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Original Research Article

Comparative Analysis of Cardiac Autonomic Modulation during Cold Pressor Test and Acute Exercise in Healthy Students

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ABSTRACT

Background: Heart rate variability (HRV) analysis is a technique employed to explore the activity of autonomic nervous system. The aim of the present study was to compare and evaluate the analysis of cardiac autonomic modulation during cold pressor test and acute exercise in healthy subjects.
Methods: The subjects consisted of 50 healthy students within the age group 17-20 years.
The electrocardiogram recording was taken during the exposure of cold pressor test and acute exercise.
Results: HRV analysis showed the significant increase ($P < 0.05$) in the Low frequency component (LF) during CPT when compared to acute exercise. A non-significant decrease in the high frequency component (HF) was observed during CPT when compared to acute exercise
Conclusion: The findings in healthy subjects suggest that in the clinical setting increase in cardiac sympathetic activity is more during Cold pressor test when compared to acute exercise.
Key words: HRV, Actue exercise, Cold pressor test, Low frequency component, High frequency component

INTRODUCTION

The autonomic nervous system coordinates a person's responsiveness to physiological and environmental stressors. Heart rate variability provides an index of autonomic balance [1] and can be used to monitor the autonomic activity during exposures to different environmental conditions. [2,3] The reliability of HRV measures is important. Repeated heart rate variability (HRV) measures are performed in clinical settings to predict mortality of patients [4] and the general population. [5] Autonomic Nervous System (ANS) state at different stages of any procedure would result in improved monitoring and safety for patients undergoing diagnostic or therapeutic interventions. The effectiveness of any technique that maybe used to detect differences within or between individuals on separate occasions is dependent upon its reliability. Numerous studies have investigated HRV in both healthy and diseased human populations [5,6] but there is a paucity of data on the reliability of HRV measurement. [6] Previous studies show that the measures of HRV taken during rest may be more reliable than those made during

interventions such as tilt or cold pressor testing. [7] HRV measurements, although reproducible, have large differences between and with-in subjects. The peripheral vascular vasomotion is generated and modulated by the sympathetic nervous activity. [8] Studies have demonstrated that lowering the temperature induces peripheral vasoconstriction and decreases vasomotion; these responses are reversed if the temperature is raised. [9]

The Cold Pressor test (CPT) is capable of inducing a reproducible sympathetic activation by way of nociceptive and temperature receptors10. The normal response to exposure of a limb to cold water involves reflex arteriolar vasoconstriction producing an increase in blood pressure and cardiac output triggered by cutaneous pain receptors. Increased blood pressure is a response to enhanced sympathetic activity expressed as an increase in vascular resistance. The initial increase in heart rate is blunted by beta adrenoreceptor blockers suggesting that sympathetic rather than parasympathetic outflow mediates this response. [10]

Physical activity is associated with haemodynamic changes and alters the loading conditions of the heart. [11] Cardiovascular responses to physical activity depend on the type and intensity of exercise. [12] The mechanism of the exercise induced tachycardia appears to involve parasympathetic and spinal sympathetic reflex circuits (Brainbridge reflex). The latter mechanism is important to mention, since stimulation of cardio vascular sympathetic afferent fibres produce cardio vascular reflexes that operate through a positive feedback mechanism and thus may be particularly responsible for the increased sympatho-adrenal activity of exercise. [11, 12] Thus, both the sympathetic and parasympathetic arms of the ANS play a pivotal role during exercise.

Power spectral analysis of heart rate variability (HRV) has been used as a sensitive index of autonomic nervous activities. [12-14] In humans, power spectral analysis of R-R interval variability has revealed that there are two major spectral components: the high frequency (HF) component at the respiratory frequency and the low frequency (LF) component at 0.03 to 0.15 Hz. The HF component corresponds to the respiratory sinus arrhythmia and is modulated solely by the parasympathetic nervous system, [15-17] whereas the LF component corresponds to blood pressure oscillations occurring around .1 Hz, (i.e., the Mayer waves) and is jointly modulated by the sympathetic and parasympathetic nervous systems. [18,19] In addition, the LF/HF ratio is also a useful parameter that reflects the balance of autonomic nervous activities. [20,21] The present study aimed in evaluating the effect of cold pressor test and acute exercise as a better predictor of sympathetic activity in assessing cardiac autonomic modulation.

MATERIALS AND METHODS

A total of 50 students studying their MBBS Course in Kasturba Medical College Bejai, Mangalore were selected . The selected students were in the age group 17-20 years. After detailed enquiry of the medical history of the subjects, those with history of smoking, alcoholism, medical illness were excluded. Informed written consent was obtained from all participants, and the experiment protocol was approved by Ethics committee of the college. The experiments were carried out in the morning in fasting state. Subjects refrained from caffeinated beverages for at least 12 hours prior to the experiments and had completed their evening meal by 9 P.M. they were also instructed to avoid strenuous physical activity from the previous evening.

ECG RECORDING: [22] The recordings of ECG of all subjects were done by the same person of our team in order to avoid any inter–observer error. To quantify heart rate, the analog ECG signal was obtained using lead II to obtain a QRS complex of sufficient amplitude and stable base line. ECG signals were conveyed through an A/D converter to PC and were analyzed offline after visual checking of abnormal ECG. Heart rate variation during normal breathing for a period of 5 minutes was recorded, with subject supine, awake and resting. In the present study one of the variables of the time domain analysis SDNN (standard deviation of all the N-N intervals) and the two main frequency components that are the low frequency (LF) components (0.04 to 0.15Hz) and the high frequency (HF) components (0.15 to 0.4 Hz) was measured.

COLD PRESSOR TEST: Before each test, the subjects, rested 20 min to ensure hemodynamic stabilization. The procedure consisted of ECG data collection for 5 minutes in the upright posture followed by 1 minute with one hand submerged into the cold water at 0–1°C followed by removal of the hand from the bath and continuation of recording for another 5 min. [10]

ACUTE EXERCISE: The subjects are asked to jog on a treadmill for 5 minutes at a speed of 6km per hour, then immediately HRV was recorded for 1 min and continued for every 5min consecutively 3 times.

Statistical analysis: The statistical analysis was done using ANOVA (Analysis of variance), student's unpaired t test, Mannwhitney U test, Tukey's Test. P value was taken as significant at 5 percent confidence level. ($p < 0.05$)

RESULTS

Results showed LF during CPT was significantly increased ($P < 0.05$) than LF during exercise but which is not significant. A non-significant decrease in the HF was observed in, the HF during CPT when compared to acute exercise

Table 1:- Comparison of LF and HF Power during CPT (cold pressor test) and immediately after acute exercise

HRV	CPT	EXERCISE
LF POWER	50.52±25.15	41.29±20.03*
HF POWER	1084.2±853.9	1176±839.6

P value<0.05; CPT compared to exercise

DISCUSSION

Cardiac autonomic functions can be influenced by multiple factors. The LF power reflects modulation of sympathetic tone with contribution from the parasympathetic tone (PS), while HF power reflects the modulation of parasympathetic tone alone. In certain pathophysiological conditions such as the fight or flight, the SNS and PNS can be separately activated, [23] however. For example, in response to stress, SNS is preferentially activated to mobilize the source of energy, while in peaceful conditions; PNS is preferentially activated to conserve the source of energy. In these conditions, the activations of both SNS and PNS may attenuate each other to avoid detrimental effect of the over expression of either one of the nervous activities. [23]

HRV changes during CPTwas associated with a significant increase in the LF component and a no significant decrease in the HF component, which might probably result in a high LF/HF ratio. The present study is in accordance with the previous studies which reflect the predominance of sympathetic activity during cold pressor test. [10, 24,25] Furthermore, in this study the amount of high frequency fluctuation reduces substantially during CPT compared to acute exercise, indicates the parasympathetic activity changes.

CONCLUSION

The findings in healthy subjects suggest that in the clinical setting an increase in cardiac sympathetic reactivity is more during Cold pressor test when compared to acute exercise. Further studies are needed to determine sympathetic nerve responses to the CPT in a large sample size.

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