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Comparison of the effect of Physical stressor and Mental stressor in evaluation of the effect of progressive muscle relaxation on the cardiovascular autonomic functions in offsprings of hypertensives

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Abstract

Background and Objective: Progressive muscle relaxation is one of the techniques found to be effective in reducing the hyperacivity of the sympathetic nervous system in susceptible individuals. Many studies have used physical and mental stressors to evaluate the effect of relaxation techniques leading to different results. Hence the present study compared the effect of two laboratory stressors in the evaluation of effect of relaxation techniques.

Materials and Methods: The study involved normotensive offspring of hypertensives who were participants of relaxation training programme at Bengaluru. They were divided into group A and group B with 20 subjects in each group by randomization. There were two recording sessions for each subject in each group. During the first recording session HR, HRV and BP responses to mental stress (serial subtraction math) were measured in all the subjects in group A, whereas in group B, HR, HRV and BP responses to physical stress (isometric handgrip test) were measured. Then both the groups underwent twelve weeks of relaxation training under the guidance of experts. At the end of twelve weeks, second recording session was held and the same parameters were reassessed in all the subjects with respective stressors.

Results: In group A, relaxation training has caused significant decline in heart rate reactivity, reactivity values of total power, LF power, reactivity as well as recovery of diastolic pressure. No significant change was seen in LFnu, HF, HFnu, LF/HF and systolic blood pressure. In group B, no significant change was observed in any of the measured parameters.

Conclusion: Hence the study concludes that mental stressor is the suitable tool for assessing the effect of relaxation techniques on the cardiovascular autonomic activity.

Keywords: Mental stressor, Physical stressor, Progressive muscle relaxation, Heart rate, Heart rate variability, Blood pressure, Reactivity, Recovery

Introduction

Rapid industrialization, environmental pollution, changing living conditions and unfavorable working environment are considered to be the important sources of psychological stress in the present day life. The ill effects of the chronic stress on the physiological systems are well known. As a result, the stress invariably affects the productivity of the individual in terms of both personal as well as professional development. The relaxation techniques are considered as effective means to counteract the effects of stress. The practice of progressive muscle relaxation technique has been found to alter sympathovagal balance towards parasympathetic activity. The study of effect of progressive muscle relaxation requires induction of stress on autonomic nervous system. Several studies[1] have used physical stressor as a method to induce stress and others have used mental stressor. This has lead to difference of opinion in the interpretation of effect of relaxation techniques. Hence, the present study compares the effect of physical stressor and mental stressor as tool for the assessment of effect of relaxation techniques on the cardiovascular system.

Materials and Methods

Data were collected from participants of a premiere relaxation training centre, situated in Bengaluru. The questionnaire was set on the basis of inclusion and exclusion criteria and is as follows,

Inclusion criteria:

- Healthy male subjects, in the age group of 18 to 30 years, who are offsprings of hypertensive subjects.
- Systolic blood pressure <140mmHg and diastolic blood pressure <90mmHg.

Exclusion criteria:

- Individuals who had practiced yoga/ meditation earlier.
- Chronic nicotine or alcohol use.
- Individuals who are on chronic medication that affects heart rate or blood pressure.
- Individuals suffering from diabetes mellitus, obesity and other chronic systemic diseases.
- Highly trained athletes.

The subjects were selected based on the above said criteria. The subjects were randomly allocated into two groups – Group A and Group B after being matched for age and BMI. Purpose and the nature of the proposed study were explained to the subjects and written consent was obtained from each of them. Detailed medical and personal history was taken. Thorough physical examination was conducted. Parental history of hypertension was confirmed by verification of the prescription from the physician. Ethical clearance was obtained from the ethical committee of the institution.

Experimental Protocol: The tests were carried out in the training centre between 5.00 pm and 7.00 pm. The laboratory environment was calm. The subjects were clearly instructed not to have coffee, tea or heavy food from 2 hours before test. The subjects were made to sit in the lab relaxed for 10 min to get accustomed to the new environment. The standards of task force of European Society of Cardiology were followed during the recording procedure[2]. Then the tests were carried out as follows,

1. **Baseline BP, HR and HRV for both groups:** The ECG was recorded at rest in the sitting position along with quiet respiratory movements for each subject for the period of 5 minutes using RMS polyrite D hardware 2.5 equipment. The blood pressure was measured at the end of 5 minutes using mercury sphygmomanometer.
2. BP, HR and HRV responses during mental arithmetic for group A and during isometric handgrip test for Group B.

After 5 minutes of baseline recording, the serial subtraction mental arithmetic task was applied to the subjects in the Group A for the next 5 minutes, while the ECG was recorded continuously. The mental serial subtraction task has been shown to cause sharp increases in cardiovascular parameters[3]. The current study used a serial subtraction task adopted from Cacioppo et al[4]. No consideration was given to participant's math ability. Participants were instructed to respond in pace with a metronome set at 40 beats per minute. When participants did not respond in the allotted time, they were told to keep pace with the metronome. When an incorrect response was given, participants were told wrong and were given their last correct number and to continue subtracting from the correct number. The blood pressure was recorded at the end of 5 minutes. For Group B, isometric handgrip test was applied. The subjects were asked to maintain 30% of T_{max} for 5 minutes while the ECG was recorded continuously[5]. The blood pressure was recorded at the end of 5 minutes

3. **BP, HR and HRV responses during recovery from mental arithmetic task and isometric handgrip test:** After 5 minutes of task, the subjects in the both groups were told that the task was over and to relax. The ECG was recorded continuously for another 5 minutes and the blood pressure was recorded at the end of 5 minutes for both groups.
4. After the initial recording session, the subjects in both group A and group B attended relaxation training programme. The programme consisted of oriental classes explaining the scientific basis and benefits of practicing relaxation techniques, followed by training sessions for the period of twelve weeks. During the training period, the subjects were taught progressive muscular relaxation by the experts in training centre, for the period of 30 minutes per day, 5 days in a week for twelve weeks. They were asked to impart these practices in their daily activities since the goal of relaxation technique is to diminish the distinction between formal relaxation practice and everyday life.
5. After the period of twelve weeks, both group A and group B underwent final recording session. The procedures were same as that of initial recording session consisting of baseline recording of BP, HR, and HRV at rest in the sitting position, recording during the task and during recovery from the task.

Frequency domain analysis of RR interval was done by HRV analysis V 1.1 software (biomedical signal analysis group, Finland) and the data were expressed as mean ± SD. Students paired 't' test and repeated measures analysis of variance were used to compare the means before and after relaxation training. Chi square test and Fischer's exact test were used to analyze parameters on categorical scale. For all comparisons, $P<0.05$ was considered statistically significant[6].

Results

There was no statistically significant difference between age (p=0.852) and BMI (p=0.929) of the subjects in both group A and group B. The laboratory mental stressor significantly (p<0.001) altered all the parameters from their baseline values in group A. Similarly, isometric handgrip also significantly (p<0.001) altered all the parameters from their baseline values.

Following twelve weeks of relaxation training, the following changes were noted in the group A.

a. The heart rate response during mental stress decreased significantly (p<0.001).
b. Total Power during mental stress decreased significantly (p=0.003).
c. Low Frequency power is decreased significantly (p=0.043).
d. The baseline systolic blood pressure is not significantly reduced after relaxation training while the reactivity and recovery values decreased significantly (p=0.001 and 0.005 respectively).
e. The reactivity and recovery values of diastolic pressure also decreased significantly (p=0.001) following relaxation training.

No significant difference was noted in any of the parameters in the Group B.

Parameter		Group A		Group B		Stressor effect		Training effect	
		Pre	Post	Pre	Post	Group A	Group B	Group A	Group B
Mean HR (beats /min)	A	75.1±3.5	74.3±3.3	72.4±4.1	71.8±4.2	<0.001	<0.001	0.213	0.519
	B	82.4±3.9	76.4±3	79.4±4.9	79.1±4.5			<0.001	0.652
	C	76.30±5	74.1±3.2	71.9±4.3	70.6±4.1			0.187	0.465
TP (ms^2)	A	904.7±289.1	886.3±191.4	934.7±240.9	892.1±199.3	<0.001	<0.001	0.365	0.719
	B	1652.5±494.3	1306.5±333.7	1558.4±440.2	1497.8±408.7			0.003	0.502
	C	941.9±218.2	779.7±225.5	895.6±261.8	830.5±242.3			0.204	0.668
HF (ms^2)	A	177.6±54.9	131.3±33.8	171.4±51.7	160.7±45.5	<0.001	<0.001	0.584	0.668
	B	216.4±73.4	167.6±41.8	221.3±69.7	236.1±69.9			0.909	0.559
	C	178.9±77.6	124.9±34.9	168.3±66.1	158.1±51			0.697	0.781
LF (ms^2)	A	492.5±153.7	512.6±149	499.1±151.5	456.4±170.6	<0.001	<0.001	0.273	0.423
	B	945.6±398.8	802.2±262.2	863.1±365.7	915.5±255.8			0.043	0.281
	C	479±193.6	417.3±107.7	463.8±156.7	426.5±145.4			0.241	0.488
HFnu	A	28.3±9.8	20.9±4.4	26.7±8.8	25.5±7.5	<0.001	<0.001	0.146	0.571
	B	19.1±5	17.9±4.2	21.8±5.8	19.5±6.1			0.223	0.734
	C	28.3±7	23.3±5.8	27.4±6.5	24.4±5.8			0.506	0.788
LFnu	A	71.7±9.8	79.1±4.4	72.6±8.7	75.5±6.6	<0.001	<0.001	0.146	0.571
	B	80.9±5	82.1±4.2	79.7±6.1	79.5±5.5			0.223	0.734
	C	71.7±7	76.7±5.8	73.0±6.4	74.6±6.8			0.506	0.788
LF/HF	A	2.9±1.2	4±1	3.0±1.4	3.4±1.7	<0.001	<0.001	0.341	0.666
	B	4.7±1.9	4.8±1.1	4.2±1.5	4.4±1.6			0.172	0.438
	C	2.7±0.8	3.5±1	3.1±1.1	3.3±1			0.531	0.803
SBP (mmHg)	A	115.1±6.9	113.2±4.7	117.5±6.1	115.4±5.8	<0.001	<0.001	0.565	0.592
	B	121.2±7.7	116.4±4.6	121.6±7.7	120±5.9			0.001	0.461
	C	120.5±7.7	115.5±5.1	118.6±6.7	119.9±5.4			0.005	0.560
DBP (mmHg)	A	76.2±5.3	74.4±3.8	77.7±5.3	74.8±5.9	<0.001	<0.001	0.267	0.726
	B	79.9±5.6	75.9±4.5	80.8±3.1	79.2±5.1			<0.001	0.522
	C	80.2±5.3	75.4±4.5	79.1±6.3	78.1±5.7			<0.001	0.399

Significance was reckoned as:
$0.05<P<0.10$ - Suggestive of significance;
$0.01<P\leq0.05$ - Moderately significant;
$P\leq0.01$- Strongly significant.

HR – heart rate
TP – total power
HF – high frequency power
HFnu – high frequency power normalized units
LF nu – low frequency power normalized units
SBP – systolic blood pressure
DBP – diastolic blood pressure
A – baseline values
B – reactivity to mental stressor
C – recovery from mental stressor

Discussion

The laboratory mental stressor was used to produce the excitatory cardiovascular responses in group A. Serial subtraction mental arithmetic was used in the present study to induce mental stress in group A. The isometric handgrip test was used to produce the excitatory cardiovascular responses in group B.

The mean heart rate is significantly increased during mental stress as well as physical stress. This is attributed to increased sympathetic drive coupled with parasympathetic withdrawal that occur during stress. Total power is increased significantly during stress in both groups. Similar observation was made by Lucini et al[7]. Total power is indicative of overall HRV. High HRV is a sign of good adaptation to the stressor. High variability in offsprings of hypertensives show that they adapt to the given stress by bringing about necessary modulation in the autonomic nervous system. Autonomic modulation of cardiovascular system in normotensive members with hypertensive family members and that of hypertensives is a continuum. Studies have shown that the hypertensives have low TP in response to stress. The transition occurs over a period of time, from high HRV to low HRV that is, from high to low autonomic modulation favouring the hypertensive state.

LF power increased significantly during stress in both groups. But Sloan RP et al found decrease in LF power during laboratory mental stressor[8]. According to Piccirillo et al, though LF cannot be fully attributed to sympathetic modulation at SA node, its increase is a sufficiently reliable index of increased sympathetic activity[8]. Changes in LF power in the present study agree with Piccirillo et al[9]. LFnu, the parameter which indicates the relative change in LF with respect to HF, is also increased during mental stress showing increased sympathetic activity. This is in agreement with Lucini et al, where they also found increase in

LFnu during stress. HF power indicates vagal modulation at SA node. Normally the respiratory variations in cardiac vagal discharge are accounted for the power in the high frequency spectrum. Hence it was ensured that the respiratory rate does not fall below 9/min so that LF component of the frequency spectrum is not affected by respiration. In the present study, HF is increased during mental stress. LevyMN studied peripheral interactions of sympathetic and parasympathetic systems in the heart and also found that the sympathetic nerve activity could excite parasympathetic fibres thus increasing the vagal activity. He termed this as reciprocal excitation[10]. This could explain increase in HF during stress, observed in the present study. HFnu is decreased during stress in both groups. Similar observation was made by Lucini et al. It means that the parasympathetic activity is relatively lesser than the sympathetic activity during mental stress. Though HF is increased during mental stress, HFnu is decreased indicating the dominant sympathetic activity during the stressful situation. LF/HF is increased during stress in both groups. Lucini et al also made similar observation. LF/HF is an indicator of sympathovagal balance. Increase in the ratio during stress shows that the balance is shifted towards sympathetic activity.

Systolic and diastolic blood pressure increased significantly during stress in both groups. Widgren BR et al speculated that such increased systolic and diastolic blood pressure responses to stress seen in offsprings of hypertensives could be related to subsequent development of high blood pressure in future[11].

Following relaxation training for about 12 weeks, the group A showed significant changes in several parameters (heart rate, total power, low frequency power, systolic and diastolic blood pressures) whereas group B did not show any significant changes in any of the parameters. The mental stressor used in group A causes variations in autonomic profile initiated primarily by a change in the central command. The stressor activates the HPA axis which leads to behavioural and peripheral changes that improve the ability of the organism to adjust homeostasis. This response is highly influenced by the perception of the stimulus by the subject, in this study, is altered by the relaxation training. Whereas, in case of isometric handgrip test, the cardiovascular responses are mediated mainly by metabolic and mechanical changes in response to contraction of the muscle and partly by influence of cardiovascular centres. Hence the response is less influenced by the perception of the stimulus by the subject. The study concludes that mental stressor is considered as more appropriate laboratory stressor than physical stressor, in the evaluation of cardiovascular autonomic responses to the relaxation training.

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