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Repeatability of Blood Pressure and Heart Rate Responses to Standard Autonomic Reflex Test over A Five Day Period

Shyam Sundar day,Sujata Biswas*
Department of Physiology, College of Medicine and JNM hospital, Kalyani, India;
Corresponding author: Shyam Sundar day

Abstract: *The repeatability of the cardiovascular responses to reflex tests has been the subject of several studies. We have studied heart rate and blood pressure response to mental arithmetic. Mental arithmetic has used as means of assessing cardiovascular autonomic reactivity to mental load. Ten healthy subjects were recruited for the mental arithmetic task. Same task was repeated by the same individuals for 5 successive days. Reliability or reproducibility of the mental task responses was measured using the intraclass correlation coefficient. We observed a significant declining trend in heart rate response to mental arithmetic task. It shows that the individuals become more and more familiar with a particular task if it is carried out repeatedly.*

Keywords*: Repeatability of HR and BP, Familiar stressors, unfamiliar stressors, autonomic reflex test, mental arithmetic task.*

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I. Introduction

Hans Selye's theory of the stress response which includes an alarm phase, resistance phase and phase of exhaustion has been widely researched and debated (Pacak et al). In contemporary physiology, stress is defined as any stimulus that is associated with an increase in plasma levels of ACTH (Ganong WF). However, an increase in blood pressure and / or heart rate is used as an index of sympathoadrenomedullary axis activation (Ganong WF). Cardiovascular responses to different models of laboratory stressors including cold stress, immobilization, hypoglycemia, hemorrhage etc have been widely studied in laboratory animals (Pacak et al). It has been noted that familiar stress is associated with a predominantly noradrenergic response and unfamiliar stress (a stressful situation in which the individual does not know what to expect) with an adrenergic response (Ganong WF). Blood pressure (BP) and heart rate (HR) responses to mental arithmetic have been used as a means of assessing cardiovascular autonomic reactivity to mental load (Locatelli)Arithmetic changes in responses over time has been suggested to be appropriate for cardiovascular reactivity assessment (Llabre M et al, 1991)Repeatability means if the person can repeat the measurement in the future what he or she did in the past . Reproducibility means if a second person can reproduce the measurement made by first person. In a metaanalysis of studies on reproducibility of BP and HR reactivity to laboratory stressors, Swain and Suls (1996) have noted that reproducibility is related to test-retest interval. The reproducibility is higher with shorter test-retest intervals and much lesser with longer test-retest intervals. In fact, they note that changes in HR had the greatest reproducibility followed by systolic blood pressure and diastolic blood pressure. This study was designed to examine whether the HR response and the pressor response to a stressor was reproducible over a 5 day period in young healthy subjects. The broader purpose of this investigation is implications for the usage of these parameters for monitoring cardiovascular reactivity in studies evaluating effects of short-term interventions on BP and HR responses to this test.

Methods: 10 motivated healthy adult male and female subjects, aged 25± 3.2 years (mean ± SD) were recruited for this study. They were all made to sit comfortably on a chair with their back supported for more than 5 minutes before taking basal BP, HR and performing the task. The test was carried out in department of physiology between 8 a.m. and 12:30 p.m , after 1-2 hrs of light breakfast. After taking the basal HR and BP the subject was asked to do mental arithmetic for 2 minutes (serial subtraction of 7 from 1000). The same mental arithmetic was used for same subjects for 5 successive days and also for others. Changes in BP and HR responses to mental arithmetic have been used as a means of assessing cardiovascular autonomic reactivity response to mental load.

Statistical analysis: Since repeated measurements were made on the same subjects, a repeated measures one-way analysis of variance (ANOVA) was used to determine if there was a significant difference among column means; i.e. whether time per se had any effect on the BP and HR responses to the various stressors. In each case,

the P value was insignificant which meant that time had no significant effect on the mean values of the parameters measured. Reliability or reproducibility of the responses was measured using the intraclass correlation coefficient (Kirkwood and Sterne). Reliability was defined as the ratio of the variance of the true underlying values between individuals to the total variance of the observed values which is a combination of variation between individuals and measurement error (or variation in measurement between individuals due to true changes in responses).

Results: The baseline characteristics of subjects are presented in table 1.Within-group and within individual mean and SD of the pressor and heart rate responses to mental arithmetic task from day 1 to 5 is presented in Tables-2 and the ICCs for BP and HR responses are mentioned in the same tables. The reproducibility of BP and HR responses to mental arithmetic task is presented in Table 3. It can be seen from Table 3 that the P value for effective matching was < 0.05 in almost all instances (column 10).The ICC, which is an index of reproducibility or repeatability of the pressor and HR responses was > 0.9 in most instances; i.e., reproducible. On the other hand, there was a significant linear trend or nonlinear trend in some of the responses (see below) and the ICC was much lesser in these instances (< 0.9)

Response to mental arithmetic: There is a treatment effect in the HR response to mental arithmetic with a significant trend toward lower HR responses from day 1 through day 5 ($P = 0.002$).

II. Results

Table 1: Reproducibility of subjects' (n= 10) baseline blood pressure and heart rate

Parameter	Day	Column mean ± SD	Intraclass correlation coefficient
SP	1	111 ± 10	0.98
	2	110 ± 11	
	3	108 ± 14	
	4	106 ± 13	
	5	108 ± 14	
DP	1	62 ± 6	0.98
	2	61 ± 7	
	3	61 ± 7	
	4	60 ± 6	
	5	63 ± 9	
HR	1	79 ± 13	0.99
	2	77 ± 13	
	3	76 ± 12	
	4	77 ± 11	
	5	77 ± 11	

SP: systolic pressure; DP: diastolic pressure; HR: heart rate

Table 2 Reproducibility of subjects' (n= 10) systolic pressure (SP), diastolic pressure (DP) and HR response to mental arithmetic

Parameter	Day	Column mean ± SD	Intraclass correlation coefficient
SP response	1	13 ± 8	0.88
	2	13 ± 6	
	3	12 ± 5	
	4	12 ± 4	
	5	8 ± 3	
DP response	1	11 ± 9	0.91
	2	11 ± 5	
	3	8 ± 4	
	4	9 ± 6	
	5	6 ± 9	
HR response	1	8 ± 3	0.76
	2	7 ± 9	
	3	0 ± 5	
	4	2 ± 5	
	5	3 ± 4	

Table 3: Reproducibility of blood pressure (BP) and heart rate (HR) responses to mental task. The significant P values are shown in bold-face type

1	2	3	4	5	6	7	8	9	10
Stressor	Response variable	F statistic	P value	Slope of linear trend	r squared; linear trend	P value; linear trend	P value; non-linear trend	Intraclass correlation coefficient	P value for effective matching
Response to mental arithmetic	SP	1.72	0.17	-1.19	0.097	0.03	0.70	0.88	0.18
	DP	1.67	0.18	-1.29	0.07	0.02	0.79	0.91	0.001
	HR	4.64	0.004	-1.6	0.14	0.002	0.07	0.76	0.03

Result:

The baseline heart rate and blood pressure of all the subjects are presented in table 1. The within group and within individual mean and SD of the blood pressure and heart rate responses to mental arithmetic from day 1 to 5 is presented in table 2. The repeatability of BP and HR responses of mental arithmetic is presented in table 3. Response to mental arithmetic shows a treatment effect in the HR response with a significant trend toward lower HR responses from day 1 through day 5 (P = 0.002).

III. Discussion

The purpose of the study was to determine the effect of repeated exposure (five days) to the same stressor on HR and BP responses. It is the change in BP and HR to mental arithmetic task that is being analyzed for its repeatability. We had chosen mental arithmetic task as a stressor which is a psychological stressor. The psychological tasks are motivationally relevant in the sense that they test physiological mechanisms linked to appraisal of stress, motivation, central autonomic mechanisms from cortex to medulla. The mental arithmetic test was much more standard as all the subjects did the same arithmetic all the time. Since subjects were encouraged not to make mistakes, the measured responses would reflect the effect of motivation on central neural pathways as well as peripheral mechanisms mediating HR and BP changes .We observed a significant declining trend in the HR response to mental arithmetic (P=0.002). The fact that there is a decline in the magnitude of the HR response to repeated exposure to the same standard simple mental arithmetic over a 5 days period. It is may be due to the fact that the individual becomes more and more familiar with it as it is carried out repeatedly.

IV. Conclusion

After the study it is worth speculating on the significant of an adrenergic versus nor adrenergic response to a stressor. An adrenergic response which is characterized by an increase in the release of adrenalin, has been shown to occur in situations in which the individual does not know what to expect. In this instance, the sympathetic system activates adrenal medulla. It is likely that the slightly longer half life of adrenaline, its ability to produce vasodilatation in liver and raise blood glucose, and its vasodilator effects in skeletal muscle might prepare the stressed individual better for the fight or flight reaction. Therefore we can conclude that a decline in HR response to simple mental arithmetic possibly because of increase familiarity.

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