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Original Article

Physical exercise and cardiac autonomic activity in healthy adult men

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Abstract

Physical inactivity is an important risk factor for cardiovascular mortality and morbidity. Regular exercise is known to improve health and maintain physical fitness. The heart rate response to exercise reflects autonomic control of heart and has shown to predict cardiovascular prognosis. Decreased heart rate variability (HRV) is known as a risk factor for cardiovascular mortality. The objective of this study was to study the effect of exercise on cardiac autonomic activity. Thirty two healthy adult men in the age group of 18-25 years with normal body mass index (BMI) were recruited from different physical fitness centers, who were undergoing regular exercise for past 3 months. Resting ECG was recorded for 5 minutes and analyzed for frequency analysis of HRV. HRV parameters of the subjects were compared with fifty age and BMI matched subjects who were not undergoing any exercise program. Physical activity level of all subjects was assessed by using Global Physical Activity Questionnaire. The exercising (E) subjects were found to have a lesser heart rate (73.27±8.6 vs 74.41±8.59) compared to non-exercising (NE) group, which was not significant. No significant difference was found in frequency domain parameters of HRV between exercising and non-exercising group with LF (47.12±19.17 vs 43.55±16.66), HF (41.03±17.65 vs 46.03±15.89) and LF/HF (1.61±1.16 vs 1.22±0.93) respectively. Physical activity level was significantly different between the two groups (4175±1481.53 vs 1176.4±1103.83, $p<0.001$). This study showed 3 months of exercise did not have any effect on cardiac autonomic activity despite the difference in physical activity.

Introduction

Lifestyle diseases like, obesity, diabetes mellitus, hypertension, hyperlipidemia, coronary artery diseases and cancers are the leading causes of death worldwide. The burden of cardiovascular diseases and diabetes mellitus is very high in developing countries.

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Among the various risk factors, physical inactivity is an important risk factor for cardiovascular diseases and for increased cardiovascular mortality. Worldwide, physical inactivity is estimated to be the primary cause of approximately 21-25% of breast and colon cancers, 27% of diabetes and approximately 30% of ischemic heart disease (1). According to WHO, physical activity includes exercise as well as other activities which involve bodily movements and are done as part of playing, working, active transportation, household chores and recreational activities. Regular physical activity can contribute to an enormous health benefit in the general population (2).

Scientific evidences have demonstrated the beneficial effects of exercise, especially cardio protection. It not only helps to improve but also maintains physical fitness and health (3). Regular endurance or resistance training results in specific changes in the muscular, neurohumoral systems and also in cardiovascular system by autonomic control (4). However, aerobic and strength training exercises are found to have variable effects on autonomic control of heart (5). A study has shown that aerobic conditioning enhances autonomic control of the heart by training induced reduction in the heart rate or heart rate variability (HRV). An increase in high frequency power of HRV was seen after aerobic conditioning but not strength training (5). But controversial results are also seen where few studies did not show any beneficial effect of training or, no difference between those were trained in, comparison with the sedentary participants in heart rate (6, 7, 8) or HRV (9, 10, 11, 12). Gender also has shown to play a significant role in exercise related cardio protection (5).

Many studies are done, where measures of HRV have been compared between well-trained young athletes, in middle-aged sedentary subjects and persons having cardiovascular diseases. This study was undertaken to evaluate the effect of physical exercise on cardiac autonomic activity in healthy adult men along with their daily physical activity level.

Methodology

Healthy young men (n = 32), of 18-25years who were undergoing regular exercise programme (endurance training - treadmill walking, running, cycling etc.) for a period of minimum 3 months, 3-5 days per week, for at least 30 minutes per day (3) were recruited for the study from various physical fitness centers of Bangalore. Age and BMI matched men who did not undergo any exercise programme were taken as the non-exercising group (n = 50). These subjects were recruited from the general population. All the subjects were found to be apparently healthy as assessed by history and clinical examination. Written informed consent was taken from all subjects. The study was approved by the Ethics Review Committee of the Institution. It was conducted in the Autonomic Function Test Lab in the Department of Physiology. All subjects underwent anthropometric assessment which included recording of height using a stadiometer and weight to the nearest 100 gms. BMI was calculated using the formula weight divided by height squared (kilograms per meters squared). Blood pressure recording was done in all participants, using a sphygmomanometer. Physical activity level of all the subjects was assessed using Global Physical Activity Questionnaire (13).

ECG recording

Lead II ECG recording was done for all between 9 and 10 am after 10 minutes of rest, by the ECG data acquisition system (Power lab, AD Instruments, Australia), by the same person. ECG was recorded continuously for 5 minutes for both the groups in supine position with eyes closed. A minimum gap of 2-3 hours between breakfast and ECG recording was given. Subjects were asked to refrain from alcohol or caffeinated beverages and not to do any type of strenuous physical activity 24 hours before ECG recording.

HRV analysis

The data from ECG recording was analyzed for HRV, using software (Lab Chart 6. Pro, ADI Australia), after exclusion of artifacts automatically. Spectral analysis was performed using the Fast Fourier Transform. Frequency domain parameters like total power (TP) , high frequency (HF), (0.15 - 0.4 Hz) , low frequency (LF), (0.04 - 0.15 Hz) and LF/HF components were obtained. Spectral powers of HF, LF were expressed in absolute (ms^2) and normalized units (nu). HRV analysis was done according to the standard guidelines prescribed by Task Force of the North American Society of Pacing Electrophysiology (14).

Physical activity assessment

Global Physical Activity Questionnaire (GPAQ) was used to evaluate the physical activity profiles of the subjects. GPAQ gives the time spent doing different types of physical activity in a typical week. It collects information on physical activity participation in three settings (activity at work, travel to and from places and recreational activities) and sedentary behavior.

The data was analyzed using METs (Metabolic Equivalents) which are commonly used in the analysis of physical activity. One MET is defined as 1kcal/kg/hour. Total physical activity is expressed as MET-minutes/week (13).

Statistical methods involve

The results were presented as mean±SD (standard deviation). Comparison of variables between groups was done by using t- test and Mann-Whitney test wherever appropriate. $P<0.05$ was considered as level of significance.

Results

There was no significant difference in the anthropometric measures like height, weight and BMI between the exercising and non-exercising groups (Table I). Heart rate was found to be less in exercising group in comparison to non-exercising group (73.27±8.6 vs 74.41±8.59) which was not significant statistically. There was no significant difference in systolic (116.50±9.3 vs 112.56±8.3) and diastolic blood pressure (75.69±9.51 vs 76.26±8.13) between the groups. Total power of HRV was compared using Mann-Whitney test, which was not statistically significant (P=0.783). There was no significant difference in LF and HF components of frequency domain parameters both in absolute and normalized units. LF/HF component did not show any significance statistically (Table II). There was significant difference between the physical activity level between the exercising and non-exercising groups (4175±1481.53 vs 1176.4±1103.83, $p<0.001$).

TABLE I : Characteristics of the study subjects.

	Exercising (n=32)	*Non-exercising (n=50)*	*P-value*
Age (years)	21±2.62	20.36±1.63	0.59
Height(meter)	1.71±0.06	1.69±0.07	0.43
Weight(kg)	70.30±11.73	69.61±8.18	0.75
BMI(kg/mt^2)	24±3.05	23.01±3.37	0.18
GPAQ (MET-min/week)	4175±1481.534	1176.4±1103.831	<0.001

Values are expressed as Mean±SD. Statistical analysis was done by t-test.

TABLE II : Comparison of Heart rate, Blood Pressure and Frequency domain parameters of HRVin study subjects.

	Exercising	*Non-exercising*	*P-value*
HearRate(beats/min)	73.27±8.6	74.41±8.59	0.542
SBP (mm Hg)	116.50±9.3	112.56±8.3	0.066
DBP (mm Hg)	75.69±9.51	76.26±8.13	0.896
Total power	2891.98±1744.08	3243.53±2436.71	0.783
LF(ms^2)	932.59±847.50	914.47±756.98	0.879
LF(nu)	47.12±19.17	43.55±16.66	0.376
HF(ms^2)	751.27±537.95	1114.97±1067.15	0.242
HF(nu)	41.03±17.65	46.03±15.89	0.186
LF/HF	1.61±1.16	1.22±0.93	0.153

Values are expressed as Mean±SD. Statistical analysis was done by Mann-Whitney testfor Total power, LF(ms^2), HF(ms^2) and t-test for LF(nu), HF(nu), LF/HF.

Discussion

Many biological mechanisms are proposed to account for the risk-reduction and cardio-protection effect of physical exercise. Out of them, autonomic nervous system is known to have an effect by regulating the heart rate (5).

In normal individual, there is a delicate balance between sympathetic and parasympathetic divisions of autonomic nervous system. Measurement of the HRV components, namely, HF in absolute power (HF ms^2) represents parasympathetic control and the LF represents both sympathetic and parasympathetic modulation of the heart. Activation of sympathetic division proportionately reduces the activity in parasympathetic division resulting in sympathetic predominance. Similarly, activation of parasympathetic division reduces the activity in sympathetic division resulting in parasympathetic predominance. Irrespective of which division of the ANS is predominant, the total power increases. LF and HF are represented in normalized units (nu), in proportion to total power. These relative measurements (HF nu, LF nu) provide quantitative evaluation of graded changes in the state of parasympathetic and sympathetic modulation. The LF/HF ratio provides an index of sympathetic relative to parasympathetic nervous system tone, in other words, the sympathovagal balance. A desirable response was one which showed an increase in HF and decrease in the LF/HF ratio as this is believed to indicate an increase in parasympathetic modulation (14).

Exercise training has shown to increase the vagal tone i.e. the parasympathetic component of ANS and thereby improving the cardiovascular status (15). In the present study, in which, effect of 3 months of aerobic exercise on cardiac autonomic modulation was evaluated, heart rate was found to be less in exercising than the non-exercising groups, which was not statistically significant. Similar findings were observed, where after training, resting heart rate did not differ significantly between trained and untrained subjects (6).

But few studies have shown a significant decrease in resting heart rate after 24 sessions of moderate intensity training program (16) and a small reduction in resting heart rate after 20 weeks of endurance training (17) compared to the controls.

Bradycardia is a well-known consequence of regular aerobic training and has been attributed to adaptation to the autonomic nervous system, i.e. either an increase in vagal activity or a decrease in sympathetic activity, or else to reduced intrinsic heart rate (18, 19). But it is reported that, prolonged and intense exercise return the changes in heart rate variability back to control levels, which may be true for heart rate (20). In present study we have taken a minimum period of 3 months of exercise as inclusion criteria and the total duration and intensity of the exercise were not determined in the participants.

Exercise training has also shown to improve blood pressure and is associated with decrease in the incidence of hypertension. Regular exercise has been found to lower blood pressure (10 mmHg average reduction in both systolic and diastolic pressure) (21). In contrast to this, our study did not show any significant change in both systolic and diastolic blood pressure.

In a study, sedentary hypertensive adults did moderate intensity aerobic training for 6 weeks and were compared with controls who maintained existing levels of physical activity. The trained group showed a reduction in both systolic and diastolic blood pressure compared to controls but the results were not significant (22).

Similar finding was seen in another study, where five hundred and seven healthy sedentary persons had undergone an endurance training program for 20 weeks. Small changes (i.e., < 3 mm Hg) in resting systolic (SBP), diastolic (DBP) blood pressure was seen after the training period (17).

In the current study, there was no significant change in frequency domain parameters of HRV (TP, LFms^2, LF nu, HF ms^2 and HF nu) between the exercising and non-exercising groups. LF/HF ratio was less in non-exercising group compared to exercising group (Table II).

Moderate intensity exercise (12) and endurance training (23, 11) were found to have no significant effect on frequency domain parameters of HRV in men.

Evidence of decreased power in variables reflecting vagal activity in the frequency domain (eg, total power and high-frequency power) parameters were seen in athletes who were doing regular endurance training in comparison with the controls (9). The effect of aerobic training for 12 weeks period in one hundred and forty nine sedentary young adults showed a rise in high frequency power after aerobic conditioning showing the vagal predominance. These data suggested that aerobic conditioning produced small but expected autonomic effect (5).

Thirty eight young men had undergone a high intensity intermittent exercise (3 times per week for 20 minutes) training for a period of 12 weeks following which a higher HRV was observed in subjects compared to controls (24).

The present study contrasts the findings of another study where, middle aged sedentary males were trained for a period of 8 weeks. Increased HF nu power and the decreased LF nu power as well as the decreased LF/HF ratio showed an alteration in autonomic regulation of heart rate towards increased vagal dominance after aerobic training (18).

Various factors along with duration (25) and intensity (11) are found to contribute for the exercise responses in autonomic activity. The HERITAGE Family study, based on 720 healthy sedentary subjects, summarized the contribution of age, gender, race and baseline fitness level to response to aerobic training. They found that, initial level of a phenotype is a major determinant of training response for some traits, such as submaximal exercise heart rate and blood pressure. Familial factors also contribute significantly to the exercise response (26).

In accordance with the large interindividual variation in the training response to physical exercise, wide intersubject variation has also been observed in cardiovascular autonomic regulation in healthy subjects when measured by the heart rate variability indices (27).

Similarly genetic background also has shown to cause considerable variation in the baseline aerobic capacity and the changes in aerobic fitness after exercise training intervention. A 13 sequence variants in mitochondrial DNA have been shown to influence relevant fitness and performance phenotypes (28).

It is also seen that long-duration and/or intense training may not necessarily lead to greater enhancement in heart rate variability as prolonged (12 months) and intense training (from walking to running) may return these changes in heart rate variability back to the control level (20).

There was a significant difference in the total physical activity level between the exercising and non-exercising groups conforming that exercising group were doing extra activities in addition to their daily physical activity. Among the 3 domains (activity at work, travel to and from places and recreational activities), physical activity level of most of the subjects, in this study, fell under recreational activities. Different levels of physical activity have shown to affect HRV. A study has shown that, moderate and vigorous physical activities were associated with higher HRV, with vigorous activity being associated with a higher high-frequency power in men (29). But in spite of the difference in activity level, we did not get results as expected i.e. a better parasympathetic response.

Limitations

This study being a retrospective one, the actual exercise regimen could not be monitored. So the potential limitation of this study is the self reported measures of adherence to exercise regimen and also physical activity levels, which were also assessed based on questionnaires, which is again a subjective evaluation. Studies have shown that self-reported measures of physical activity were both higher and lower than directly measured physical activity (30). However because the groups differed precisely in their physical activity level assed by GPAQ, it appeared that they exercised. Further studies are needed to confirm this hypothesis.

The autonomic activity was measured only in frequency domain, it would have been better to measure the tone in time domain also as autonomic activity should be based on the collective analysis of time domain and frequency domain parameters of HRV.

Conclusion

Our study indicates, three months of regular exercise did not have significant effect on cardiac autonomic activity, including heart rate variability as measured by frequency domain parameters, despite the significant difference in the physical activity levels.

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