Article

Power Spectral Analysis of Heart Rate Variability in Adolescent Male Athletes

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Abstract

Background: Cardiac autonomic nervous activities (CANA) deteriorate with age, obesity, sedentary life style and in various cardiac and noncardiac disease conditions. Regular physical exercise may improve CANA in health and diseases. Power spectral analysis (PSA) of Heart rate variability (HRV) is one of the most promising newer techniques to quantify CANA. **Objective:** To analyze HRV by Power Spectral method in order to find out the influence of regular physical exercise on CANA in male adolescent athletes. **Method:** This cross sectional study was carried out on 62 adolescent male athletes aged 12-18 years (group B), in the Department of Physiology, Bangabandhu Sheikh Mujib Medical University from 1st July 2007 to 30th June 2008. For comparison, 30 age, sex, BMI and socioeconomic condition matched apparently healthy sedentary subjects (group A) were also studied. The study subjects were selected from the BKSP (Bangladesh Krira Shikka Prothistan, Savar, Dhaka) and the control from a residential school of Dhaka city.Power spectral measures of HRV including Total Power (TP), Very Low Frequency Power (VLF) Low Frequency(LF), High Frequency (HF) LF/HF were measured by a Polygraph . For statistical analysis, Idependent-Sample t-test was used. **Results:** Total power, HFnu power and the VLF,LF,HF were significantly ($P<0.001$) higher and LFnu power and the LF/HF ratio were significantly ($P<0.001$) lower in athletes than those of nonathletes which indicate higher cardiac parasympathetic and lower sympathetic activity in athletes. **Conclusion:** Cardiac Autonomic regulation with increased parasympathetic and decreased sympathetic modulation may occur with in athletes engaged with regular physical exercise.

Key words: Power Spectral Analysis (PSA), CANA, Athelet, Adolescent

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Introduction

The cardiac autonomic nervous activities deteriorate in health and various cardiac and non-cardiac disease conditions. Regular physical exercise may be a non-pharmacological, easy, safe and economic tool to improve the cardiac autonomic nervous activities in health and diseases[1]. Power spectral analysis (PSA) of Heart rate variability (HRV) is one of the most promising newer techniques to quantify CANA[2].

In healthy individual, HRV declines with age and also in people with sedentary life style [3,4]. HRV also declines in several cardiac and noncardiac disease conditions like myocardial infarction, heart failure, hypertension, cardio-myopathy , after heart transplant, ventricular arrhythmias, conditions lead to cardiac arrest or sudden death, obesity , diabetes , renal failure and chronically undernourished person[5-17].

Regular physical exercise improves CANA in healthy individuals[3,18-23]. This kind of improvement of CANA is also observed in Myocardial infarction, coronary artery disease, heart failure, Obesity, type 2 diabetes[24-34].

Though, it was evident that regular physical exercise improves CANA in health and diseases by some studies; yet, a few group of investigators, failed to prove it in healthy individuals[35-37]. On the contrary, some other group of investigators showed that physical exercise does not improve, even in some cases deteriorates CANA in disease conditions[38-41]. Thus, the effect of physical exercise on CANA remains still controversial. In recent days, PSA of HRV to quantify CANA has gained worldwide popularity because it is independent, non-invasive and to some extent detailed informative. The HRV parameters in PSA, as suggested by the Task Force, include Total power, VLF, LF and HF power in absolute value and in normalized unit, and the LF/HF ratio. The total power indicates the total variability of the R-R intervals, the VLF power is supposed to be influenced by thermoregulatory and renin-angiotensin system, LF power by predominantly sympathetic and also parasympathetic, and HF power is strongly associated with vagal tone and represents primary respiratory variation.[2]

In Bangladesh, the number of patients with diabetes, cardiac diseases and renal failure are increasing day by day. Again, a large number of people in our country may be found affected with autonomic nerve dysfunction due to under or over nutrition. In addition, due to rapid urbanization and mechanization of life, sedentary life style may also affect Cardiac Autonomic Nerve Activity in all age groups. Therefore, people should be aware of the adverse effect of sedentary life and also about the benefit of physical exercise as preventive and prognostic measures. Moreover, Power Spectral Analysis of HRV to assess CANA, should also be introduced in our country for research and clinical use, what is already a widely accepted electrophysiologic procedure in many developed countries.

Though, in our country, a few studies were done to assess the CANA in diabetes[13] and obesity,[42] by conventional method; but no study was undertaken to document the effect of regular physical exercise on CANA. Moreover PSA of HRV to assess CANA is not yet done in our country .Therefore, this study was carried out to assess the CANA, by PSA of HRV, in healthy adolescent male athletes who perform regular physical exercise and also compare them with healthy adolescent male with sedentary life style in order to evaluate the effect of regular physical exercise on CANA as well as to introduce PSA of HRV in our country for assessing cardiac autonomic nerve function status.

Methods

This cross-sectional study was carried out in the department of physiology of Bangabandhu Sheikh Mujib Medical University from July 2007 to June 2008. Departmental Ethical Committee approved the protocol. Total number of 92 apparently healthy male adolescents age ranged from 12-18 years were selected, of them 30 non-athletes (sedentary) were taken as control (Group A) and 62 athletes were selected as study group (Group B). Control subjects were selected from a residential school in Dhaka city and the study (Group B) was from Bangladesh Krira Shikkha Prothistan (BKSP), a residential sports academy in Bangladesh. All the control subjects were passing a sedentary life style while the study subjects were exposed to regular physical exercise for at least one year. The subjects were excluded from the study for any subject suffering from systemic diseases, drug users specially drug affecting nervous system and smokers. All ethical considerations for the subjects were taken into account before inclusion in to the study. The aims and benefits of the study were explained to each subject and were encouraged to participate voluntarily. A written informed consent was taken from each subjects and their authority. A detail history regarding physical activity and medical, personal, socio-economic history were taken and thorough clinical examinations of the subjects were done. All these information were recorded in a prefixed questionnaire. Then the subjects

were advised to have his meal by 9:00 p.m., to remain free from any physical and mental stress, not to take any drugs affecting nervous system and to have a good sleep at night before the examination day. The subject was also asked to avoid tea or coffee at breakfast and to attend at the Autonomic Nerve Function Test Laboratory between 9:00 am to 11:00 am on the day of examination. Then after taking detailed history and all physical examinations, the subject was kept under complete bed rest in supine position for 20 minutes in a cool and calm environment at "Autonomic Nerve Function Test Laboratory" of the department of physiology. During this period he was restricted to talk, eat, drink, any physical or mental activity and even sleep. Then all preparations for recording of the HRV parameters was made by connecting the channels for ECG of a Polygraph (RMS INDIA Version-2.2). Then a five minutes ECG recording was taken in resting supine position. After recording, all the non-sinus beats were filtered out from the ECG and the frequency domain measures of the HRV i.e. Total power ,VLF power, LF power, HF power, LFnu, HFnu and the LF/HF ratio) were obtained from the time series. Measurement of serum glucose and creatinine levels were done in all subjects.All data was recorded systematically in preformed data collection sheet and were expressed as mean±SD. Statistical analysis was performed by using SPSS for windows version 12.0. Independent-Sample t-test was performed as applicable.

Results

The anthropometric parameters of the subjects are presented in Table I. Groups were matched for age and BMI. The mean value of Total power, VLF, LF and HF power was significantly (P<0.001) higher in group B than those of group A (Table II).The mean HFnu was significantly (p<0.001) higher and LFnu & LF/HF ratio were lower in group B than those of group A. (Table III).All these finding indicate higher parasympathetic and lower sympathetic with sympathovagal balance towards more parasympathetic predominance in athletes.

Table I: Mean±SD Age, Height, Weight and BMI in two groups (n=92).

Parameters	Group A (n=30)	Group B (n=62)	P values
Age(years)	15.1±2.54	14.99±2.23	0.843 ^{ns}
Height(meter)	1.58±6.57	1.68±12.17	0.000***
Weight(kg)	45.44±6.77	52.15±10.36	0.000***
BMI(kg/m^2)	18.09±1.72	18.19±1.61	0.79^{ns}

BMI = Body Mass Index.

Group A: Apparently healthy adolescent male non-athletes.

Group B: Apparently healthy adolescent male athletes.

*** = P < 0.001.

ns = p>0.05.

n = number of subjects.

Table II: Heart Rate Variability Parameters by Frequency domain method (short term) in absolute value in two groups (n=92).

Parameters	Group A (n=30)	Group B (n=62)	P values
Total power or	2833.19 ±	5387.34±	0.000***
Variance(ms^2)	282.67	850.26	
VLF power	2456.83±	3117.18±	0.000***
(ms^2)	251.72	681.99	
LF power	233.28±	1125.28±	0.000***
(ms^2)	50.35	212.84	
HF power	139.18±	1123.80±	0.000***
(ms^2)	29.91	270.82	

Variance = Total Power, ms = millisecond, ms^2 = squared millisecond.

Group A: Apparently healthy adolescent male non-athletes.

Group B: Apparently healthy adolescent male athletes.

*** = P < 0.001.

n = number of subjects.

Table III: Heart Rate Variability Parameters by Frequency domain method (short term) in two groups (n=92).

Parameters	Group A (n=30)	Group B (n=62)	P values
LF power (n.u.)	62.78±1.81	50.20±2.21	0.000***
HF power (n.u.)	37.29±1.75	49.81±2.23	0.000***
LF/HF ratio	1.7±0.14	1.02±.09	0.000***

LF power (n.u.) = Low frequency power in normalized unit, HF power (n.u.) = High frequency power in normalized unit, LF/HF = Ratio of low and high frequency power.

Group A: Apparently healthy adolescent male non-athletes.

Group B: Apparently healthy adolescent male athletes.

*** = P < 0.001.

n = number of subjects.

Discussion

The present study analyzed the power spectral components of HRV parameters including the total power, LF power, HF power, VLF power, LFnu, HFnu and LF/HF ratio in adolescent male athletes in order to assess the influence of regular physical exercise on CANA. In this study, all these HRV parameters in both the groups were within normal ranges according to the standard provided by the Task Force.[2]

Significantly higher values of total power ,LF,HF,VLF power were observed in athletes in comparison to non athlete which were similar to the findings reported by other investigators[18,22,34,43-48]. On the contrary, no such findings were reported by other group of investigators in their studies[3,19,20,37-40].

Again, significantly lower LFnu and higher HFnu observed in the athletes of the present series are consistent with the findings of most of the investigators in this field[4,15,23,31,33] though, some investigators fond no such effects on these.[18,36,39,49,50]

.In this study, the LF/HF ratio was significantly lower in athletes in comparison to nonathletes. Similar effects of exercise on sympathovagal balance were reported by most of the investigators of different countries[15,19,22-26,31-33,36,46] but a few other group of researchers found no suc effects of regular physical exercise on the LF/HF ratio[3,18,37].

The exact mechanism of exercise-induced changes in CANA is still remains unclear. It has been suggested that physical exercise increases both acetylcholine and choline-acetyl transferase content in cardiac tissue and consequently increases cardiac parasympathetic nervous activity[51]. Billman et al. suggested that physical exercise attenuates cardiac beta-receptor activity and thereby might attenuate the effects of sympathetic activity on heart[52].

Changes in the total power, LF power, HF power, LFnu, HFnu and LF/HF ratio of the HRV parameters indicate altered CANA. It has been suggested that exercise induced changes in HRV parameters reflect exercise induced changes in CANA[3,18,19,23]. It has also been suggested that the changes in the HF and HFnu components of spectral HRV parameters denote changes in the cardiac parasympathetic activity.Therefore, increased values of these parameters in athletes are suggestive of exercise induced increase in cardiac parasympathetic activity[3,19,49].

Similarly, changes in the LF power and LFnu power are indicative of changes in either the cardiac sympathetic activity or both sympathetic and parasympathetic activity[2]. showing It has been suggested that physical exercise might cause decrease in LFnu power and thereby suggestive of decrease in the cardiac sympathetic activity [23, 33]. Higher LF but Lower LF nu in the athletes of the present study though creates controversy on the status of their sympathetic activity but the finding on LFnu which is more representative for sympathetic activity indicate presence of decreased sympathetic activity in the subjects of this series.

Again, the changes in the LF/HF ratio reflects the altered state of the cardiac sympatho-vagal balance. Some groups of investigators suggested that physical exercise could affect the LF/HF ratio,by bringing the changes in the sympatho-vagal balance[19,22,24]. In the present study, higher HF power and HFnu percentage in the athletes showed higher cardiac parasympathetic activity in them. However, as because the acetylcholine and choline-acetyl transferase activity in the cardiac tissue were not possible to measure in the subjects of his study; so, the exact mechanism of exercise induced increase in cardiac parasympathetic activity cannot be revealed from this type of study. Again, similar to parasympathetic activity the exact mechanism of decrease cardiac sympathetic activity in athletes cannot be elucidated as measurement of the cardiac beta-receptors responsiveness was not possible in this study. Reduced LF/HF ratio in athletes of the present series indicate the state of balance towards parasympathetic predominance which may be due to an effect of increased parasympathetic activity.

Conclusion

Increased parasympathetic and decreased sympathetic activity with shifting of cardiac sympatho-vagal balance towards more parasympathetic in athlete indicate that regular physical exercise can improve cardiac autonomic nervous activities. and thereby may be beneficial in preventing the occurrence of different cardiac diseases caused by cardiac autonomic neuropathy.

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