Pharmacology Biochemistry & Behavior, Vol. 37, pp. 697–702. © Pergamon Press plc, 1990. Printed in the U.S.A. 0091-3057/90 $3.00 + .00

Comparison of Neuroendocrine Measurements Under Laboratory and Naturalistic Conditions

ULF LUNDBERG,[1] BO MELIN, MATS FREDRIKSON, MARTTI TUOMISTO AND MARIANNE FRANKENHAEUSER

Psychology Division, Department of Psychiatry and Psychology, Karolinska Institutet and Department of Psychology, University of Stockholm

Received 8 June 1990

LUNDBERG, U., B. MELIN, M. FREDRIKSON, M. TUOMISTO AND M. FRANKENHAEUSER. *Comparison of neuroendocrine measurements under laboratory and naturalistic conditions.* PHARMACOL BIOCHEM BEHAV **37**(4) 697–702, 1990.—Urinary catecholamines and cortisol were measured in healthy nonsmoking white collar workers (14 male and 15 female managers, 15 male and 14 female clerical workers), aged 30–50 years, during a one-hour period of laboratory-induced stress comprising five tests and a Type A interview, and during a subsequent period of rest in the laboratory. Values were compared with data obtained four months earlier from the same subjects during a normal day at work (4 values) and during a work-free day at home (4 values). No significant group differences were found during rest in the laboratory. However, during laboratory-induced stress, female managers had the highest norepinephrine values, which contributed to significantly ($p<0.01$) higher values in women than in men. Correlations between absolute measurements from laboratory and naturalistic conditions were generally positive and reached significance in most cases. Correlations between reactivity measurements in the laboratory and at work (change from rest to stress and from home to work, respectively) were generally low, whereas correlations between reactivity at different times of the day were relatively high. The data suggest that generalizability of neuroendocrine reactivity from laboratory stress to real-life stress is low. However, in agreement with earlier experimental findings, absolute levels of catecholamine and cortisol excretion were consistent over conditions and time.

Consistency Reactivity Urinary catecholamines and cortisol Lab-field comparison

EXCRETION rates of catecholamines and cortisol provide sensitive indicators of the impact of environmental demands on healthy individuals [see (2,3)]. The greater part of the empirical research investigating relationships between psychological variables, catecholamines and cortisol, has been carried out in laboratory settings, where subjects have been exposed to mental tasks, noise, electric shocks, etc. However, the same measurements have been used successfully in field studies to predict the impact of examination stress in schools, crowding in trains, assembly line work, etc.

Data from earlier studies (1,11) show that consistency in urinary catecholamine and cortisol excretion is relatively high over different experimental conditions and time intervals ranging from 24 hours to 12 weeks. However, since the same groups have not been studied in both laboratory and naturalistic settings, it has not been possible to determine the extent to which reactivity to laboratory-induced stress will predict reactivity to various natural stressors in real life. An opportunity to study the same individuals under these two sets of conditions was provided within the frame of a larger project concerned with occupational stress (6). The particular focus of this paper is to examine the consistency in catecholamine and cortisol excretion induced by a series of frequently used stress tests in a controlled laboratory experiment and by real-life stress during a normal day at work.

METHOD

Subjects and General Design

Fifty-eight nonsmoking male (14 managers, 15 clerical workers) and female (15 managers, 14 clerical workers) white collar workers participated in the study. All subjects were healthy (as determined by a medical check-up) and the four groups had been matched for age (range 30–50 years, mean for men 41.2 years, women 41.5 years).

[1]Requests for reprints should be addressed to Ulf Lundberg, Ph.D., Department of Psychology, University of Stockholm, S-106 91 Stockholm, Sweden.

TABLE 1

MEANS AND STANDARD DEVIATIONS OF URINARY CATECHOLAMINES AND CORTISOL (pmol/min/kg) IN MALE AND FEMALE WHITE COLLAR WORKERS (MANAGERS AND CLERICAL WORKERS) DURING EXPERIMENTAL STRESS (9–10 a.m.) AND REST (11 a.m.–NOON) IN THE LABORATORY

	Managers				Clerical Workers				ANOVA	
	Men (n = 14)		Women (n = 15)		Men (n = 15)		Women (n = 14)			
	Stress	Rest	Stress	Rest	Stress	Rest	Stress	Rest	Sex	Cond.
Epinephrine										
Mean	0.51	0.42	0.61	0.41	0.52	0.40	0.45	0.40		*
SD	0.27	0.18	0.46	0.21	0.28	0.19	0.20	0.15		
Norepinephrine										
Mean	1.49	2.02	2.72	2.36	1.73	2.16	2.15	2.23	*	
SD	0.52	0.54	1.61	0.72	0.51	0.71	0.75	0.78		
Cortisol										
Mean	3.75	2.82	4.31	2.62	3.53	1.59	2.91	1.55		†
SD	4.31	1.51	3.74	2.75	2.11	0.70	2.42	0.61		

*$p<0.01$; †$p<0.0001$.

Differences between the sexes and between conditions (rest versus stress) were tested with analysis of variance (ANOVA).

Neuroendocrine data from a laboratory experiment were compared with earlier reported data (6) obtained from the same subjects during a normal day at work and a work-free day at home. The interval between measurements at work and at home was one week, and the laboratory experiment was performed about four months later.

The Laboratory Experiment

The subjects were allowed to be absent from their work with full payment while participating in the experimental session (9 a.m. to noon) in a laboratory at the workplace. However, one male manager and one female clerical worker were not able to participate in the laboratory experiment.

Experimental stress (about 9–10 a.m.) was induced by five different tests separated by 2-min intervals: mirror drawing (2 min), mental arithmetic (4 min), the Stroop color word test (4 min), hand grip (2 min), cold pressor (1 min), and by a stressful videotaped Type A interview (about 30 min). The subject voided urine immediately before the stress tests and a urine sample was obtained after the Type A interview. Thus, the urinary measurements of the present study represent the total 50–60-min stress period of which 3 min represent mainly physical stress (hand grip, cold pressor) and about 40 min mental stress (about 10 min represent intervals between tests). The stress tests were selected on

TABLE 2

PRODUCT MOMENT CORRELATION COEFFICIENTS BETWEEN EPINEPHRINE EXCRETION (pmol/min/kg) DURING LABORATORY AND NATURALISTIC CONDITIONS FOR 29 MALE AND 29 FEMALE WHITE COLLAR WORKERS

	At Work				At Home				In the Lab
	11 a.m.	1 p.m.	3 p.m.	5 p.m.	11 a.m.	1 p.m.	3 p.m.	5 p.m.	Stress
Males									
In the lab									
Stress	.48†	.35	.38*	.36*	.43*	.26	.37*	.52†	
Rest	.33	.58†	.32	.34	.28	.31	.42*	.36*	.42*
At work									
1 p.m.	.38*								
3 p.m.	.56†	.73†							
5 p.m.	.45*	.50†	.63†						
At home									
11 a.m.	.24	.03	.01	.18					
1 p.m.	.16	.29	.28	.28	.17				
3 p.m.	.30	.26	.05	.45*	.60†	.47†			
5 p.m.	.56†	.34	.57†	.36*	.32	.37*	.23		
Females									
In the lab									
Stress	.48†	.39*	.58†	.60†	.38*	.36*	.14	.27	
Rest	.44*	.51†	.35	.55†	.24	.35	.23	.41*	.41*
At work									
1 p.m.	.76†								
3 p.m.	.32	.33							
5 p.m.	.73†	.87†	.51†						
At home									
11 a.m.	.74†	.76†	.13	.66†					
1 p.m.	.70†	.73†	.19	.65†	.91†				
3 p.m.	.22	.50†	.12	.35	.59†	.71†			
5 p.m.	.37*	.70†	.31	.64†	.66†	.75†	.82†		

*$p<0.05$; †$p<0.01$.

TABLE 3

PRODUCT MOMENT CORRELATION COEFFICIENTS BETWEEN NOREPINEPHRINE EXCRETION (pmol/min/kg) DURING LABORATORY AND NATURALISTIC CONDITIONS FOR 29 MALE AND 29 FEMALE WHITE COLLAR WORKERS

	At Work				At Home				In the Lab
	11 a.m.	1 p.m.	3 p.m.	5 p.m.	11 a.m.	1 p.m.	3 p.m.	5 p.m.	Stress
					Males				
In the lab									
Stress	.17	−.01	−.00	.29	.44*	.10	.54†	.22	
Rest	.31	.46†	.19	.34	.40*	.03	.33	.40*	.39*
At work									
1 p.m.	.51†								
3 p.m.	.74†	.58†							
5 p.m.	.48†	.26	.43*						
At home									
11 a.m.	.27	.00	.17	.27					
1 p.m.	.13	.09	.04	.15	.13				
3 p.m.	.25	.25	.21	.39*	.42*	.31			
5 p.m.	.27	.34	.25	.16	.48†	.54†	.31		
					Females				
In the lab									
Stress	.11	.05	.53†	.33	.12	.21	−.00	.25	
Rest	.20	.47†	.17	.41*	.33	.27	.18	.35	.40*
At work									
1 p.m.	.54†								
3 p.m.	.36*	.34							
5 p.m.	.67†	.78†	.48†						
At home									
11 a.m.	.49†	.48†	.12	.30					
1 p.m.	.71†	.54†	.42*	.60†	.60†				
3 p.m.	.38*	.53†	.23	.42*	.48†	.65†			
5 p.m.	.51†	.72†	.55†	.72†	.53†	.75†	.58†		

*$p<0.05$; †$p<0.01$.

the basis of our earlier studies, where they have been found to induce significant sympathetic arousal under laboratory conditions [e.g., (4, 5, 12)]. For details about the Type A interview, see Lundberg et al. (13).

Physiological baseline levels were determined in urine samples obtained after a 50-min period of rest between 11 a.m.–noon on the day of the laboratory session. During the rest period the subjects read magazines and listened to music and a urine sample was obtained at the end.

Cortisol excretion (pmol/min/kg) was determined by radioimmunoassay, epinephrine and norepinephrine (pmol/min/kg) by fluorophotometric assay (14).

Naturalistic Conditions

The data from the work and home settings were obtained under the following conditions [for details see (6)]. At work the subjects spent most of their day in their office or in meetings. Days involving travel or other external activities were avoided. They voided at 9 a.m., and urine samples were collected every second hour, i.e., at 11 a.m., and at 1, 3 and 5 p.m. During the work-free day at home (a paid weekday off the job), the subjects were asked to relax, to avoid all stressful activities and to spend the day reading magazines and listening to music. Urine samples were obtained at the same time of the day at home as on the job.

RESULTS

Neuroendocrine Responses to Stress in the Laboratory

Means and standard deviations for catecholamine and cortisol excretion during rest and experimental stress in the laboratory are shown for the four groups in Table 1. There were no significant group differences during rest. However, during laboratory-induced stress, norepinephrine excretion was significantly higher in women than in men ($F=10.45$, $p<0.01$). Pairwise comparisons between the four groups showed that female managers had significantly higher values than their male colleagues ($t=2.78$, $p<0.01$), whereas the corresponding sex difference for clerical workers did not reach significance ($t=1.90$, $p<0.10$). The high norepinephrine values of the female managers are consistent with earlier findings from women in traditionally male occupations (bus drivers, lawyers, engineers) [see (3) for a review].

Epinephrine ($F=10.7$, $p<0.01$) and cortisol excretion rates ($F=31.7$, $p<0.0001$) were significantly higher during laboratory-induced stress compared to rest. However, due to the normal diurnal rhythms of these hormones (epinephrine increasing and cortisol decreasing during morning hours), the difference values

TABLE 4

PRODUCT MOMENT CORRELATION COEFFICIENTS BETWEEN CORTISOL EXCRETION (pmol/min/kg) DURING LABORATORY AND NATURALISTIC CONDITIONS FOR 29 MALE AND 29 FEMALE WHITE COLLAR WORKERS

	At Work				At Home				In the Lab
	11 a.m.	1 p.m.	3 p.m.	5 p.m.	11 a.m.	1 p.m.	3 p.m.	5 p.m.	Stress
Males									
In the lab									
Stress	.77†	.69†	.76†	.79†	−.01	.17	.20	.09	
Rest	.79†	.75†	.74†	.91†	−.18	.22	.28	.10	.89†
At work									
1 p.m.	.77†								
3 p.m.	.68†	.77†							
5 p.m.	.75†	.70†	.72†						
At home									
11 a.m.	−.16	−.24	−.33	−.16					
1 p.m.	.22	.21	.08	.24	.24				
3 p.m.	.16	.20	.22	.30	−.05	.20			
5 p.m.	.16	.19	.30	.19	−.19	−.04	.30		
Females									
In the lab									
Stress	.41*	.45*	.52†	.28	−.23	.14	−.14	−.01	
Rest	.39*	.26	.45†	.47†	−.27	−.05	−.21	−.02	.70†
At work									
1 p.m.	.59†								
3 p.m.	.80†	.54†							
5 p.m.	.56†	.30	.68†						
At home									
11 a.m.	−.06	.03	−.31	−.16					
1 p.m.	.26	.31	.30	.35	−.10				
3 p.m.	.04	.17	−.06	.12	−.05	.52†			
5 p.m.	.00	.06	−.08	.06	.18	.28	.43*		

*$p<0.05$; †$p<0.01$.

represent an underestimation of epinephrine reactivity and an overestimation of cortisol reactivity. Although the correlations calculated below are not systematically influenced by these diurnal factors, reactivity to stress in the laboratory was also calculated by using the corresponding (9–11 a.m.) value during the work-free day at home as baseline.

Correlations Between Absolute Levels in the Different Conditions

As no main effect of occupational level was found in the data, all men and all women, respectively, were treated together in the correlational analyses. Correlations between neuroendocrine (absolute) values under laboratory (rest and stress) and naturalistic conditions (at work and at home) are shown in Tables 2–4.

For epinephrine (Table 2), all correlations were positive and reached significance in 54 of the 90 cases. Correlations were particularly high in women (31 significant values of 45).

For norepinephrine (Table 3), correlations were also positive except for three values that were close to zero. Again, the data suggest higher consistency over conditions in women. For example, levels at work were significantly correlated with levels at home in 13 of the 16 cases for women, but only in one case for men.

As shown in Table 4, cortisol measurements were also significantly positively correlated in 29 of 90 cases but close to zero in several cases. However, there is a very consistent pattern in the data for both sexes: measurements at home were not significantly correlated with any of the values at work or in the laboratory. For example, whereas measurements at work correlated significantly (15 of 16 cases) with measurements obtained in the laboratory four months later, there was no significant correlation between cortisol levels at work and at home, only one week apart, for men or women. In fact, cortisol levels were more or less independent between the different times of the day at home (significant in only two cases of 12), in contrast to the high correlations (11 significant of 12) between measurements at work.

Correlations Between Reactivity Measurements

Table 5 shows correlations between reactivity values for epinephrine, i.e., changes from rest/home to stress in the laboratory and from home to the work condition at each time of the day. Correlations between stress reactivity in the laboratory and at work reached significance ($p<0.05$) in one case only, using the resting level in the laboratory as baseline, and in three cases (of eight), using the home level (9–11 a.m.) as baseline. However, in two of these three cases the association can be explained by the fact

TABLE 5

PRODUCT MOMENT CORRELATION COEFFICIENTS BETWEEN EPINEPHRINE REACTIVITY DURING LABORATORY STRESS AND NATURALISTIC CONDITIONS AT WORK FOR 29 MALE AND 29 FEMALE WHITE COLLAR WORKERS

	Stress at Work			
	11 a.m.	1 p.m.	3 p.m.	5 p.m.
		Males		
Lab stress				
base = lab	.09	−.07	.08	−.07
base = home	.43*	.15	.32	.02
At work				
1 p.m.	.30			
3 p.m.	.52†	.41*		
5 p.m.	.02	.19	−.01	
		Females		
Lab stress				
base = lab	−.05	−.08	.24	.37*
base = home	.51†	.19	.60†	.31
At work				
1 p.m.	.42*			
3 p.m.	.65†	.33		
5 p.m.	.51†	.50†	.56†	

*$p<0.05$; †$p<0.01$.

Experimental stress reactivity was related to two separate baseline levels: rest in the laboratory (lab) and rest at home (home), reactivity at work to home levels.

TABLE 6

PRODUCT MOMENT CORRELATION COEFFICIENTS BETWEEN NOREPINEPHRINE REACTIVITY DURING LABORATORY STRESS AND NATURALISTIC CONDITIONS AT WORK FOR 29 MALE AND 29 FEMALE WHITE COLLAR WORKERS

	Stress at Work			
	11 a.m.	1 p.m.	3 p.m.	5 p.m.
		Males		
Lab stress				
base = lab	.12	−.37*	−.23	.10
base = home	.42*	.02	−.15	.17
At work				
1 p.m.	.29			
3 p.m.	.52†	.38*		
5 p.m.	.29	.18	.06	
		Females		
Lab stress				
base = lab	.07	−.30	.41*	.03
base = home	.32	−.06	.53†	.30
At work				
1 p.m.	−.05			
3 p.m.	.25	.08		
5 p.m.	.52†	.32	.17	

*$p<0.05$; †$p<0.01$.

Experimental stress reactivity was related to two separate baseline levels: rest in the laboratory (lab) and rest at home (home), reactivity at work to home levels.

that identical baseline values were used for the two reactivity measurements. Reactivity values during different times of the day at work were significantly positively correlated in seven of the twelve cases for men and women.

Corresponding correlations for norepinephrine (Table 6) were lower, but the pattern was very similar. Correlations between stress reactivity in the laboratory and at work reached one positive and one negative significant correlation using the rest period in the laboratory as baseline, and two positive correlations using the home level as baseline.

The correlations between cortisol reactivity measurements (Table 7) were generally low. However, correlations between stress reactivity in the laboratory and at work reached significance in two cases for both sexes.

TABLE 7

PRODUCT MOMENT CORRELATION COEFFICIENTS BETWEEN CORTISOL REACTIVITY DURING LABORATORY STRESS AND NATURALISTIC CONDITIONS AT WORK FOR 29 MALE AND 29 FEMALE WHITE COLLAR WORKERS

	Stress at work			
	11 a.m.	1 p.m.	3 p.m.	5 p.m.
		Males		
Lab stress				
base = lab	−.15	−.30	.10	−.28
base = home	.07	.40*	.41*	.24
At work				
1 p.m.	.24			
3 p.m.	.28	.24		
5 p.m.	.16	−.12	.06	
		Females		
Lab stress				
base = lab	.30	.42*	.38*	−.12
base = home	.13	−.06	.28	−.03
At work				
1 p.m.	.46*			
3 p.m.	.57†	.57†		
5 p.m.	.42*	.11	.25	

*$p<0.05$; †$p<0.01$.

Experimental stress reactivity was related to two separate baseline levels: rest in the laboratory (lab) and rest at home (home), reactivity at work to home levels.

DISCUSSION

From a practical as well as a theoretical point of view it is important to determine to what extent physiological measurements in the laboratory reflect measurements in everyday life. Catecholamine and cortisol data are consistent with earlier cardiovascular data (7,8) and show that correlations between absolute measurements in the laboratory and in real life situations are high (see Tables 2–4).

An interesting finding was the very high correlation between cortisol excretion in the laboratory and at work over the four-month period, in contrast to the complete lack of association between cortisol levels at home and at work over the one-week period. Considering that the laboratory session was performed as part of a normal day at work, a tentative explanation for these findings is that the work setting induced a particular (conditioned?) cortisol response in each individual in both cases, whereas corti-

sol levels at home were more "random." The fact that cortisol levels at the different times of the day at work (and between stress and rest in the laboratory) were highly correlated and cortisol levels at home were not, supports the idea of a specific individual cortisol response in the work setting.

A related question of interest is the consistency of reactivity values, i.e., to what extent the magnitude of change in physiological arousal from baseline to stress is stable over conditions and time (10, 15, 17). In this case, too, our neuroendocrine data are in agreement with cardiovascular data (7, 8, 17) showing low consistency between reactivity in laboratory and naturalistic settings.

Although one cannot exclude the possibility that the four-month interval between measurements at work and in the laboratory contributed to lower correlations, the very high correlations between absolute levels over the same time period (Tables 2–4) indicate that this is not an important factor. In agreement with this, a recent study of plasma catecholamines in rats over a one-year period shows high stability (16). Neither are seasonal variations likely to affect these measurements (9).

In order to test the hypothesis that individuals can be defined as "high" and "low responders," respectively, it is important to determine to what extent stress responses are consistent over various conditions. The naturalistic stress conditions at work comprise a variety of stressors associated with white collar jobs and differ in many respects from the experimental stress conditions in the laboratory. However, the increase in epinephrine but not norepinephrine output indicates that both conditions were associated with mental rather than physical stress [cf. (18)]. Consequently, individuals cannot be consistently classified as "high" and "low responsers," respectively. The data in Tables 5–7 suggest that reactivity measurements are relatively consistent over various natural conditions during a day at work, but do not generalize to experimental conditions at another occasion. The extent to which physiological reactivity is consistent over time and conditions is closely related to the predictive power of this measure and underscores the importance of testing laboratory findings in real life studies.

ACKNOWLEDGEMENTS

The study has been supported by grants from the John D. and Catherine T. MacArthur Foundation Network on Health and Behavior, the Swedish Work Environment Fund, and the Swedish Medical Research Council.

REFERENCES

1. Forsman, L.; Lundberg, U. Consistency in catecholamine and cortisol excretion in males and females. Pharmacol. Biochem. Behav. 17:555–562; 1982.
2. Frankenhaeuser, M. Psychoneuroendocrine approaches to the study of emotion as related to stress and coping. In: Howe, H. E.; Dienstbier, R. A., eds. Nebraska symposium on motivation. Lincoln: University of Nebraska Press; 1979:123–161.
3. Frankenhaeuser, M. The sympathetic-adrenal and pituitary-adrenal response to challenge: comparison between the sexes. In: Dembroski, T. M.; Schmidt, T. H.; Blümchen, G., eds. Biobehavioral bases of coronary heart disease. New York: Karger; 1983:91–105.
4. Frankenhaeuser, M.; Dunne, E.; Lundberg, U. Sex differences in sympathetic adrenal medullary reactions induced by different stressors. Psychopharmacology (Berlin) 47:1–5; 1976.
5. Frankenhaeuser, M.; Lundberg, U. The influence of cognitive set on performance and arousal under different noise loads. Motiv. Emotion 1:139–149; 1977.
6. Frankenhaeuser, M.; Lundberg, U.; Fredrikson, M.; Melin, B.; Tuomisto, M.; Myrsten, A-L.; Hedman, M.; Bergman-Losman, B.; Wallin, L. Stress on and off the job as related to sex and occupational status in white-collar workers. J. Organ. Behav. 10:321–346; 1989.
7. Fredrikson, M.; Blumenthal, J. A.; Evans, D.; Sherwood, A.; Light, K. C. Cardiovascular responses in the laboratory and in the natural environment: Is blood pressure reactivity to laboratory-induced mental stress related to blood pressure during everyday life? J. Psychosom. Res. 33:753–762; 1989.
8. Harshfield, G. A.; James, G. D.; Schlussel, Y.; Yee, L. S.; Blank, S. G.; Pickering, T. G. Do laboratory tests of blood pressure reactivity predict blood pressure changes during everyday life? Am. J. Hypertens. 1:168–174; 1988.
9. Johansson, G.; Post, B. Catecholamine output of males and females over a one-year period. Acta Physiol. Scand. 92:557–565; 1974.
10. Krantz, D. S.; Manuck, S. B. Acute psychophysiologic reactivity and risk of cardiovascular disease: A review and methodologic critique. Psychol. Bull. 96:435–464; 1984.
11. Lundberg, U.; Forsman, L. Consistency in catecholamine and cortisol excretion patterns over experimental conditions. Pharmacol. Biochem. Behav. 12:449–452; 1980.
12. Lundberg, U.; Hanson, U.; Andersson, K.; Eneroth, P.; Frankenhaeuser, M.; Hagenfeldt, K. Hirsute women with elevated androgen levels: psychological characteristics, steroid hormones and catecholamines. J. Psychosom. Obstet. Gynaecol. 2:86–93; 1983.
13. Lundberg, U.; Hedman, M.; Melin, B.; Frankenhaeuser, M. Type A behavior in healthy males and females as related to physiological reactivity and blood lipids. Psychosom. Med. 51:113–122; 1989.
14. Lundberg, U.; Holmberg, L.; Frankenhaeuser, M. Urinary catecholamines: comparison between HPLC with electrochemical detection and fluorophotometric assay. Pharmacol. Biochem. Behav. 31:287–289; 1988.
15. Pickering, T. G.; Gerin, W. Ambulatory blood pressure monitoring and cardiovascular reactivity testing for the evaluation of the role of psychosocial factors and prognosis in hypertensive patients. Am. Heart J. 116:665–672; 1988.
16. Taylor, J.; Weyers, P.; Harris, N.; Vogel, W. H. The plasma catecholamine stress response is characteristic for a given animal over a one-year period. Physiol. Behav. 46:853–856; 1989.
17. Van Egeren, L. F.; Sparrow, A. W. Laboratory stress testing to assess real-life cardiovascular reactivity. Psychosom. Med. 51:1–9; 1989.
18. Ward, M.; Mefford, I. N.; Parker, S. D.; Chesney, M. A.; Taylor, C. B.; Keegan, D. L.; Barchas, J. D. Epinephrine and norepinephrine responses in continuously collected human plasma to a series of stressors. Psychosom. Med. 45:471–486; 1983.