Original Article

Role of exercise in modulating autonomic response to psychological stress

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Objective: To investigate the effect of exercise on improving heart rate variability, which is a parameter to asses' autonomic control?

Methodology: It was a control trial conducted at Islamic International Medical College and CMH Kharian Medical College from May to December 2018. Participants were labelled as stressed and controls on the basis of DASS questionnaire Performa. Study included 40 stressed participants for recording of heart rate variability. Participants were subjected to cycling exercise, five days a week for a period of six consecutive weeks after which heart rate variability was recorded again.

Results: There was significant reduction in $LFms^2$ and LFnu and LF/HF post exercise ($p = 0.004$, 0.001, and 0.001, respectively). HFnu after exercise significantly increased in stressed subjects ($p < 0.001$).

Conclusion: This study suggests that exercise attenuates stress induced changes in autonomic system and relieves stress.

Keywords: Stress, heart rate variability, frequency domain methods, low frequency, moderate exercise.

INTRODUCTION

Stress can be labeled as a state of physiological and/or psychological disparity that results from inconsistency between situational calls and an individual's capacity and/or drive to meet these demands.[1] Too much stress pooled up with psychological factors can be damaging and can disrupt the ability of a person to perform normal tasks. It can cause poor quality of life and low self-esteem.[2]Psychological Stress causes activation of two fundamental responses; "Hypothalamic-Pituitary-Adrenal response (HPA)" and "autonomic response".

Autonomic nervous system (ANS) comprises of the sympathetic and the parasympathetic systems, both acting in balance with each other. Sympathetic nervous system (SNS) is active in conditions of stress and parasympathetic nervous system (PNS) is 'active' in conditions of rest.[3] Sympathetic stimulation increases heart rate and decreases heart rate variability (HRV).[4] ANS along with 'HPA axis' has a main role in physiological responses to stress. ANS stumbles on the side of caution and when an individual is in doubt, prepares for the worst, thus maximizing survival and adaptation response.[5]

HRV is the most imperative quantitative measure of autonomic status of heart.[6] It provides a measure of the interaction between all the physiological factors that modulate normal heart rate.[7] Low HRV is associated with different medical and psychological health problems and psychological stresses.[8] HRV is analyzed by time and frequency domain methods. For short term recording of HRV, the 'frequency domain method' is commonly used because of easy setting and is based on spectral analysis of HRV. Three frequency components are usually identified in spectral band. The first, 'high–frequency' (HF) component of HRV, spans the 0.15–0.4 Hz, and is due to heart rate variation induced by respiration and is predominantly mediated by Vagal outflow. The second is the 'lower – frequency' (LF) component of HRV, ranged as 0.05 – 0.15 Hz, and is postulated as being mediated by sympathetic and parasympathetic system, whereas the third, 'very low frequency' (VLF) component is less than 0.04 Hz. LF and HF are reported in normalized units to avoid Skewness of distribution. LF/HF ratio reflects balance between sympathetic and parasympathetic nervous system.[9]

Exercise training improves HRV in healthy individuals and has a protective effect on the cardiovascular system by reducing heart rate through increased cardiac Vagal tone.[10] The mechanisms by which exercise produces change in ANS are not fully known. Regular exercise improved cognitive performance.[11] Limited data is available on the role of exercise in normalizing the cardiovascular and biochemical changes in psychologically stressed subjects, especially in Pakistan. This study aimed to evaluate the role of exercise in relieving stress induced changes in the body and to establish the beneficial effects of moderate exercise on 'stress instituted waning' of cardiac autonomic modulation.

METHODOLOGY

This study was a randomized control study, conducted in the Physiology labs at CMH Kharian Medical College (CKMC) and Islamic International Medical College Riphah University (IIMC), from May to December 2018 after approval from ethical research committee IIMC and ethical committee at CKMC. Written informed consent was taken from all subjects. A total of 40 participants, from both genders, ranging in age from 24 to 37 years were included in the study. They were labelled as stressed after filling "DASS questionnaire proforma".[12] Only healthy subjects in age of 20-45 years having moderate and severe stress were included in the study. Participants having any chronic illness and mild stress were excluded.

The subjects were asked to report to the lab at morning time between 08:00 to 09:00 hours. Weight was recorded and were made to relax for 5 minutes and their blood pressure was measured. Recording of HRV was undertaken from ten minutes ECG in sitting position using AD Instrument power lab model Yam 4/25T.

Ten minutes ECG was recorded and analysed for HRV according to the standard guidelines, published by 'Task Force of European Society of Cardiology and the North American Society of Pacing Electrophysiology'.[13] HRV was recorded in quiet environment at ambient temperature. ECG of the subjects was recorded in a sitting position by connecting MLA 250 shielded lead wires to Bio AMP cable, plugged in power lab. Data in power lab was analysed using software 'Lab chart 7 Pro'. The frequency domain was accessed using 'Fast Fourier transform' to determine LF and HF and LF/HF ratio, respectively.

Subjects were then subjected to a supervised exercise for a period of five days a week for six consecutive weeks using exercise cycle model HF – 700. Exercise was done at speed of thirteen miles per hour for half an hour period at moderate resistance. After the completion of exercise, they were called again for recording of ECG for subsequent HRV analysis.

Statistical Analysis: The data were used to extract descriptive, multivariate and a univariate analysis through SPSS 21 was used for the analysis of the data. The normality of each quantitative variable was checked separately and tested through Shapiro Wilk's test. All HRV indices were log transformed and normality checked again in order to avoid skewed data. Paired t test was applied to check the effect of exercise on HRV indices. $p < 0.05$ was considered significant

RESULTS

Mean age of the subjects was 35 ± 2 years and BMI was 24.00 ± 2.3 kg/m^2. Descriptive statistics are shown in Table 1. HRV indices before and after exercise showed mean LFms^2 was 677.27 ± 465.97 before exercise which was significantly reduced post exercise (p-0.05) (Table 2).

Table 1: Descriptive characteristics of subjects (n = 40).

Characteristics	Stressed Subjects ± SD
Age years	35 ± 2
Weight (kg)	60.70 ± 13.72
BMI (kg/m^2)	24 .00 ± 2.3
Heart rate /min	79.31 ±8.93
Systolic blood pressure (mmHg)	117 ± 7
Diastolic blood pressure (mmHg)	77 ± 8

Table 2: Heart rate variability parameters in stressed subjects before and after exercise.

Parameters	Before Exercise ± SD	After Exercise ± SD	t value	p value
LFms^2 Ref Value: 1175ms^2	677.27 ± 465.97	415.57 ± 251.08.	3.084	0.004*
HFms^2 Ref Value: 975 ms^2	293.28 ± 178.44	351.23 ± 256.60	0.946	0.350
LFnu Ref Value: 56	62.71 ± 12.60	50.27 ± 17.32	3.832	0.001*
HFnu Ref Value: 29	28.07 ± 11.15	38.12 ± 14.28	-3.469	< 0.001**
LF/HF Ref range: 1.5 – 2.0	3.01 ± 2.55	1.68 ± 1.11	4.566	0.001**

*p value ≤ 0.05 (significant); **p value ≤ 0.001 (highly significant).

Mean LFnu and LF/HF after exercise were 50.27 ± 17.32 and 1.68 ± 1.11, respectively and were significantly lower than the pre-exercise value (p = 0.001). Mean HFnu after exercise was 38.12 ± 14.28 and significantly increased after exercise (p-0.001). No significant difference was found HFms2 after exercise.

DISCUSSION

Exercise and increased physical activity have protective effect on cardiovascular system. Exercise is recommended as a therapeutic intervention for restoring autonomic balance in psychologically stressed subjects. Various research articles have investigated the effect of exercise on cardiac autonomic function and have proven that exercise training results in better functioning of cardiac autonomic pathways. Clinical studies are trying to unleash the ability of exercise to cure symptoms of psychological stress.[14] Both acute and chronic exercise may lead to improved cognitive performance, whereas psychological stress is known to impair cognitive functions.[15,16]

Central autonomic adaptations produced by exercise are still to be explored but it has been proved that autonomic adaptations are due to increase in the Vagal tone.[17] The current study showed that exercise resulted in decrease in LFnu, LF/HF ratio, and LFms in stressed students, after exercise, and decrease in LFnu and LF/HF ratio in stressed faculty post exercise. There was increase HFnu in both the stressed groups after exercise. These results showed that exercise caused significant reduction in sympathetic activity and significant improvement in Vagal activity in stressed faculty and students. A study by May et al showed increase in HF and LF with moderate physical activity in psychologically stressed young adults.[18]

Increase in LF in stressed young adults was contrary to the finding of our study. Pichot et al, reported increase in LF in absolute and normalized units after exercise in elderly men.[19] These findings were contrary to the finding of our study. Increase HF after exercise in the study by Pichot et al, was in accordance with our finding. Pichot also demonstrated a decrease in LF/HF ratio after training, a finding which was not proved in our study. A study by Sloan et al reported increase HF in absolute units.[20]

Sandercock et al, reported increase in HF and LF after 8 weeks of exercise program in subjects with heart disease.[21] No difference was found in LF/HF ratio after exercise, which was contrary to the finding of our study. A study by Uusitalo et al, showed that exercise played a significant role in decreasing LF but had no effect on HF.[22] A study by Okazaki et al showed no change in LFnu and HFnu after six months of exercise. The indices increased to similar levels as the young controls after 12 months of training.[23] Hautalau et al, reported that eight weeks of home based exercise program resulted in improvement in HF.[24]

CONCLUSION

Autonomic imbalance as a result of stress can be predicted by quantifying HRV parameters and results in increase in LF and LF/HF ratio reflecting increase in sympathetic tone and decrease in parasympathetic tone as reflected by decreased HF. This autonomic imbalance can be normalized through moderate exercise which causes parasympathetic enhancement and decreased sympathetic cardiac activity.

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