 16.7 (1.8) years. Casual BP was 111.2 (8.1)/70.1 (6.7) mm Hg. The sample included 55.8% with children in the home, and 57.2% who were married. Subjects exercised between 0 and 34 [mean (SD) = 4.8 (5.9)] hours per week.

Subjects were excluded if they reported any health problems, taking any medication, or using oral contraceptives. They were requested to refrain from the use of short-term acting drugs (eg, aspirin, antihistamines) at least 1 day before and during any of the study sessions. Subjects had an average body mass index (BMI) of 23.4 (3.4) kg/m^2. We excluded those with severe obesity (BMI $\geq$ 30 kg/m^2), those who had been pregnant or lactating within the last 12 months, and postmenopausal women. Based on the average of three casual BP recordings taken according to standard assessment (32) over each of five sessions, only two subjects had BP levels that were over normal limits (141/89 and 138/93 mm Hg) (32). A minimum of 1 year of nursing experience was required for inclusion in the study. Only four of the subjects were smokers. Information on length of menstrual cycle was obtained from subjects. Those reporting irregular cycles or cycles of $<$ 24 or $>$ 34 days were excluded.

Design

Subjects were seen during two separate phases of their menstrual cycle. For the follicular phase, subjects were scheduled on days 4 to 8 after the beginning of menstruation. The luteal phase was scheduled 5 to 10 days after the surge in luteinizing hormone, as determined by the Clearplan home ovulation testing kit (Fisons Consumer Health, Sydney, Australia). This kit uses monoclonal antibody technology to detect the amount of luteinizing hormone normally occurring 24 to 36 hours before ovulation (approximately midcycle) (33, 34). Days were adjusted for women with cycles longer or shorter than 28 days. To confirm the occurrence of ovulation in the postovulatory phase, plasma progesterone levels were measured during the luteal phase in blood samples collected after removal of the ambulatory monitor in the morning. Analyses were done on the total group of 138 subjects, and then repeated with only those subjects who had progesterone levels of at least 3 ng/ml on both of their luteal phase sessions (N = 113). Because results with the two different groups of subjects were the same, all of our findings are based on all 138 subjects.

Each subject participated in a total of five separate sessions: one initial session where information was obtained on demographics and health history and four 24-hour ambulatory recording sessions. The ambulatory monitoring occurred on 2 work days and 2 off work days over a period of a few months. Half the subjects began the sequence of 4 study days in the follicular phase and half in the luteal phase, followed by the other study days in succession. Within phase, day (work day and off day) was counterbalanced.

Procedure

Ambulatory Monitor. The Accutracker II (Suntech Medical Instruments, Raleigh, NC) was used for 24-hour ambulatory BP and HR

monitoring (5). About one-half hour before the subject's work shift in the morning, an assistant met the subject at work (between 6 AM and 7:30 AM) and applied the ambulatory monitor with the cuff on the nondominant arm. Subjects were instructed to keep their arms still and at their sides each time the instrument operated. On their off day, subjects were hooked up at a time as close as possible to the beginning of their work day. All subjects were monitored for four 24-hour days. On each measurement occasion, single readings of SBP, DBP, and HR were obtained. The ambulatory recorder was programmed to operate three times an hour on a random schedule during the day and once an hour at night during sleep. Actual time of awake and sleep periods was noted in subject's diary. For each cuff inflation, subjects also indicated their location and posture.

Ambulatory data were first edited for artifacts based on Accutracker reading codes (insufficient electrocardiogram or Korotkoff sounds) and extreme values (> 200/120 or < 70/40 mm Hg). Editing was done entirely by set rules (5). Far outside values were excluded by the stem-and-leaf program of Systat (Evanston, IL). Of the total 36,877 readings, there were 4,190 exclusions (11.4%). For every subject, ambulatory measures for each of the four 24-hour sessions were divided into three time periods. The waking hours were divided into two periods: daytime and evening. The third period was at night during sleep. Work hours on days when subjects were at their job were used to determine the corresponding time periods on days when subjects were not working. Only sleep values were included in the night category. Awake values included both the daytime and evening categories. Classification of each reading as awake or asleep was based on diary entries and postsession reports.

Activity Monitor. An actigraph (Mini-Motionlogger, Ambulatory Monitoring Inc., Ardsley, NY) was worn on the nondominant wrist and used to record frequency of movements in 1-minute intervals during each 24-hour period of ambulatory monitoring (35). We obtained average measures for daytime, evening, and night periods and for the 2- and 10-minute periods preceding each BP reading (35). The activity monitor was used to confirm the differentiation of sleep from awake readings. In addition, averaged data for daytime, evening, and night periods and for the 2- and 10-minute period preceding each BP reading were used separately as covariates in analyses of physiological measures. The same results were obtained whether longer or shorter time periods were used in analyses.

Job Strain. The assessment of job strain was done with a 10-item questionnaire adapted by Steptoe et al. (36) from Karasek and Theorell (18). Items were rated on a 4-point scale from 1 = "strongly disagree" to 4 = "strongly agree" and included information on job demands (3 items), job control (3 items), and skill utilization (4 items). Job strain was defined as follows: [job demands/((job control + skill utilization)/2)] × 10, where the denominator is a measure of decision latitude. Subjects were divided by a median split into high (≥10) vs low (<10) job strain. We analyzed job strain [following Steptoe's (36) definition] and also looked at its separate components, decision latitude and job demands.

Biochemical Assays

Plasma Progesterone. Plasma progesterone levels were measured in duplicate (100 μl/assay tube) by solid-phase radioimmunoassay (RIA) using a commercially prepared kit (Coat-A-Count, Diagnostics Products Corp., Los Angeles, CA). The intraassay coefficient of variance (CV) is 2.6% and the interassay CV 5.1% at highest concentrations expected in this study with a minimum detectable dose = 0.03 ng/ml (95% confidence). Data reduction for progesterone RIA assay was done by a computer-assisted four-parameter logistics program (37).

Urinary Measures. For each of the four sessions, urine was collected over a 24-hour period and stored in two separate bottles for the waking (daytime and evening) period and the period at night during sleep. Nighttime samples included all urine output collected during the night. Total sample volumes were recorded. The urine to be used for catecholamine analysis was acidified to pH 3.0 with 6N HCl, and three 10-ml aliquots were stored at −45°C until assayed. Creatinine samples were corrected for the subject's weight to verify complete collection of urine.

Urine creatinine levels were determined spectrophotometrically using a commercially available colorimetric Jaffe-type assay (38) (Stanbio Laboratory, Inc., San Antonio, TX). Intraassay and interassay CVs were <9% at 5.6 mg/dl with reassay recoveries greater than 96%.

Urinary-free cortisol levels were determined in reconstituted methylene chloride extracts by an automated immunofluorescence procedure on an Abbott TDx Analyzer (Abbott Laboratories; Abbott Park, IL). The assay had less than 9% cross-reactivity with 11-deoxycortisol, corticosterone, cortisone, and less than 1% cross-reactivity with 10 other naturally occurring steroids. The interassay and intraassay CVs are <8% at 4 μg/dl and <4% at 40 μg/dl with a minimum detectable level (95% confidence) of 0.64 μg/dl. Urine extraction efficiencies were greater than 85%.

Urinary catecholamine levels (norepinephrine, epinephrine) were determined by a commercially available ^{125}I-RIA (American Laboratory Products Company, Windham, NH). Urine samples (25 μl) were extracted using a macrotiter plate coated with a cis-diol-specific boronate affinity gel (60 minutes, room temperature, orbital shaker at 900 rpm) (39). The bound catecholamines were acylated (15 minutes, room temperature, orbital shaker 900 rpm), eluted with 0.025 M HCl (0.75 μl), and then enzymatically converted with catechol-PO-methyltransferase (water bath 37°C, 60 minutes) into N-acylnormetanephrine and N-acylmetanephrine. Acylated extracts were assayed in duplicate by two separate RIAs using norepinephrine and epinephrine antigens, respectively. Labeled and unlabeled complexes were separated by immunoprecipitation, and the aspirated pellets were quantified using a gamma counter (ICN Biomedical, formerly Micromedic, Isoflex Gamma Counter). Results were obtained by interpolation from the standard curve. The analytical sensitivities were 135 pg/ml and 22 pg/ml for norepinephrine and epinephrine, respectively, with an intraassay CV ≤6% and interassay CV <7% for both catecholamines. A computer-assisted four-parameter logistics program (37) was used for the RIA assay. Although results are equivocal, there is some suggestion that catecholamine values may be influenced by the inclusion of bananas in the diet (40). We found the values for catecholamines were unaffected by the intake of bananas.

Data Analysis

To correct for differences in urinary volume, epinephrine, norepinephrine, and cortisol levels were divided by the concentration of creatinine, resulting in units of measurement in terms of nanograms per milligram of creatinine. In addition, these values were changed to logs in the statistical analyses. (Values reported in the text have been converted back to antilog values.) All 138 subjects were not included in every analysis because of missing data for some subjects during one of the four sessions. Three subjects lacked ambulatory night data; 3 subjects lacked ambulatory evening data; 3 subjects had incomplete urine collections.

To determine the influence of menstrual cycle Phase (Luteal/Follicular), Day (Work Day/Off day), and Time of Day (Daytime/Evening) on the cardiovascular responses during waking, we did 3-way within-subject ANOVAs using mean values separately for SBP, DBP, and HR. For catecholamines and cortisol and for night-

time, cardiovascular measures 2-way ANOVAs were calculated for Phase and Day. Prior analyses were repeated by including the following between-groups variables one at a time: high- (N = 74) and low- (N = 64) job strain, high- (N = 75) and low- (N = 63) job demands, high- (N = 72) and low- (N = 66) decision latitude, the presence (N = 77) or absence (N = 61) of children in the home, whether subjects were married (N = 79) or were not married (N = 59), and whether subjects were employed as nurses for a relatively long (14–30 years, N = 70) or short time (1–13 years, N = 68). Where groups were divided by median split, the sizes of the groups varied to avoid overlapping scores. For the between-group analyses, except for years working as a nurse, the groups did not differ on any of the following variables: age, BMI, education, alcohol intake, caffeine intake, length of shift (8 or 12 hours). Concerning years employed in nursing, age was used as a covariate. When any effects were significant ($p < .05$), analyses were repeated using the average activity value as a covariate. An index of posture (ratio of instances of standing to total number of readings) was also used as a covariate. The 3-way interactions were followed up by 2-way ANOVAs. To test for specific effects when there were significant interactions, t tests were calculated. In every case, comparisons were made between two cells where one factor was always held constant. Significance levels for t tests reflect Bonferroni adjusted p values.

RESULTS

Basic Analyses on Work Days and Off Days

In the Day × Time of Day × Phase analyses of waking cardiovascular values (see Table 1 for F and p values) there were significant Day effects. Values were higher during work than off days for SBP (2.8 mm Hg) and DBP (2.3 mm Hg) (values represent differences). There were also significant Time of Day effects, with DBP 1.9 mm Hg higher and HR 3.4 bpm higher in the daytime than in the evening. Phase differences were also found, with day HR being 1.7 bpm higher and night HR 3.3 bpm higher during the luteal than the follicular phase. There were significant Day X Time of Day interactions for DBP [$F(1/134) = 16.87$, $p = .0001$] and for HR [$F(1/134) = 17.60$, $p = .0001$] because of high levels in the daytime during the work day (Figure 1).

For the Day × Phase (Table 1) analyses of the neuroendocrine measures, there was a Day effect for epinephrine, with levels during the day being 1.58 ng/mg creatinine higher during work than off days. A Phase effect indicated higher levels of norepinephrine in the luteal than in the follicular phase during the day (difference of 6.19 ng/mg creatinine) and during the night (difference of 2.93 ng/mg creatinine). Activity did not influence these cardiovascular or neuroendocrine findings. However, there was a small Day effect for HR and norepinephrine during the day and a Time of Day

TABLE 1. Significant Main Effects of ANOVA of Ambulatory Blood Pressure and Heart Rate, Catecholamines, and Cortisol During Work and Off Days, Daytime and Evening, and Luteal and Follicular Phases of Menstrual Cycle (N = 135)

Variable	Conditions		F	p
	Work Day	Off Day		
Day				
SBP[a]	119.0 (9.7)	116.2 (9.1)	49.03	<.0001
DBP[a]	71.8 (7.2)	69.5 (7.1)	69.64	<.0001
Epinephrine day	8.13 (1.65)	6.55 (1.68)	26.71	<.0001
Time of day	Daytime	Evening		
DBP	71.6 (6.6)	69.7 (7.7)	55.83	<.0001
HR	80.9 (9.4)	77.5 (9.3)	124.55	<.0001
Phase	Luteal	Follicular		
HR[a]	80.2 (9.2)	78.5 (9.1)	23.83	<.0001
HR night	67.8 (8.6)	64.5 (8.6)	76.63	<.0001
Norepinephrine				
Day	38.55 (1.65)	32.36 (1.66)	16.10	<.0001
Night	22.70 (1.71)	19.77 (1.72)	9.02	<.003

Values are mean (SD). BP values are in mm Hg; HR in bpm; catecholamines and cortisol in ng/mg of creatinine.
[a] Average of daytime and evening values.

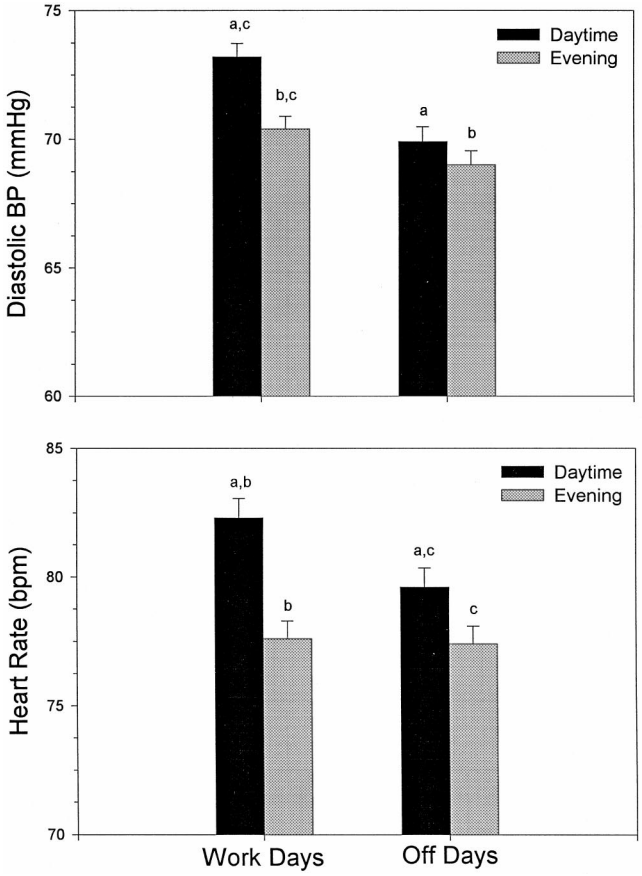

Fig. 1. DBP and HR (mean, standard error) during the daytime and evening for work and off days. Bars designated with the same letter (*a-a*; *b-b*; *c-c*) represent values that significantly differ from one another. The decrease in DBP from work to off days was significantly greater in the daytime than in the evening; and the decrease in HR from daytime to evening was significantly greater during work than off days. (Significance indicates $p < .05$ with Bonferroni correction).

effect for SBP during the day. These effects were no longer significant with activity as a covariate. Posture did not influence any of the findings.

Job Strain

There were no differences between high- and low-job strain for any of the cardiovascular or neuroendocrine measures. Neither was decision latitude related to the physiological measures. However, some physiological measures (independent of activity) were significantly related to job demands. There was a Time of Day × Job Demands interaction for waking SBP [$F(1/133) = 6.93$, $p = .009$]. Because of higher levels in the daytime, high job demands subjects had a significant difference between daytime and evening SBP (Figure 2). There was a Day × Job Demands interaction for nighttime epinephrine [$F(1/132) = 4.50$, $p = .036$]. During the night, high job demands subjects had higher epinephrine levels during work than off days (Figure 3). Finally, there was a Day × Time of Day × Job Demands interaction for waking HR [$F(1/133) = 5.38$, $p = .022$]. The 3-way interaction for HR was examined by computing 2-way ANOVAs separately for high and low job demands subjects, resulting in a significant Day × Job Demands effect for high job demands subjects [$F(1/72) = 25.94$, $p = .0001$]. These effects were similar but not significant for low job demands subjects. Nurses with high job demands scores had elevated daytime HR values on the work compared with the off day (Figure 4).

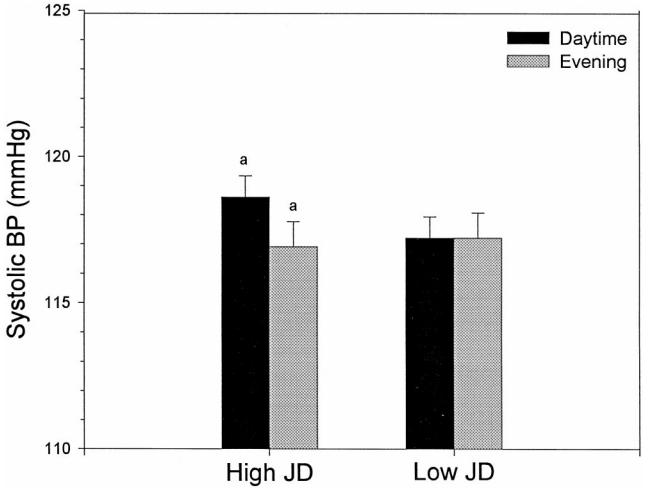

Fig. 2. SBP (mean, standard error) in high and low job demands (JD) groups for daytime and evening. Bars designated with the same letter (*a-a*; *b-b*) represent values that significantly differ from one another ($p < .05$ with Bonferroni correction).

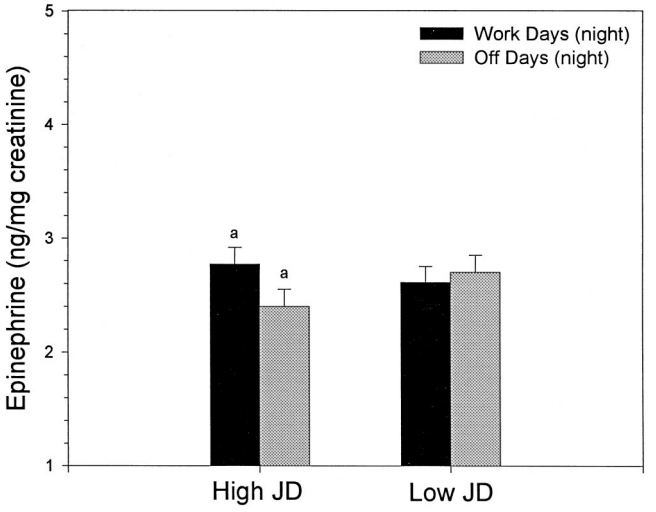

Fig. 3. Epinephrine (mean, standard error) in high and low job demands (JD) groups for work days and off days during the night. Bars designated with the same letter (*a-a*) represent values that significantly differ from one another ($p < .05$ with Bonferroni correction).

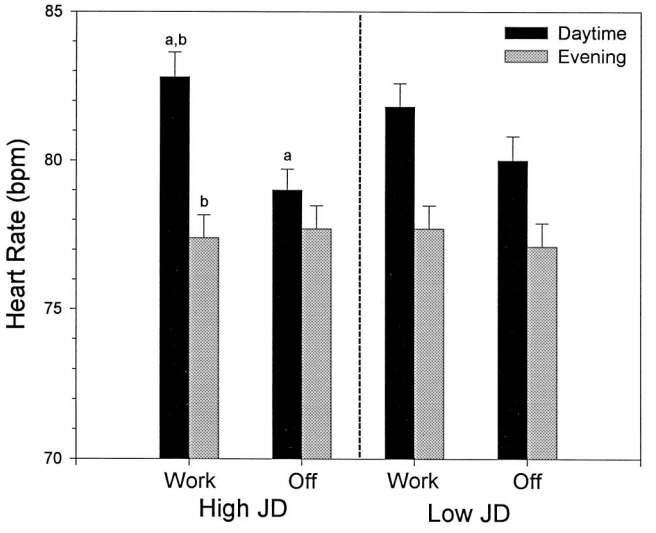

Fig. 4. HR (mean, standard error) in high and low job demands (JD) groups for daytime and evening during work and off days. Bars designated with the same letter (*a-a*; *b-b*) represent values that significantly differ from one another ($p < .05$ with Bonferroni correction).

Years Worked in Nursing

A significant Years × Day [$F(1/133) = 4.51$, $p = .036$] interaction was found for night DBP. Subjects with long work histories had higher DBP on off days than those with short work histories (Figure 5). In addition, there was a main effect for norepinephrine both during waking hours [$F(1/132) = 4.43$, $p = .037$] and during the night [$F(1/131) = 4.78$, $p = .031$]. For nurses who had long work histories, norepinephrine was 39.08 (1.72) ng/mg creatinine during waking and

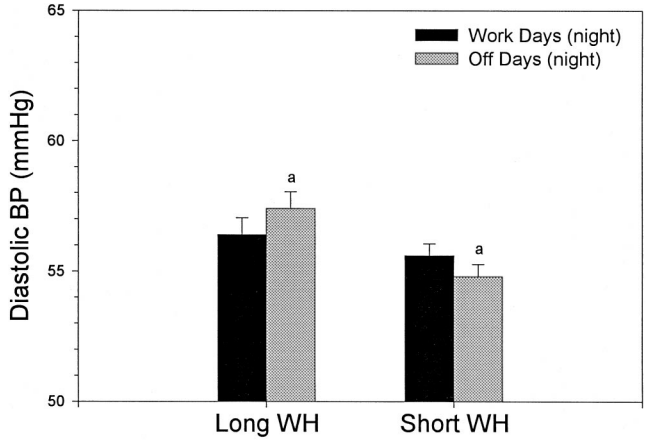

Fig. 5. Nighttime DBP (mean, standard error) during work and off days in subjects with a long and with a short work history (WH). Bars designated with the same letter (*a*-*a*) represent values that significantly differ from one another ($p < .05$ with Bonferroni correction).

Fig. 6. Norepinephrine (mean, standard error) during the day for work and off days in subjects who are married and those who are not. Bars designated with the same letter (*a*-*a*) represent values that significantly differ from one another ($p < .05$ with Bonferroni correction).

23.71 (1.63) ng/mg creatinine during the night, compared with 31.84 (1.58) and 18.92 (1.54) in nurses with short work histories. These effects were independent of age and activity as measured by the actigraph.

Marriage and Children

There was a main effect for Marriage [$F(1/132) = 7.85$, $p = .006$] for cortisol during the night, with married subjects having higher levels [28.31 (2.05) ng/mg creatinine] than those who were not married [22.08 (1.64) ng/mg creatinine]. There was also an interaction for Marriage × Day for waking norepinephrine [$F(1/133) = 4.88$, $p = .029$]. Nurses who were not married showed significant decreases in norepinephrine on off days as compared with work days, whereas the 2 days were similar in married nurses (Figure 6). Finally, there was a significant Time of Day × Child interaction for waking HR [$F(1/133) = 7.56$, $p = .007$]. Although all nurses showed a significant HR drop from daytime to evening hours, the drop was greater in those women with no children living in the home (Figure 7).

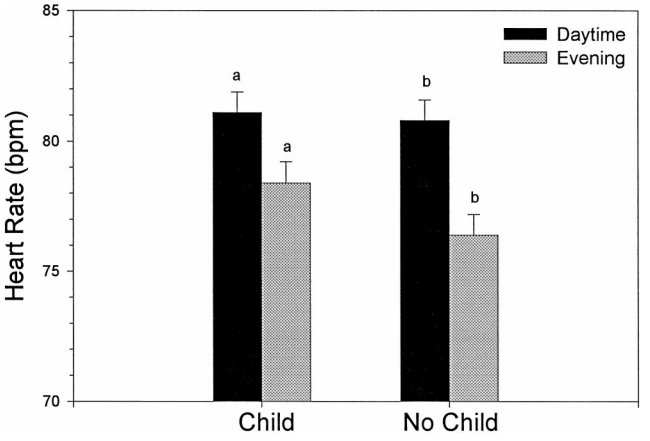

Fig. 7. HR (mean, standard error) during the daytime and evening in subjects with and without children living in the home. Bars designated with the same letter (*a*-*a*; *b*-*b*) represent values that significantly differ from one another. Also, the decrease in HR from daytime to evening was significantly greater in women without children than in those with children ($p < .05$ with Bonferroni correction).

DISCUSSION

Effects of Work

For a group of healthy female nurses, SBP, HR, and epinephrine were higher on work than off days during waking hours. In addition, DBP and HR were higher during daytime than during evening hours. The significant Day × Job interaction for DBP and HR (Figure 1) indicates that the effects were primarily due to elevated readings obtained while subjects were at work. The presence of elevated work values is consistent with findings of investigators who studied subjects' BP and HR during work hours on a work day and compared these measures with similar hours on the nonwork day (1, 2, 41). Pieper et al. (42) studied the entire 24-hour work day (as in the present study) in normotensive and hypertensive men; they reported no overall day differences in work vs nonwork. However, their finding of elevated SBP and DBP during the portion of the day when the men were at their jobs is consistent with our results for DBP.

In her study of male and female middle managers and clerical workers, Frankenhaeuser et al. (43) reported that BP, HR, and epinephrine levels were sig-

nificantly elevated while at work, with significant decreases at home at the end of the work day. However, whereas BP and norepinephrine of male managers dropped at the end of the work day, the levels of female managers not only failed to drop in the evening but sometimes increased in value. For men and women in varying occupations, BP was higher on the work than the off day, but the differences were not apparent during the night (3). The failure to "unwind" in the evening which Frankenhaeuser et al. (43) noted in female managers was not found for BP for the nurses in our study.

Menstrual Phase Effects

Our failure to find a significant relationship between ambulatory BP and menstrual cycle phase confirms the results of other investigators (10, 11), although it is at odds with the higher ambulatory SBP reported by Manhem et al. (7, 9) in 11 normotensive women during the luteal as compared with the follicular phase. In a discussion of nonambulatory studies, Stoney (12) concluded that when a between-subjects design was used, the results of investigations on cardiovascular variables and menstrual cycle phase were small and inconsistent. Moreover, within-subject studies have generally found no effect of menstrual cycle phase on cardiovascular responses to stress.

Concerning variables other than BP, our results of higher HR during the luteal phase are consistent with those of Manhem et al. (7, 9). However, unlike Manhem et al. (7), who did not find significant catecholamine differences as a function of menstrual cycle phase, we found that waking and nighttime norepinephrine levels in nurses were higher during the luteal than the follicular phase. Saab (44) concluded in her review that minimal evidence exists for increased stress-induced catecholamines in the luteal phase. In addition, all six of the women studied during a complete ovulatory cycle had higher plasma norepinephrine, but not epinephrine differences, during the luteal phase compared with the follicular phase (45). The results for urinary values were similar, but the difference between the two phases was smaller. Sato et al. (6) did not find menstrual phase related to HR or BP level, but instead showed that phase was related to power spectral analysis of HR variability. They felt that this measure of HR variability was more sensitive in assessing very small fluctuations in autonomic activity during the menstrual cycle. The present findings of increased HR and norepinephrine during the luteal phase is consistent with the conclusions of Sato et al. (6) suggesting a predominance of sympathetic activity during this phase.

Activity

The fact that activity, as measured by an actigraph, had a limited influence on our findings for BP and HR is consistent with a prior study of active, healthy men and women between the ages of 50 and 78 years (35). In an attempt to determine and to control for the influence of activity on ambulatory BP at work, some investigators have recorded measures felt to be related to activity, such as posture and diary ratings of type or level of activity (1, 42, 46). Differences in posture did not account for the findings.

Job Strain

Our failure to find a significant relationship between ambulatory BP and job strain supports the conclusions of some investigators (17, 24) that the concept of job strain may be more applicable to men than women. However, these findings contrast with the results reported in other studies (16, 25). Note that there are different methods of defining high-job strain, and that our results are based on the adaptation by Steptoe et al. (36) of the job strain concept. To be certain that our negative findings were not due to our use of this definition of job strain, we repeated our analyses using the four quadrants of job strain based on combinations of high- and low-job demands and high- and low-decision latitude (18). Again, the high-job strain group did not differ significantly from any of the other three job strain quadrants. Although in the current study job strain was not related to BP, SBP was elevated in high job demands nurses during daytime hours relative to evening hours (Figure 2). Also, high demands subjects had elevated daytime HR values on work days and a greater epinephrine difference between work and off days. (Figures 3 and 4).

Steptoe et al. (36) reported that high systolic stress reactivity in the laboratory combined with high-job strain ratings led to increased SBP on the afternoon of the work day. The job strain scores for the high [11.7 (1.7)] and for the low [8.37 (1.2)] groups of nurses in this study are comparable to the values reported by Steptoe et al. for male firefighters. However, the nurses differ from the firefighters on two of the components of the job strain score: higher job demands [10.2 (1.8)] coupled with greater job control [9.2 (1.6)]. This may help to explain why job demands, and not job strain, was a significant variable in this group.

Years Worked in Nursing

Rather than greater work experience being associated with a reduction in physiological levels, as we had hypothesized, nurses with longer work histories

had higher norepinephrine levels during waking hours and during the nighttime on all four sessions. Also, compared with nurses with a short work history, those having a long work history had higher nighttime DBP during off days (Figure 5). This effect was independent of age. Because there were no differences in women with a long work history compared with those with a short work history concerning either marital status or children in the home, results were not due to either of these factors. In discussing this issue informally with our subjects, nurses working in the field longer were more aware of recent changes in the medical field and their negative impact on the nursing profession.

Marriage and Children

One problem with applying the job strain concept to women is that it fails to include a woman's dual role at home and at work and the responsibilities that many women have with children at home. Where the issue of marital status has been explored among women with mild hypertension in a number of occupations, being married was associated with a higher ambulatory BP than being single (16). Also, among women in technical and clerical fields, those who were married had higher ambulatory DBP at work than single women (17). We did not find a relationship between marital status and BP. An association between marital satisfaction and health has been suggested by Gove et al. (47). In response to the following 5-point question: "How much enjoyment do you get from your home life?" 85% of married nurses in the present study responded with ratings of either 4 or 5 (1 = no enjoyment; 5 = a great deal of enjoyment). This level of home enjoyment could be related to high marital satisfaction, resulting in less stress and lower BPs than those found in other studies. However, lower sympathetic arousal was found in unmarried nurses, as evidenced by low levels of norepinephrine during the waking portion of their off days (Figure 6). Also, nighttime cortisol was lower in unmarried nurses during all four ambulatory recording days. In contrast, Luecken et al. (48) found no relationship between marital status and either catecholamines or cortisol during two 24-hour work days. Unlike the nurses in our study, these women were employed in clerical and customer service jobs and were 41% black. In addition, neither menopausal status nor menstrual cycle phase was considered.

Reviews of studies on women with children indicate that being a parent had little impact on a woman's health (49). However, investigators found that when compared with working women with no children, those with children at home had higher 24-hour cortisol excretion levels, with no effect on catecholamines (48). Pickering (17) reported that having children was related to higher SBP and DBP at work and at home, with less of a likelihood for BP to decrease in the evening. In the present study, the only effect related to the presence of children in the home was a greater decrease in HR from daytime to evening hours in nurses with no children (Figure 7).

CONCLUSIONS

Our findings of increases in both catecholamines and the cardiovascular measures on work days as compared with off work days suggest that elevations in BP and HR may in part be the result of stimulation of the sympathetic nervous system. Frankenhaeuser (31) proposed that catecholamines (particularly epinephrine) are indicators of mental arousal and are unrelated to positive or negative affect, whereas cortisol generally increases during negative affect. She referred to increased norepinephrine and epinephrine with no increase in cortisol as effort without distress. When elevations in catecholamines are accompanied by increases in cortisol, this was felt to be a sign of negative emotion or distress. For the present group of nurses, work was not associated with increases in cortisol. Cortisol was a significant factor only in the analysis of marital status. Subjects who were single had lower cortisol levels during the night than married subjects, indicating that the distress or stress factor for married subjects may have been greater during the nighttime hours, possibly because of a greater role conflict between marriage and career.

Although many of the significant BP effects represented small differences, these differences were clinically meaningful. We need to be aware of factors that lead to increases in BP, even small ones, that are maintained over time and can have an eventual impact on cardiovascular risk. A DBP decrease as small as 2 mm Hg could have an immense impact on public health, leading to a 6% reduction in coronary risk and a 15% reduction in stroke and transient ischemic attacks (50). Because nurses are frequently faced with daily exposures to illness and disease, as well as "life and death" conditions, we had expected greater elevations in cardiovascular and neuroendocrine responses to the work environment. However, a recent study of air traffic controllers showed that the ambulatory BP of men engaged in this so-called "stressful" occupation did not differ from men employed in various other jobs (51). The investigators concluded that the stressful nature of their jobs did not influence their daily BP, because these men were able to cope effectively with the requirements of their job. The nurses in our study

also may have learned to cope with their daily activities at work. The feeling of having relatively high control over their work may have aided them in this respect.

There is evidence showing that women are not affected by job strain in the same manner as men (17, 24). The findings of Blumenthal et al. (16) of elevated SBP in high job strain women in a variety of occupations may have been partially accounted for by the fact that their subjects had mild hypertension and were somewhat older (29–59 years) than the nurses in our study.

Our nurses showed no spill-over effects of daytime BP to the rest of the day. On both work and off days, BP decreased in the evening, with a much larger drop during the night. Studies show that work does not pose a health risk for women. On the contrary, women working outside of the home were often healthier than those who worked only at home (see review in 27). Also, women in female-dominated professions, such as nursing, had higher work self-esteem and less role conflicts than those in fields dominated by men or in nonprofessional jobs (52).

Finally, it is important to note that these results may not generalize to other samples of women. The subjects were in a female-dominated profession of college-educated, highly skilled workers. In addition, by restricting our study to women who were healthy and nonhypertensive, we may have excluded subjects who chronically respond to work stress with large increases in BP.

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