A Comparative Study Of Heart Rate Variability (HRV) Of Female Science Students From Sports And Non-Sports Background

Pawan Kumar[a], Anil Bali[b], Lalit Kapur[c]
[a]Department Of Physical Education, Bhaskaracharya College Of Applied Sciences, University Of Delhi, Dwarka, New Delhi- 110075, India,
[b]Department Of Biology, Bhaskaracharya College Of Applied Sciences, University Of Delhi, Dwarka, New Delhi- 110075, India,
[c]Department Of Chemistry, Bhaskaracharya College Of Applied Sciences, University Of Delhi, Dwarka, New Delhi- 110075, India

Abstract

The objective of the study was to compare heart rate variability (HRV) of female science students from sports and non-sports background. The data was collected on 14 female science students (7 sports and 7 non-sports). Ages of the sample ranged from 17 to 21 years of same socio-economic status from different games/sports. The heart rate variability (HRV) was performed, which quantifies autonomic drive to the myocardium. The ECG analog were filtered and quantified using the software namely HRV Software, Biomedical Signal Analysis Group, Department of Applied Physics, University of Kupio, Finland. Collected data was computed with Mean, Standard Deviation and Anova. Our experimental data indicate that sports activity has positive effect on heart rate of students playing sports. This has been demonstrated through Time domain and Frequency Domain Analysis. Mean projections are optimistic when compared for sports tonon sports students. Though the statistical analysis of the data suggested that results related to SDNN, RMSSD, NN50 count, pNN50, RR triangular index, HF, Total Power LF:HF, LF (N.U and HF (N.U.) are insignificant at .05 level of significance. On the other hand our experimental data indicate the statistical significant results obtained in case of mean heart rate. This suggests that mild and intermediate sports activities are sufficient to have positive effect on heart rate.

KEYWORDS: Autonomic, HRV, LF, HF, NN50, pNN50

Our body reacts to nearly everything happening around us through our emotions, observations, thoughts and activity. Our brain guides the body by regulating heart and other organs through autonomic nervous system. This physiological variation of heart rate, controlled by autonomic nervous system, is called Heart Rate Variability (also commonly known as HRV). Measuring heart rate variation reveals wide range of information about our body and health.Heart rate variability (HRV) is calculated based on variation of time in milliseconds between two heartbeats. HRV varies as one breathe in and out (see picture below). HRV is a relatively new method for assessing stress. What makes HRV interesting is the fact that it can reflect changes in stress while other physiological parameters, like blood pressure, are still in normal or accepted ranges. That's why HRV is becoming increasingly popular parameter in the fields of sports and sports science, corporate health, cardiology, ergonomics, diabetes care and relaxation training therapy. HRV is also being widely used on physiological research of autonomic nervous system[1].

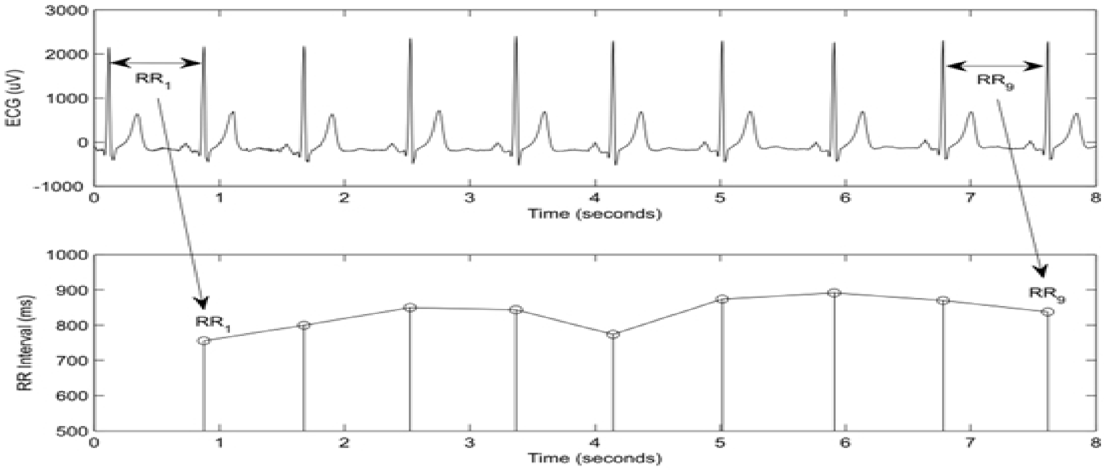


Fig. 1-- Heart rate variability[1]

Physiology of Heart Rate Variability

The physiological background of HRV has been attributed to the sympathovagal system. In mammals, HRV has also been examined in situations which are known to be associated with marked changes in the tone of the autonomic nervous system including investigations into specific diseases which impair the autonomic system, such as diabetes. HRV has also been used to demonstrate the development of tonic vagal influence on the heart. HRV has been studied in humans in order to assess sympathovagal balance. HRV provoked by atropine administration has been reported as a method of the diagnosis of brain death Quantification of HRV has also been used as the standard for evaluating other psychological methods. Physiological studies in humans have reported an increase of HRV, interpreted as an increase of cardiac vagal tone at rest, following intensive exercise for several day[6].

The understanding of the significance of HRV is ongoing. However, it has been suggested that HRV is an important method for assessing cardiovascular autonomic parameters that are partially under the regulatory control of innervations from the sympathetic and parasympathetic systems[7,8]

Analysis of heart rate variation (HRV) has become a popular noninvasive tool for assessing the activities of the autonomic nervous system (ANS). HRV analysis is based on the concept that fast fluctuations may specifically reflect changes of sympathetic and vagal activity. It shows that the structure generating the signal is not simply linear, but also involves nonlinear contributions[9].The cardiovascular system is mostly controlled by autonomic regulation through the activity of sympathetic and parasympathetic pathways of the autonomic nervous system. Analysis of HRV permits insight in this control mechanism. It can easily be determined from ECG recordings, resulting in time series (RR-intervals) that are usually analysed in time and frequency domains. As a first approach, it can be assumed that power in different frequency bands corresponds to activity of sympathetic (0.04–0.15Hz) and parasympathetic (0.15–0.4Hz) nerves. However, other mechanisms (and feedback loops) are also at work, especially in the low frequency band[10].

Time-and Frequency-Domain Analysis of Heart Rate Variability

The time-and frequency-domain measures of HRV were analyzed by the methods recommended by the Task Force of the European Society of Cardiology[12]. The standard deviation of all normal R-R intervals (SDNN) and the difference between the maximum hourly HRV (circadian rhythm) were computed as standard time-domain measures of HRV. Spectral power was quantified both by Fast Fourier Transform analysis and by autoregressive analysis in 4 frequency bands[1], ≤ 0.003 Hz(ultralow frequency [ULF]), 0.003 to 0.04 Hz(very-low frequency [VLF]), 0.04 to 0.15 Hz (low frequency [LF]), and 0.15 to 0.40 Hz (high frequency [HF]). ULF and VLF spectral components were computed over the entire recording interval by the fast Fourier method[11]. LF and HF components were computed from segments of 512 R-R intervals by the autoregressive method.

Time Domain Analysis[12]

Time-domain analysis is most commonly used in clinical applications of HRV. It is probably the simplest method of analysis and it is less sensitive to noise and signal artifacts than the frequency-domain methods. Time domain analysis use instantaneous heart rateorinter-beat-intervals.

Time Domain Measures

- Mean NN Interval
- Mean Heart Rate
- Difference between longest and shortest NN interval
- SDNN: Standard deviation of NN of normal-to-normal intervals (a representation of overall HRV)
- SD/RR: Coefficient of the variance of HRV
- RMSSD: Square root of the mean squared difference of successive NN intervals (correlates to high frequency components)

Frequency Domain Analysis[12]

ECG and blood pressure signals contain identifiable frequencies that contain physiologic information. Frequency domain techniques are performed on the inter-beat-interval signal, a plot of the R-R intervals (ms) versus time or beat number. It is very important with frequency domain techniques that the data points be equidistant. Therefore, the inter-beat-interval data must be interpolated.

There are typically three main frequency components of HRV. Ranges for each of the frequency components vary based on species being studied.

- Very Low Frequency (VLF)
- Low Frequency (LF)
- High Frequency (HF)

Parameters derived from frequency components

- Total Power (TP)
- VLF, LF, HF
- Normalized LF and HF (removes VLF component)

- LF/HF ratio

It is widely presumed that regular physical activity induces adaptations in the autonomic nervous system. One of the possible adaptations is an increase in parasympathetic activity and HRV[13,14,15,16].

It is seen that there are many health problems which are occurring at very young age due to less participation in sports activities and more stress due to academics and other socio-economic and environmental factors. This work was undertaken to investigateheart rate variability of selected variables of science students (female) from sports and non-sports background.

Materials and Methods

The study was conducted on 14 female science students (7 sports and 7 non-sports). Ages of the sample ranged from 17 to 21 years of same socio-economic status from different games/sports.

Students were asked to come with two hours fasting before the test. No medication was taken before 48 hours of the testing. Subjects rested for 30 minutes before the commencement of the test and then heart rate variability (HRV) was performed, which quantifies autonomic drive to the myocardium. The ECG analog were filtered and quantified using the software namely HRV Software, Biomedical Signal Analysis Group, Department of Applied Physics, University of Kupio, Finland. Both sympathetic and parasympathetic drives to myocardium were assessed by SDNN, LF (Normalized Power), LF/HF ratio, LF (Absolute power), TP (Absolute Power), NN50 count, pNN50 count, SDSD, RMSSD, HF (Normalized Power), HF (Absolute Power) , and SDSD with regard to HRV variables (sympathetic and parasympathetic activity and reactivity).

This was achieved by simultaneous measurement of ECG. Collected data was computed with Mean, Standard Deviation and Anova done on SPSS software.

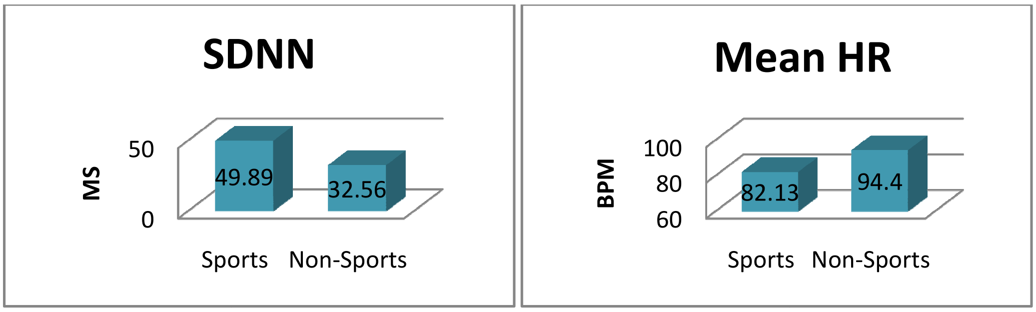
Results

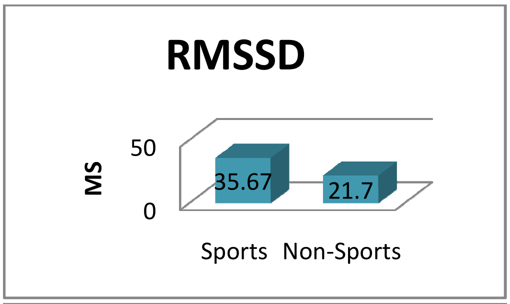
Table- 1 Descriptive Statistics of Heart Rate Variability of Female Science Student from Sports and Non-Sports Background

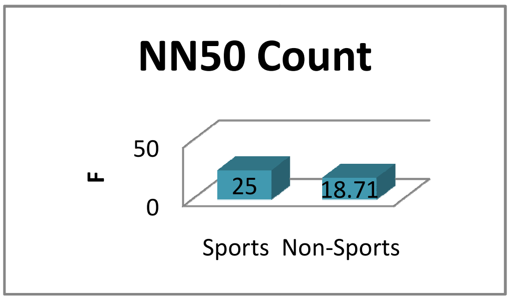
Variables		Unit	Mean	Std. Deviation	Std. Error
SDNN	Sports	Ms	49.89	32.65	12.34
	Non-Sports		32.56	10.68	4.04
MEAN HR	Sports	Bpm	82.13	8.33	3.15
	Non-Sports		94.40	12.33	4.66
RMSSD	Sports	Ms	35.67	28.29	10.69
	Non-Sports		21.70	8.34	3.15
NN 50 Count	Sports	F	25.00	20.00	7.56
	Non-Sports		18.71	15.17	5.74

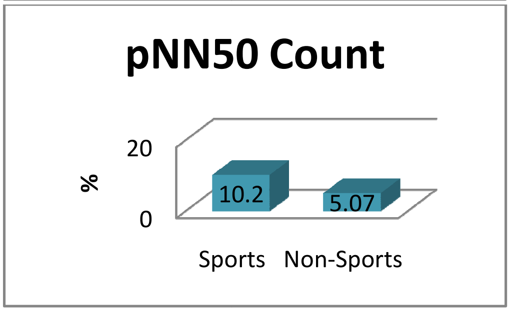
pNN 50 Count	Sports	%	10.20	8.47	3.20
	Non-Sports		5.07	3.17	1.20
RR triangular index	Sports		6.58	2.58	0.98
	Non-Sports		6.37	1.52	0.57
LF	Sports	ms^2	1310.29	1740.87	657.99
	Non-Sports		354.14	291.05	110.01
HF	Sports	ms^2	928.71	1354.98	512.13
	Non-Sports		278.43	251.72	95.14
Total Power (Absolute Power)	Sports	ms^2	2975.86	3993.20	1509.29
	Non-Sports		1094.86	785.02	296.71
LF : HF	Sports		1.55	0.84	0.32
	Non-Sports		1.48	0.63	0.24
LF (N.U.)	Sports	n.u	56.70	15.29	5.78
	Non-Sports		57.14	11.85	4.48
HF (N.U.)	Sports	n.u	43.31	15.25	5.76
	Non-Sports		42.80	11.87	4.49

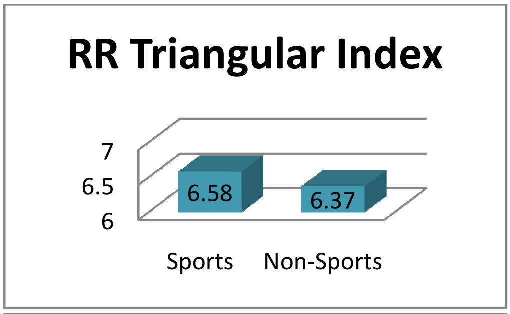
N= 14; MS- milli second; bpm- beat per minute; f- frequency; SDNN- Standard deviation of all NN intervals; HR- Heart Rate; RMSSD- The square root of the mean of the sum of the squares of differences between adjacent NN intervals; NN 50 Count- Number of pairs of adjacent NN intervals differing by more than 50 ms in the entire recording. Three variants are possible counting all such NN intervals pairs or only pairs in which the first or the second interval is longer; pNN50- NN50 count divided by the total number of all NN intervals. LF- Low Frequency; HF- High Frequency; N.U- Normalized Unit.

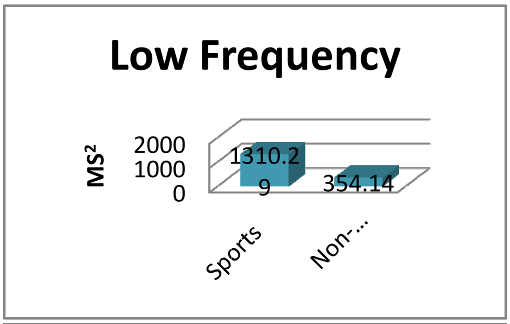


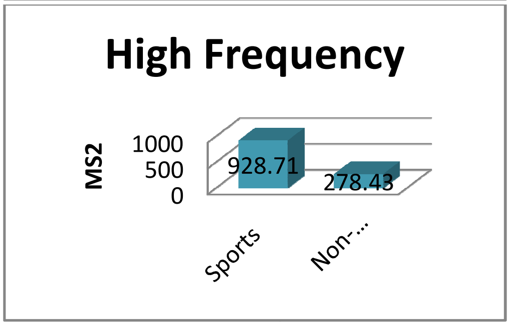

RMSSD
MS
50
0
35.67
21.7
Sports
Non-Sports

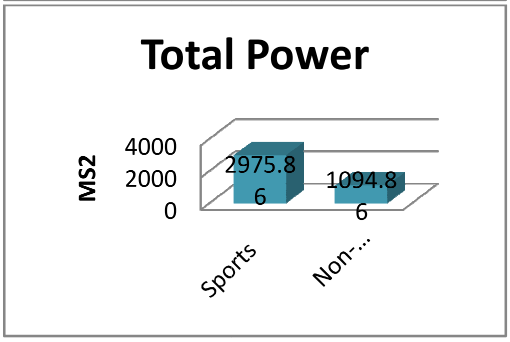

NN50 Count
F
50
0
25
18.71
Sports
Non-Sports

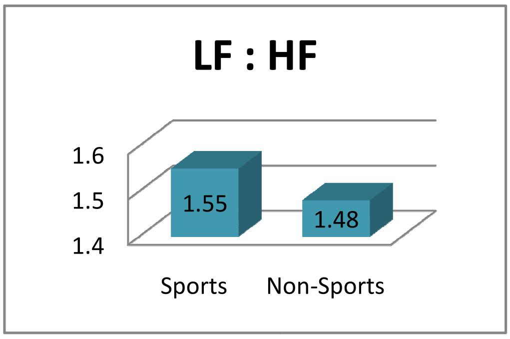

pNN50 Count
%
20
0
10.2
5.07
Sports
Non-Sports

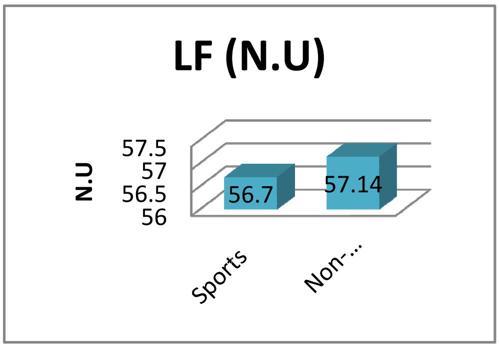

RR Triangular Index
7
6.5
6
6.58
6.37
Sports
Non-Sports


Low Frequency
MS²
2000
1000
0
1310.2
9
354.14
Sports
Non-...


High Frequency
MS2
1000
500
0
928.71
278.43
Sports
Non-...


Total Power
MS2
4000
2000
0
2975.8
6
1094.8
6
Sports
Non-...


LF : HF
1.6
1.5
1.4
1.55
1.48
Sports
Non-Sports


LF (N.U)
N.U
57.5
57
56.5
56
56.7
57.14
Sports
Non-...

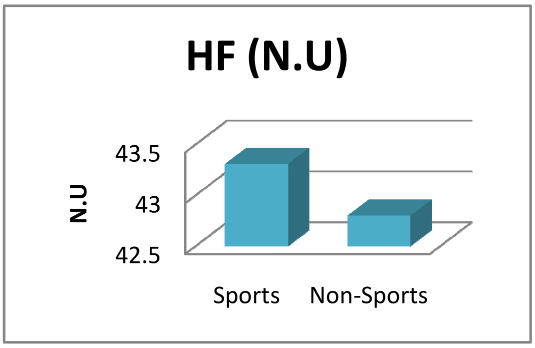

HF (N.U)
N.U
43.5
43
42.5
Sports
Non-Sports

Fig.2-- Graphical Presentation of Heart Rate Variability (Mean Value) of Female Science Student from Sports and Non-Sports Background

Table-2 shows that the mean heart rate (F= 4.76) is significant at .05 level of significance. Whereas, SDNN, RMSSD, NN 50 count, pNN50 count, HRV triangular index, LF, HF, Total Power, LF: HF, LF (N.U.) and HF (N.U.) with F= 1.78, 1.57, .44, 2.25, .04, 2.05, 1.56, 1.50, .03 .00, .01 respectively are insignificant at .05 level of significance

Table-2-- Comparison among Heart Rate Variability of Female Science Student from Sports and Non-Sports Background

Variables	Mean Square	F	Sig.
SDNN	1050.98	1.78	0.21
MEAN HR	526.81	4.76	0.05*
RMSSD	683.20	1.57	0.23
NN50 Count	138.29	0.44	0.52
pNN50Count	92.06	2.25	0.16
HRV triangular index	0.16	0.04	0.85
LF	3199732.07	2.05	0.18
HF	1480050.29	1.56	0.24
Total Power (Absolute Power)	12380000.00	1.50	0.25
LF : HF	0.02	0.03	0.86
LF (N.U.)	0.69	0.00	0.95
HF (N.U.)	0.93	0.01	0.95

N= 14; * significance at .05 level of significance; SDNN- Standard deviation of all NN intervals; HR- Heart Rate; RMSSD- The square root of the mean of the sum of the squares of differences between adjacent NN intervals; NN 50 Count- Number of pairs of adjacent NN intervals differing by more than 50 ms in the entire recording. Three variants are possible counting all such NN intervals pairs or only pairs in which the first or the second interval is longer; pNN50- NN50 count divided by the total number of all NN intervals; bpm- beat per minute; f- frequency; MS- milli second; LF- Low Frequency; HF- High Frequency; N.U- Neutralized Unit.

Discussion

HRV allows observation of the specific frequencies resulting from the fluctuations and provides insight to autonomic function. HRV is one method used to help diagnose cardiovascular disease (myocardial infarction, congestive heart failure, coronary artery disease, hypertension, and non-cardiovascular disease (stroke, diabetes, alcoholism, cancer, glaucoma, etc). High HRV is an indication of healthy autonomic and cardiovascular response. Low HRV may indicate that the sympathetic and parasympathetic nervous systems aren't properly coordinating to provide an appropriate heart rate response.[2]Heart rate variability (HRV), the spontaneous fluctuations around the mean heart rate, is a simple noninvasive measure that reflects the autonomic balance. A reduced HRV is associated with increased incidence of total mortality and cardiac events in both post infarction patients[3,4,5].

Our experimental data indicate that sports activity has positive effect. This has been demonstrated through Heart Rate Variability (Time domain and Frequency Domain Analysis). Though the statistical analysis of the data suggested that results related to SDNN, RMSSD, NN50 count, pNN50, RR triangular index, HF, Total Power LF:HF, LF (N.U and HF (N.U.) are insignificant at .05 level of significance. This is probably due to the fact that science students do not participate in sports activity regularly and exhaustively. This suggests that vigorous and regular sports activity/exercises are must to see the statistical significant results. On the other hand our experimental data indicate the statistical significant results obtained in case of mean heart rate. This suggests that mild and intermediate sports activities are sufficient to have positive effect on heart rate.

Acknowledgment

This study has been conducted as part of the innovation project (BCAS- 301) and supported by a grant from University of Delhi. We are thankful to Mr. Sandeep, Mr. Monu, MsSakshi, MsNabainita, MrSurender Singh, Mr Ankit Sinha, MrAmarjeet, Mr Rahul Sharma, Mr Vipul and Mr Nitin(all undergraduate students) for helping to take heart rate variability data.

References

1. http://www.megaemg.com/knowledge/heart-rate-variability-hrv/
2. http://www.datasci.com/solutions/cardiovascular/heart-rate-variability
3. Bigger JT Jr., Fleiss JL, Rolnitzky LM, and Steinman RC, Frequency domain measures of heart period variability to assess risk late aftermyocardial infarction. *Circulation* 85(1992), 164-171.
4. Farrell TG, Bashir Y, Cripps T, et al, Risk stratification for arrhythmic events in postinfarction patients based on heart rate variability, ambulatory electrocardiographic variables, and the signal-averaged electrocardiogram. *J. Am. Coll. Cardiol.* 18 (1991) 687-697.
5. Kiilavuori K,Toivonen L,NäveriH, and LeinonenH, Reversal of autonomic derangements by physical training in chronic heart failure assessed by heart rate variability. *Eur. Heart J.* 16 (1995) 490-495.
6. MALIKM, "Heart Rate Variability", *Clin. Cardiol.* 13(1990) 570-576.
7. Hemingway H, Shipley M, Brunner E, Britton A, Malik M, Marmot M, Does autonomic function link social position to coronary risk? The Whitehall II study, *Circulation*. 111 (2005) 3071–3077.
8. Boullosa DA, Tuimil JL, Leicht AS, Crespo-Salgado JJ, Parasympathetic modulation and running performance in distance runners, *J Strength Cond Res.* 23(2009) 626–631.
9. Rajendra Acharya, Kannathal N, Ong Wai Sing, Luk Yi Ping and TjiLeng Chua, Heart rate analysis in normal subjects of various age groups, *BioMedical Engineering OnLine.* 3 (2004)24.
10. Aubert AE, Seps B, Beckers F, Heart Rate Variability in Athletes, *Sports Med.*12 (October 2003) 889- 919
11. Huikuri HV, Makikallio TH, Airaksinen KEJ, Seppanen T, Puukka P, Raiha IJ, Sourander LB, Power-law relationship of heart rate variability as a predictor of mortality in the elderly**",** *Circulation.* 97 (1998) 2031–2036.

12. Task Force of the European Society of Cardiology and North American Society of Pacing and electrophysiology**:** Heart Rate Variability: Standards of measurement, physiological interpretation and clinical use, *European Heart Journal*17(1996)354–381.
13. De Meersman, RE, Heart rate variability and aerobic fitness, *Am. Heart J.* 125 (1993) 726-31,
14. Dixon EM, KamathMV, McCartney N, and Fallen EL, Neural regulation of heart rate variability in endurance athletes and sedentary controls, *Cardiovasc Res.* 26 (1992) 713-719.
15. Goldsmith, R, BiggerJT, Steinman R, and Fleiss J, Comparison of 24 hour parasympathetic activity in endurance-trained and untrained young men, *J. Am. Coll. Cardiol.* 20 (1992) 552-558.
16. Seals DR and ChasePB, Influence of physical training on heart rate variability and baroreflex circulatory control, *J. Appl. Physiol*. 66 (1989) 1886-1895.