Original Research Paper

Volume - 11 | Issue - 12 | December - 2021 | PRINT ISSN No. 2249 - 555X | DOI : 10.36106/ijar

Physiology

CHANGES IN ELECTROCARDIOGRAM, HEART RATE VARIABILITY AT REST, DURING EXERCISE AND POST-EXERCISE PERIOD IN HEALTHY ADULTS

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ABSTRACT

Introduction: Physical exercise is associated with parasympathetic withdrawal and increased sympathetic activity resulting rise in the heart rate. The rate of post-exercise cardio deceleration is used as an index of cardiac vagal reactivation. Heart rate variability is a useful non- invasive, powerful tool for quantitative assessment of cardiac autonomic function. Exercise tests bring about changes in the hemodynamics of the cardiovascular system. Hence objective of this study is to evaluate the changes in ECG, HRV indices at rest, during exercise, post-exercise period.

Methodology: 100 healthy male subjects in the age group of 18-30 years were recruited from the general population of Dharmapuri from patients coming for health checkup. Frequency domain measures evaluated LF, HF and LF/HF ratio and time domain measures evaluated are SDNN, RMSSD and PNN 50% to observe the status of sympathetic and parasympathetic nervous system function. The results were be subjected for appropriate statistical analysis.

Results: In ECG, during exercise, the RR interval showed significant decrease and QTc changes were not significant. During exercise, the frequency domain parameters like LF, HF and LF/HF ratio were significantly ($p< 0.001$) reduced; time domain parameters like SDNN and PNN 50% were significantly reduced and RMSSD was significantly increased. Resting HRV parameters showed significantly ($p< 0.05$) lower values of LF, HF and RMSSD; the changes in resting values of LF/HF ratio, LF nu, HF nu and SDNN were not significant; HRV parameters after exercise showed significantly lower values in HF ($p< 0.05$), SDNN and RMSSD ($p< 0.001$); the changes in LF and LF/HF ratio were not significant.

Conclusion: During exercise, as the sympathetic activity begins to raise, further increase in the heart rate and HRV gradually increased, the HF component of HRV was found to be a convincing indicator of parasympathetic activity as it decreased in response to increases in exercise intensity and was attenuated by cholinergic receptor inhibition. We could notice a gradual increase of LF of HRV during post-exercise recovery analogous to HF which is predominantly influenced by changes of parasympathetic activity.

KEYWORDS : Hypertension; Frequency domain measures; Time domain measures; HRV.

INTRODUCTION

During exercise, many circulatory changes occur to supply the tremendous blood flow required by the muscles including the stimulatory effects on the circulation by the mass sympathetic discharge, the increased arterial pressure and cardiac output. These cardiovascular responses could vary between children, adults, and elderly normal people due to the age-related effects on the heart, as well as, on the circulatory system. The most common modes of exercise stress testing include multistage bicycle and treadmill tests, the test graded for exercise intensity. The resting ECG usually precedes the test and provides an important baseline measure to establish that the person can engage safely in the test.[1]

In humans, anticipation of physical activity inhibits the vagal nerve impulses to the heart and increases sympathetic discharge. Increase in heart rate and myocardial contractility is because of the concerted inhibition of parasympathetic areas and activation of sympathetic areas of the medulla on the heart. The tachycardia and enhanced contractility increase cardiac output. As a result, there is an increase in heart rate and blood pressure.[2]

Heart rate variability (HRV) is the amount of heart rate fluctuations around the mean heart rate. It is a valuable tool to investigate sympathetic and parasympathetic function of the Autonomic Nervous System. It is an accurate reliable, reproducible, yet simple to measure and to process.[3] Physical exercise is associated with parasympathetic withdrawal and increased sympathetic activity resulting in increase in heart rate. The rate of post-exercise cardio deceleration is used as an index of cardiac vagal reactivation. Studies have shown that cardio deceleration is independent of HRV measures during the resting period but is related to the early post exercise HRV measurements.

By using time-frequency approaches it is possible to obtain information on autonomic control when HR changes rapidly, also immediately after the cessation of endurance exercise.[4] The principle aim of this study is to evaluate the ability of HRV to quantify within-subject changes in autonomic HR control by using short term physical exercise and study the changes in HRV, electrocardiogram: at rest, during and in the post-exercise period.

MATERIALS AND METHODS

After obtaining clearance from the Institutional Ethics Committee the study was conducted in the Department of Physiology. Normal healthy non-athletic males in the age group 18-30 years were randomly selected from health checkup and included in the study. A pretested structural proforma was used to collect the relevant information and informed consent for the test protocol was obtained from the volunteer subjects of study before the start of the study. Experiments were conducted in the morning. They were instructed to complete their evening meal by 8 pm., refrain from caffeinated beverages 12 hours prior to the experiment and to avoid strenuous physical activity from the previous evening. Subjects were screened and detailed medical history was taken to exclude any disorder, which can interfere in autonomic responses or with a contraindication for exercise as per guidelines laid down by American College of Sports Medicine 2006.

Recordings were standardized and instructions followed as per the guidelines of Task Force of the European Society of Cardiology as HRV, Standards of measurement, Physiological interpretation and Clinical Use. In frequency domain analysis, spectral estimates of RR intervals is done by integrating the power as Total Power (TP) from 0.04 to 0.40 Hz, Low Frequency power (LF) from 0.04 to 0.15 Hz, High Frequency power (HF) from 0.15 to 0.40 Hz. HF reflects parasympathetic nerve activity to the heart, LF mostly reflects sympathetic changes.

The ratio of low frequency to high frequency (LF/ HF) which is a mirror of sympathovagal balance was also studied. In time domain analysis, SDNN, (standard deviation of all normal sinus RR) an index of overall Heart Rate Variability, RMSSD (root-mean-square of the successive normal sinus RR interval) and percentage of differences between adjacent normal RR intervals exceeding 50 milliseconds (pNN50%) were studied.

The data were expressed as Mean ±SD. Independent t test has been used. Analysis of variance and Post-hoc Tukey's test were used to compare the change in parameters at rest, during exercise and after exercise. The p value less than 0.05 was considered as statistical significance. SPSS version 22.0 software was used for analysis of data.

RESULTS

The present study was performed on 100 male subjects. All the subjects were in age group of 18-30 year in department of Physiology, Government Dharmapuri Medical college, Dharmapuri. On analysis of the physical characteristics of the 100 subjects, the mean height in cm is 163 ± 8.9; the mean weight in kg is 60.7 ± 7.5; the mean BMI (kg/m^2) is 22.7 ± 1.64; and the mean BSA (m^2) is 1.65 ± 0.08.

Table 1: Comparison of the ECG parameters at rest, during and after exercise.

	At rest (Mean + SD)	During exercise (Mean + SD)	After exercise (Mean + SD)	p value
RR Interval	791 + 50	451 + 27	656 + 71	< 0.001, HS
QTc	435+ 18	422 + 21	412 + 19	> 0.05, NS

When we did the comparison of the ECG parameters. The RR intervals showed significant decrease during exercise and significant increase after exercise. And the change in the QTc was not significant at rest, during and after exercise.

Table 2: Comparison of HRV parameters at rest and during exercise.

HRV	At rest (Mean + SD)	During exercise (Mean + SD)	p value
LF	1560 + 322	795 + 89	< 0.001
HF	812 + 102	715 + 112	0.05
LF/HF	1.85 + 0.41	0.85 + 0.12	< 0.001
RMSSD	44.52 + 10.89	81 + 13	< 0.001
SDNN	94.32 + 13.62	69 + 13.12	< 0.001
PNN50%	14.65 + 1.71	10.85 + 1.86	< 0.001

Table 2 shows the comparison of HRV parameters at rest and during exercise. The LF, HF, LF/HF ratio, SDNN and PNN50% were significantly reduced during exercise. The RMSSD showed a significant increase during exercise.

Table 3: Comparison of HRV parameters during and after exercise.

HRV	During exercise (Mean + SD)	After exercise (Mean + SD)	p value
LF	795 + 89	871 + 89	< 0.001
HF	715 + 112	823 + 101	> 0.05
LF/HF	0.85 + 0.12	1.11+ 0.21	< 0.001
RMSSD	81 + 13	61 + 10.89	< 0.001
SDNN	69 + 13.12	104 + 12.12	< 0.001
PNN50%	10.85 + 1.86	15.49 + 1.45	< 0.001

Table 3 shows the comparison of HRV parameters during and after exercise. LF, LF/HF ratio, SDNN and PNN50% showed a significant increase, RMSSD showed significant decrease and HF increase was not significant after exercise when compared to during exercise levels.

Table 4: Comparison of HRV parameters at rest and after exercise.

HRV	At rest (Mean + SD)	After exercise (Mean + SD)	p value
LF	1560 + 322	871 + 89	< 0.001
HF	812 + 102	823 + 101	> 0.05
LF/HF	1.85 + 0.41	1.11+ 0.21	< 0.001
RMSSD	44.52 + 10.89	61 + 10.89	< 0.05
SDNN	94.32 + 13.62	104 + 12.12	< 0.001
PNN50%	14.65 + 1.71	15.49 + 1.45	> 0.05

Table 4 shows the comparison of HRV parameters at rest and after exercise. When compared to the resting HRV parameters, after exercise the LF and LF/HF ratio decreased significantly; HF decrease was not significant; RMSSD and SDNN were significantly increased.

DISCUSSION

Exercise stress test is one of the most useful tests available to evaluate cardio- respiratory fitness, by assessment of end organ responses such as blood pressure and heart rate. In this study we evaluate changes in electrocardiograph and the heart rate variability, at rest, during exercise and immediately after exercise Tests were performed on 100 male subjects. All the subjects were in age group of 18-30 years.

On analysis of the physical characteristics of the 100 subjects, the mean height in cm is 163 ± 8.9; the mean weight in kg is 60.7 ± 7.5; the mean BMI (kg/m^2) is 22.7 ± 1.64; and the mean BSA (m^2) is 1.65 ± 0.08.

At rest, Low basal HF power, this might be due to altered sympatho vagal balance with decreased parasympathetic activity at the cardiac level. LF/HF ratio was significantly higher, LF/HF ratio is considered by some to mirror the sympathovagal balance, and the ratio of sympathetic to vagal activity was higher in this group. LF nu was significantly higher which represented the sympathetic activity and the HF nu was significantly lower which represented parasympathetic activity.

Decreased SDNN and RMSSD, which was not statistically significant. SDNN represents the long-term vagal modulation of cardiac functions. Comparatively decreased SDNN indicates diminished baroreflex modulation of RR intervals. Decreased SDNN in addition to the decreased HF would indicate poor vagal control. RMSSD reflects vagal modulation of heart rate, and therefore RMSSD is considered as a significant short-term indicator of parasympathetic drive.[5] Other studies supporting these results are Krishnan et al.[6], Surekharani et al.[7]

In our study, the RR interval showed significant decrease and the QTc decrease was not significant compared to the pre-exercise levels. Heart rate is increased during exercise, as the heart rate increases the RR intervals decreased. Initial rapid increase in the heart rate suggests a central command or a rapid reflex from mechanoreceptors in the active muscles. Later increases in HR from reflex activation of the pulmonary stretch receptors and the reflexes from exercising muscles and are due to increase in the sympathetic tone and vagal withdrawal as well as increase in circulatory catecholamines. Predominant cause for increase in HR is the increased cardiac output.[8]

In our study both LF and HF component of HRV were decreased during exercise. Even the LF/HF ratio was decreased. Similar findings are seen in the study by Sarmiento Samuel et al.[9]This response initially involves parasympathetic withdrawal and augmented sympathetic activity. The explanation for the increased sympathetic activity at the start of exercise is not fully understood at present. Some of the studies like Victor et al.[10], Rotto DM et al.[116] link metabolic acidosis to increased sympathetic activity. The decrease in LF is also seen in studies by Perini R et al.[12], and Cottin F et al.[13]. In one study they show increase in LF values as well as the LF/HF ratio during a ramp test, however it must be noted that they included VLF (0.00–0.004 Hz) values within the LF band.

In our study the time domain parameters like SDNN and PNN 50% were significantly reduced and RMSSD was significantly increased during exercise. In the studies by Javorka M et al.[14]and Kluess HA et al.[15] similar results were found.

After exercise in our study the heart rate recovery in between the two groups showed no significant changes. Similar findings were seen in the studies by Soumya et al.[16] Compared to before exercise, changes in the after-exercise values of time domain parameters like SDNN and RMSSD increased significantly and PNN50% increase was not significant in our study. And also, there was a significant decrease in the LF component of HRV and LF/HF ratio; the changes in HF component were not significant. They were predominantly influenced by the changes of parasympathetic activity. Similar results were seen in the studies by Javorka M et al.[14] and Breuer HW et al.[88]

CONCLUSION

In conclusion, the results of our study HRV changes maybe an early marker of cardiovascular autonomic changes in the normotensive offspring with hypertensive parents showing increased sympathetic and decreased parasympathetic activity, which may lead to the genetic predisposition of hypertension in young individuals with positive parental history of hypertension. Hence further studies can be planned by categorizing based on family history of hypertension.

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