

Article

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The effect of moderate versus high intensity exercise on heart rate variability in sedentary office workers

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Abstract

Background: Sedentary behavior is one of the leading modifiable risk factors for cardiovascular disease and all-cause mortality. Physical exercise exerts beneficial physiological effects on cardiovascular fitness. Different grades of physical exercise have different effects on cardiovascular health. **Objective:** To compare the effect of moderate and high intensity exercise training on heart rate variability (HRV) in sedentary office workers. **Methods:** This study was conducted on 40 healthy sedentary volunteers aged between 20-40 years of both the genders. Participants were distributed into two groups of 20 subjects each. Subjects of group I and group II performed moderate intensity and high intensity exercise respectively on bicycle ergometer for 12 weeks. Their 5-minute ECG recording was done by three channel physiograph, and frequency domain indices of HRV and heart rate (HR) were analyzed and compared before and after exercise training. Their blood pressure was also recorded and compared before and after exercise training. Independent sample t-test and paired sample t-test were used for statistical analysis. **Results:** HF, systolic and diastolic blood pressure reduced significantly after exercise in group II ($p=0.015$, 0.005 , and 0.015 respectively) while HR and LF/HF ratio reduced in both group I and group II ($p=0.000$ for HR, and 0.034 , 0.001 for LF/HF). The decrease in HR was greater after high intensity exercise than moderate intensity exercise ($p=0.025$). **Conclusion:** Parasympathetic activity improves after moderate and high intensity exercise but improvement is more after high intensity exercise training. Therefore, high intensity exercise training is more beneficial than moderate intensity exercise training.

Keywords: moderate-intensity exercise, high-intensity exercise, heart rate variability, heart rate, blood pressure

Introduction

Sedentary behavior is defined as any working behavior with energy expenditure 1.5 metabolic equivalent of task (METs)¹. In the present-day world, the innovation in technology and profound use of computers in all office tasks has led to the increase in sedentary lifestyle and more time being spent sitting before desk. Adults spend about 51-68% of daily waking hours in sedentary activities^{2,3}.

Sedentary lifestyle is a major risk factor for congestive heart failure, stroke, obesity and hypertension⁴. Cardiovascular system is regulated by autonomic nervous system including sympathetic & parasympathetic nervous system. Balance between these two components of autonomic nervous system is important for adequate functioning of cardiovascular system. Risk factors for cardiovascular diseases have a negative impact on autonomic functions⁵.

One of the important markers of autonomic functions is heart rate variability (HRV) which is negatively associated with cardiovascular risk factors such as physical inactivity⁶. Low HRV is related to increased risk of ventricular arrhythmias and coronary artery diseases⁷⁻¹⁰.

Interaction between sympathetic and parasympathetic nervous system causes variation in beat-to-beat interval in ECG. Reduced HRV indicates decreased parasympathetic activity or increased sympathetic activity. HRV can be analyzed by time and frequency domain methods. Short-term recording of frequency domain parameters is useful for analysis of sympathovagal balance¹¹. High frequency power (HF) indicates parasympathetic activity while low frequency power (LF) indicates combination of both sympathetic and parasympathetic activity¹².

HRV is influenced by duration and intensity of exercise. A short observational report showed that vigorous physical activity significantly predicted

greater HRV in young adults¹³. Some other studies compared the effect of moderate and high intensity exercise on various other physiological mechanisms¹⁴⁻¹⁷. All these previous studies were based on self-reported level of physical exercise which may vary from person to person. These facts gave us impetus to verify the effect of moderate and high intensity exercise training on heart rate variability.

Methods

This study was conducted in the department of Physiology, Dr Ram Manohar Lohia Institute of Medical Sciences, Lucknow India. The study was approved by ethics committee of Dr Ram Manohar Lohia Institute of medical Sciences, Lucknow.

Subjects

Forty healthy sedentary office professionals of both the genders aged between 20-40 years were selected randomly to participate in the study. Their participation was voluntary and a written consent was taken from all the participants. The study was done as per Helsinki Guidelines.

A detailed history was taken from all the participants to assess their physical and psychological health to exclude any clinical abnormality. The subjects not engaged in any exercise programme or doing low intensity exercise (heart rate <50% of HR_{max}) or sports activity for <20 min in a week were included in study¹⁸. Exclusion criteria were a history of smoking, athletic activity, anemia, any systemic disease, depression, anxiety, previous surgery, and medication known to have an impact on autonomic function.

All the participants were instructed to avoid tea, coffee, smoking, alcohol and additional physical activity for at least two days prior to the exercise session and not to have any feed during last two hours prior to the exercise sessions. They were randomly divided into two groups of 20 subjects each to perform exercise training on bicycle

ergometer (Avon Cycles Ltd, Ludhiana, India) for 12 weeks periods.

Exercise protocol

Participants of moderate intensity exercise group (group I) performed steady state cycling at heart rate of 50% – 74% of HR_{max} for a duration of 40 minutes, 5 days per week. Participants of high intensity exercise group (group II) performed 8 sec sprints cycling at a heart rate of 75%-84% of HR_{max} followed by 12 seconds of low intensity cycling for a duration of 20 minutes for 3 times per week¹⁹. All the exercise sessions were conducted in the Department of Physiology, Dr Ram Manohar Lohia Institute of Medical Sciences Lucknow under strict supervision.

Measurement of HRV

Measurement of HRV was conducted in quiet autonomic function lab with soothing light and comfortable temperature being maintained in the Department of Physiology and analysed according to the standards proposed by Task force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology¹². Subjects were instructed to take nothing by mouth 2 hours prior to the recording. After the explanation of procedure they were asked to take rest in the quiet autonomic function lab in supine position for 30 minutes to allow reduction of heart rate to a minimum level. Any electronic gadget or metal object, which could interfere with the recording, was removed. HRV was recorded by ECG lead II for 5 minutes at a frequency of 500 samples per second by three channel Physiograph (AD instruments South Asia (India) Pvt Ltd, New Delhi, India). All the recordings were done at a fixed time of the day (4.00 PM) to rule out diurnal variation. Recording of HRV was done two times, before beginning and after completion of exercise training of 12 weeks.

Frequency-domain parameters of HRV were analysed by spectral analysis using software LABCHART PROV8.1.8 software WITH HRV MODULE V.2.0.3. Low frequency band (LF),

high frequency band (HF), total power and LF/HF ratio were taken into consideration.

Weight and height, blood pressure and HR were also measured following the HRV recording.

Statistical analysis

Statistical analysis was performed using software SPSS version 21.0 (IBM Corp., Armonk, NY, USA). Data were represented as mean \pm standard deviation (SD) of mean. Comparisons of mean values of demographic characteristics between the two groups were done by independent sample t-test. Frequency-domain parameters of HRV, HR, systolic blood pressure (SBP), and diastolic blood pressure (DBP) of both the groups before and after exercise were compared by paired sample t-test. Post exercise parameters of group I and II were also compared by independent sample t-test. p-value < 0.05 was considered statistically significant.

Results

Forty healthy sedentary subjects (25 males and 15 females) took part in the study. They were randomly distributed in two groups of 20 subjects each. The subjects of group I and group II performed moderate and high intensity exercise, respectively. (Table I)

Table 1: Gender distribution of Participants

Gender	Group I	Group II	Total
Male	11	14	25
Female	9	6	15
Total	20	20	20

Group I = Moderate intensity exercise group, Group II = High intensity exercise group

The mean age of the subjects in group I and group II was 37.2 \pm 12.18 years & 36.87 \pm 9.71 years respectively. The mean body mass index (BMI) of the participants of both the groups was within normal range (< 25 kg/m²). Baseline characteristics of the participants in both the group were similar (p > 0.05) (Table II).

Table II: Characteristics of Participants

Variable	Group I (Mean ± SD) N = 20	Group II (Mean ± SD) N=20	¹ P value
Age (years)	37.2 ± 12.18	36.87± 9.71	0.94
Weight (kg)	65.33 ± 14.54	64.73 ± 11.76	0.94
Height (cm)	164.4 ± 6.75	166.47 ± 8.12	0.96
Body mass index (kg/m ²)	24.18± 4.79	24.19 ± 3.31	0.99

Data are represented as mean±SD, Statistical analysis was done by independent sample 't' test, Group I = Moderate intensity exercise group, Group II = High intensity exercise group

HRV parameters before exercise training

The average total power of the participants of both the groups was normal. The average LF in group I and group II was 403.26 ms² and 426.5 ms² respectively. The average HF in group I and II was 266.12 ms² and 498.49 ms² respectively, showing low parasympathetic activity. The average LF/HF ratio in group I was 2.90 showing abnormal sympathovagal balance while in group II it was 1.6 (Table III).

Changes in HRV after exercise training

Total power and LF failed to improve significantly after 12 weeks of exercise training in both the groups (p=0.703 and 0.398, respectively). LF/HF ratio reduced significantly after moderate and high, both type of exercise trainings indicating

improvement in sympathovagal balance (p=0.034 and 0.001, respectively). HF increased significantly only after high intensity exercise showing improvement in parasympathetic activity (P=0.015) which was not seen after moderate intensity exercise (p=0.269). Heart rate decreased significantly in both the groups after exercise (p=0.000) but decrease in systolic and diastolic blood pressure was significant only in group II (p=0.005, 0.015 respectively). (Table III)

Table IV shows comparison of parameters of HRV after exercise training of 12 weeks in group I and II. There was no significant difference in post exercise LF, HF, total power, LF/HF, and blood pressure in both the groups (p>0.05) but heart rate was significantly lower in group II than group I (p= 0.025).

Table III: Comparison of HRV before and after exercise in subjects of group I and group II

Parameter	Group I (N=20)			Group II (N=20)		
	Before Exercise	After exercise	¹ p-value	Before Exercise	After exercise	¹ p-value
Total Power (ms ²)	1209.95±1247.61	1362.28±1717.90	0.177	1482.02±1221.96	1563.13±922.75	0.703
LF (ms ²)	403.26±497.77	409.56±271.23	0.935	426.5±308.37	509.70±287.87	0.398
HF (ms ²)	266.12±246.73	578.65±226.89	0.269	498.49±815.52	908.39±613.97	0.015*
LF/HF	2.90±3.55	1.53±0.16	0.034*	1.60±1.05	0.62±0.14	0.001*
Hear rate (beats/minute)	83.6	77.13	0.000*	85.73	69.93	0.000*
SBP(mm Hg)	125	120.94	0.165	122.47	114.26	0.005*
DBP(mm Hg)	80.67	79.2	0.312	83.73	76.6	0.015*

Data are represented as mean±SD, statistical test used was paired sample 't' test

Group I = Moderate intensity exercise group, Group II = High intensity exercise group

LF=Low frequency, HF= High Frequency, SBP=systolic blood pressure, DBP=diastolic blood pressure

*=significant difference in between group I & II (p<0.05 significant)

Table IV: Comparison of HRV after exercise in subjects of group I and group II

Parameter	Group I N=20	Group II N=20	¹ p- value
Total Power (ms ²)	1362.28±1717.90	1563.13±922.75	0.183
LF (ms ²)	409.56±271.23	509.70±287.87	0.307
HF (ms ²)	578.65±226.89	908.39±613.97	0.245
LF/HF	1.53±0.16	0.62±0.14	0.271
Hear rate(beats/min)	77.13	69.93	0.025*
SBP(mm Hg)	120.94	114.26	0.091
DBP(mmHg)	79.2	76.6	0.216

Data are represented as mean±SD, Statistical analysis was done by independent sample 't' test

Group I = Moderate intensity exercise group, Group II = High intensity exercise group

LF=Low frequency, HF= High Frequency, SBP=systolic blood pressure, DBP=diastolic blood pressure

*=significant difference in between group I & II (p<0.05 significant)

Discussion

The level of physical activity has an important role in cardiovascular health. Regular exercise is very important to keep cardiovascular system healthy. Measurement of HRV is a non-invasive method to investigate cardiac autonomic functions²⁰. However, during interpretation of these functions, the key factor, which has to be considered, is how the intensity of exercise may affect the response. Therefore, the purpose of this research was to investigate the effect of different intensities of exercise, i.e. moderate and high, on autonomic functions in sedentary office workers.

As the vagal activity is the major contributor of HF component of HRV²¹, our results showed low parasympathetic activity in the participants despite normal BMI. BMI is an indicator of general obesity and some studies showed that central obesity is a better discriminator of cardiac autonomic functions than general obesity²². We did not measure WHR which is a parameter of central obesity. LF/HF ratio estimates the ratio between sympathetic nervous system and parasympathetic nervous system activity. Low LF/HF ratio indicates parasympathetic dominance while a high LF/HF ratio reflects

sympathetic dominance²³. One previous study demonstrated that a sedentary lifestyle counters the benefits of being a normal weight in terms of heart disease risk²⁴. In our study, baseline LH/HF ratio was high, reflecting high sympathetic activity. These results are supported by another study which also found higher LF/HF ratio in sedentary women²⁵.

LF/HF ratio is an indicator of sympathovagal balance¹². Decreased LF/HF ratio indicates increased parasympathetic activity. Exercise modulates sympathovagal balance by increasing vagal while decreasing sympathetic activity. Our study also supported this fact by showing significant decrease in LF/HF ratio in both the groups. Decrease was greater after high intensity exercise training than moderate intensity exercise & it was significant.

HF increased significantly after high intensity exercise in our study. HF increased after moderate intensity exercise too, but it was not significant. These results are comparable to the reports of higher HF with vigorous activity but not with moderate activity²⁶. The post exercise increased parasympathetic activity in this study may be due to improved baroreflex sensitivity after exercise²⁷. In addition, this study²⁶ also

observed increased LF after moderate and vigorous exercises which contradicts to our finding of no significant change in LF after both grades of exercise. They concluded it as overall increase in parasympathetic activity but they were not able to explain whether an increase in parasympathetic activity and decrease in sympathetic activity are responsible for an increase in low frequency power. Another similar study found no significant change in vagal outflow in sedentary persons after any type of exercise²⁸. We also found a significant decrease in LF/HF ratio after both moderate and high intensity exercise reflecting improvement in sympathovagal balance. This effect is similar to the observation by Alansare A et al after high intensity exercise but they failed to show significant improvement in LF/HF ratio after moderate intensity exercise²⁹. However, they did not find significant change in LF and HF. They concluded that high intensity training programme is superior to moderate intensity exercise programme in improving HRV.

In most of the previous studies^{13,26}, the physical activity was assessed by self-reported questionnaire while in this study participants performed exercise under supervision in the physiology lab on bicycle ergometer. The participants were divided into two groups. Subjects of group I performed moderate intensity exercise by cycling at heart rate of 50% – 74% of a heart rate maximum reserve for a duration of 40 minutes, 5 days per week. Subjects of group II performed high intensity exercise by 8 sec sprints cycling at a heart rate of 75%-84% of heart rate maximum reserve followed by 12 seconds of low intensity cycling for a duration of 20 minutes for 3 times per week. The HRV of the participants was measured after performing exercise for 12 weeks duration. One previous study also practiced similar exercise protocol to study the effect of exercise intensity on body composition in overweight and obese individuals¹⁹. However, another study compared

the effect of exercise intensity on HRV by involving the participants in exercise training, but its sample size was only thirteen too small for conclusion²⁹. Previous studies did not take the psychological factors such as depression in consideration¹³ while we excluded these factors from our study.

Regular physical exercise is an effective non-pharmacological approach to improve blood pressure³⁰. In this context, our study showed decrease in SBP and DBP after 12 weeks of high intensity exercise programme. Previous studies found only decrease in SBP after high intensity and moderate intensity exercise sessions^{29,31}. This improvement in blood pressure following exercise programmes may be attributed to improved vascular functions and diameter³². Our study also demonstrated decrease in heart rate after both type of exercise trainings but decrease was more after high intensity exercise training. Similar results were also found in another study³³.

There are certain limitations of our study, which should be noted. The duration of intervention was short although it was similar to those in the earlier randomized studies³⁴. We did not control the respiration of subjects during recording of HRV. Respiratory rhythm can affect the frequency domain parameters³⁵. We included participants of age group 20-40 years in our study. The results might differ in older or younger subjects³⁶.

Conclusion

This study suggested that high intensity exercise is more effective in improving sympathovagal balance and heart rate in sedentary people. This study also revealed that cardiac autonomic activity may be abnormal despite normal BMI. High intensity exercise requires less duration to produce the changes as compared to the moderate intensity exercise of extended duration. Therefore, we believe that our results will contribute in making exercise protocols more effective in the current scenario. Further studies

with greater sample size and controlled respiratory rhythm are needed to confirm this hypothesis.

Conflict of interest The authors have no conflict of interest relevant to this article.

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