FREQUENCY DOMAIN ANALYSIS OF SELECTED HEART RATE VARIABILITY (HRV) AND RESPIRATORY VARIABLES OF MALE SPORTS STUDENTS AND NON-SPORTS STUDENTS FROM SCIENCE STREAM BACKGROUND- A COMPARATIVE ANALYSIS

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Abstract— The HRV represents a physiological phenomenon that may be monitored and analyzed to determine the state of the nervous system that controls the heart. Frequency-domain analysis describes high and low frequency rates of the heart rate, which correspond to the activity of different branches of the ANS. A comparative study of frequency domain analysis of selected heart rate variability (HRV), respiratory variables of male sports students and non-sports students from science stream background was undertaken. The study was conducted on 40 male students (20 sports and 20 non- sports) aged between 17 to 21 years. Data was collected using ECG polygraphs and MIR Spirodoc device equipment. Collected data was computed for Mean, SD and ANOVA. Our results indicate that there is a positive effect of sports activity on the Heart Rate Variability and respiratory variables. The autonomic nervous system was evaluated through frequency domain analysis. The mean low frequency, high frequency and total power (absolute power) demonstrated positive effect caused by sports activities on heart rate. Though the statistical analysis showed the insignificant results at .05 level of significance. Similar results were obtained from vital capacity. The data related to respiratory rate showed the results were significant at .05 level of significance.

I. INTRODUCTION

The sympathetic and parasympathetic (autonomic) nervous systems innervate the heart and regulate heart rate (HR). The balance between these systems affects the consistency in the time between heart beats; a measure determined by calculated the heart rate variability (HRV). The HRV represents a physiological phenomenon that may be monitored and analyzed to determine the state of the nervous system that controls the heart. A simple method of detecting the autonomic response involves determining variations in consecutive time intervals between peaks of the QRS complex called the R-R interval, which can be collected in relatively simple devices such as modern wrist computers[1,18,19].

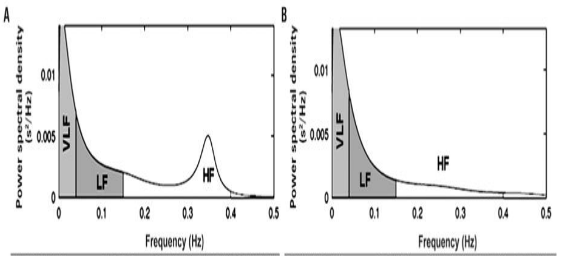
Heart rate variability (HRV) analysis has been used to evaluate patients with various cardiovascular diseases. While the vast majority of HRV studies have focused on pathological states, our study focuses on the less explored area of HRV analysis across different training intensity and sports. We aimed to measure HRV in healthy elite and masters athletes and compare to healthy, but non-athletic controls[1].

There is a large body of evidence reporting that higher variability of heart rhythm is associated with reduced mortality[2,3], improved quality of life[4] and better physical fitness[5]. The most common use of HRV analysis is in risk prediction and prevention of heart failure[6,7].

Frequency Domain Analysis

The most commonly used HRV parameters in autonomic nervous system evaluation are the frequency-domain, time domain, and Poincare plot parameters. Frequency-domain analysis describes high and low frequency rates of the variability changes, which correspond to the activity of different branches of the ANS. By applying these frequency range differences in HRV analysis, researchers are able to distinguish the individual contributions of the sympathetic and parasympathetic systems[1,2]. Low-frequency (LF) modulation (0.04-0.15 Hz) of R-R interval changes corresponds to the sympathetic and parasympathetic activities together. High-frequency (HF) modulation (0.15-0.4 Hz) of R-R interval changes is primarily regulated through innervation of the heart through the parasympathetic (vagal) nerve.

Frequency domain analysis is performed by taking a series of numbers along the time axis and computing the Fourier transform. A computationally efficient algorithm for calculating the Fourier transform, called the fast Fourier transform (FFT), can be carried out when the number of time samples is exactly a power of 2 (e.g., 256, 512, 1,024, etc.)[9]. Frequency domain methods assign bands of frequency and then count the number of NN intervals that match each band. The bands are typically high frequency (HF) from 0.15 to 0.4 Hz, low frequency (LF) from 0.04 to 0.15 Hz, and the very low frequency (VLF) from 0.0033 to 0.04 Hz8.



Frequency band	Peak (Hz)	Power (ms²)	Power (%)	Power (n.u.)
VLF (0-0,04Hz)	0,0039	464	36,4	
LF (0,04-0,15Hz)	0,0430	363	28,5	44,7
HF (0,15-0,40Hz)	0,3477	449	35,2	55,3
Total		1276		
LF/HF		0,809		

Frequency band	Peak (Hz)	Power (ms²)	Power (%)	Power (n.u.)
VLF (0-0,04Hz)	0,0039	489	46,6	
LF (0,04-0,15Hz)	0,0430	366	34,8	65,1
HF (0,15-0,40Hz)	0,1523	196	18,6	34,9
Total		1051		
LF/HF		1,869		

VLF: very low frequency band; LF: low frequency band; HF: high frequency band.

Figure 1. Spectral analysis of frequency using auto regression model, with order model 12 as per Akaike criterion for obese adolescents. Panel A: signal with predominance of parasympathetic modulation; panel B: signal with predominance of sympathetic modulation

The sympathetic and parasympathetic (autonomic) nervous systems innervate the heart and regulate heart rate (HR). The balance between these systems affects the consistency in the time between heart beats; a measure determined by calculated the heart rate variability (HRV). As illustrated in Figure 1 the HRV represents a physiological phenomenon that may be monitored and analyzed to determine the state of the nervous system that controls the heart[1].

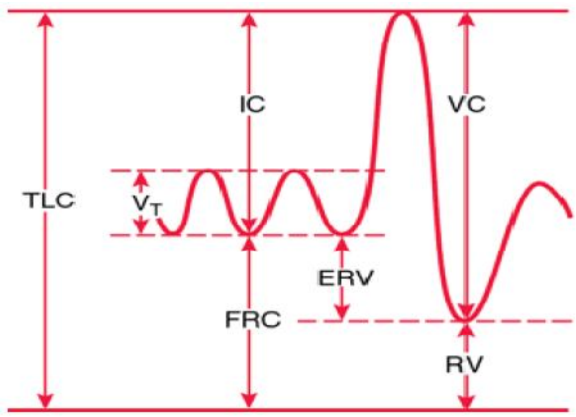
The effects of the ANS on the heart's R-R intervals are complex, resulting from both innervation of the heart and the vasculature. The heart and circulatory system are controlled primarily by higher brain centers (central command) and cardiovascular control areas in the brain stem through the activity of the ANS, which is composed of sympathetic and parasympathetic nerves. The medulla is the primary site to regulate sympathetic and parasympathetic (vagal) outflow to the heart and blood vessels. Specifically, the nucleus tractus solitarius in the medulla receives sensory input and stimulates cardiovascular responses to emotion and stress, including physical stress (e.g., exercise). From the medulla, the parasympathetic vagus nerve innervates the heart, as do sympathetic nerve fibers. The right and left vagus nerves innervate the sinoatrial (SA) and atrioventricular (AV) nodes, respectively. The atria are also innervated by vagal efferents, whereas the ventricular myocardium is sparsely innervated by vagal efferents. Sympathetic efferent nerves are present throughout the atria (including the conduction system), particularly in the SA node and ventricles.

Respiratory System

The human respiratory system is a series of organs responsible for taking in oxygen and expelling carbon dioxide. The primary organs of the respiratory system are lungs, which carry out this exchange of gases as we breathe[11].

Vital Capacity

Vital capacity (VC) the greatest volume of gas that, f ollowing maximum inhalation, can be expelled durin g a complete,slow, forced exhalation; equal to inspira tory capacity plus expiratory reserve volume.



TLC- total lung capacity; V- tidal volume; IC- inspiratory capacity; FRC- functional residual capacity; ERV-
expiratory reserve volume;
VC- vital capacity; RV- residual volume[12]

Respiratory Rate

The rate at which breaths occur, usually measured in breaths per minute, is called, the respiratory rate[13].

The HRV has long been investigated for its role in cardiac health during disease processes. However, recent studies have shown that HRV parameters are different in sports person and non- sports person or suffering from any cardiac disease. These findings suggest that the HRV parameters could be used to analyze the effect of sports and exercise training to gain insight into physiological factors and usefulness to do sports.

Depending on the health related fitness programme, significant increase vital capacity after health related fitness programme, if the capacity of the player is high then more amount of oxygen could be inhaled and maximum of CO_2 could be exhaled out. This will thus purify the blood and thus give more energy to the sedentary students[14].

It is seen that there are many problems related to health when 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. The researchers inspired by the above mentioned factors and wanted to see frequency domain analysis of selected heart rate variability (HRV) and respiratory variables of male sports students and non-sports students from science stream background.

II. OBJECTIVES

Comparison of frequency domain analysis of selected heart rate variability (HRV) and respiratory variables of male sports students and non-sports students from science stream background.

III. SAMPLE FOR THE STUDY

The study was conducted on 40 male science students (20 sports and 20 non-sports). Ages of the sample ranged from 17 to 21 years of same socio-economic status from different games/sports.

IV. METHODOLOGY

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 1) AUTONOMIC FUNCTION TEST HRV_Soft version 1.1, 2) 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. Respiratory variables were performed on MIR Spirodoc device equipment. Respiratory variables viz. were vital capacity and respiratory rate assessed by using WinspiroPRO version 6.5 software.

V. STATISTICS

Collected data was computed with Mean, Standard Deviation and Anova done on SPSS software. The findings have been presented with table numbers 1,2,3 and 4.

VI. FINDINGS

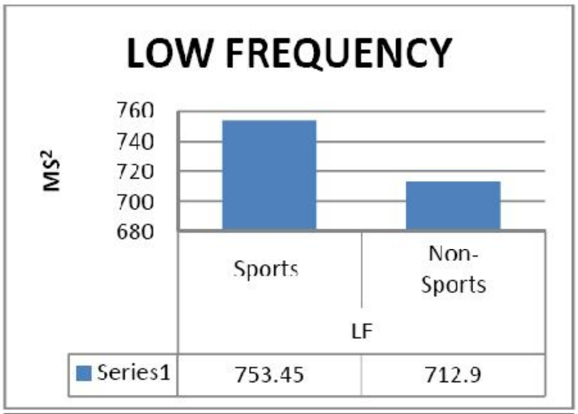
Table- 1

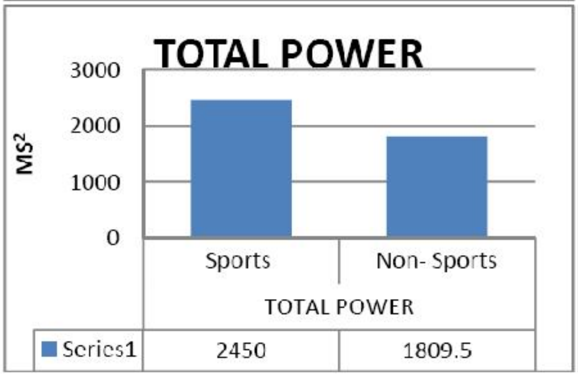
Descriptive Statistics of Frequency Domain Analysis of Selected Heart Rate Variability (HRV) of Male Sports Students and Non-Sports Students from Science Stream Background

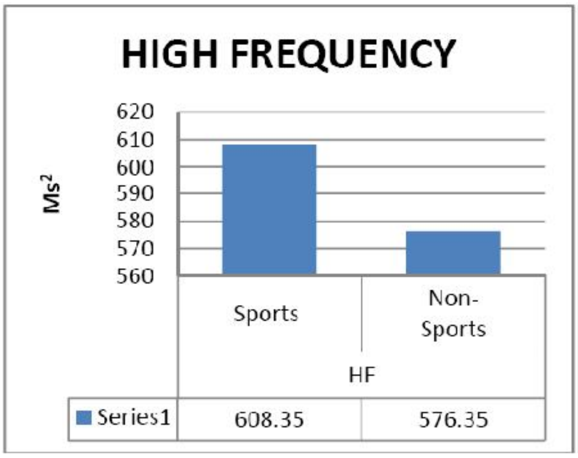
Variable		Unit	Mean	Standard Deviation	Standard Error
LF	Sports	ms^2	753.45	1145.19	256.07
	Non-Sports		712.90	1043.01	233.22
HF	Sports	ms^2	608.35	903.46	202.02
	Non-Sports		576.35	605.95	135.49
TOTAL POWER	Sports	ms^2	2450.00	2575.87	575.98
	Non-Sports		1809.50	1836.04	410.55
LF:HF	Sports	ms^2	1.52	0.88	0.20
	Non-Sports		1.30	0.92	0.21
LF (N.U)	Sports	n.u	56.49	12.27	2.74
	Non-Sports		51.34	14.15	3.16
HF (N.U)	Sports	n.u	43.49	12.26	2.74
	Non-Sports		48.62	14.16	3.17

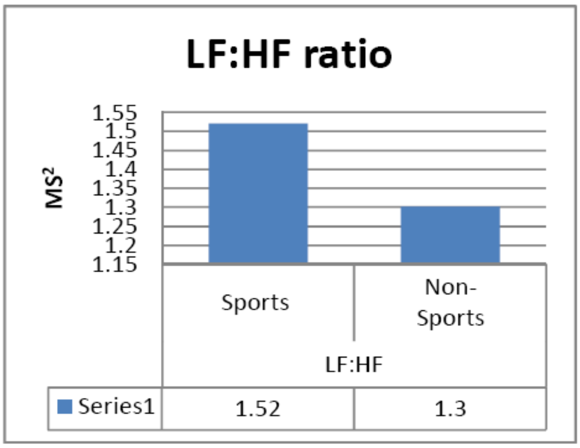
N= 40; ms- milliseconds; LF- Low Frequency; HF- High Frequency, N.U- Normalized Unit; LF (N.U)= LF power in normalized units LF/(Total Power–VLF)x100; LF (N.U)= HF power in normalized units HF/(Total Power–VLF)x100

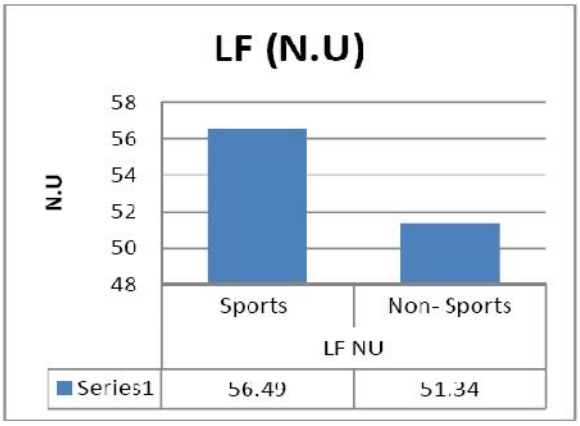
Graphical Presentation of Frequency Domain Analysis of Selected Heart Rate Variability (HRV) Variables of Male Sports Students and Non-Sports Students from Science Stream Background











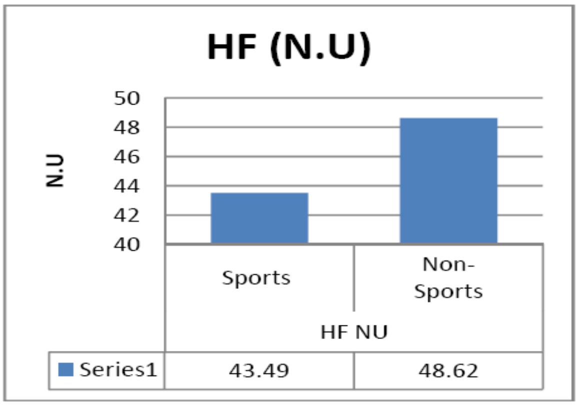
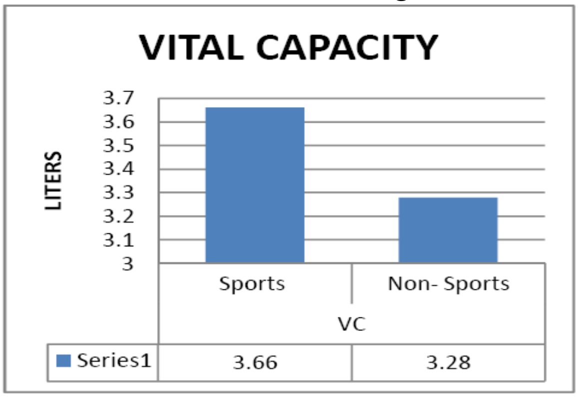


Table- 2
Descriptive Statistics of Respiratory Variables of Male Sports Students and Non-Sports Students from Science Stream Background

Variable		Unit	Mean	Std. Deviation	Std. Error
VC	Sports	L	3.66	0.94	0.21
	Non-Sports		3.28	0.52	0.12
RR	Sports	BPM	16.44	4.12	0.98
	Non-Sports		17.21	4.48	1.00

N= 40; VC- Vital Capacity; RR- Respiratory Rate: L- Liters; BPM, beat per minute

Graphical Presentation of Respiratory Variables of Male Sports Students and Non-Sports Students from Science Stream Background



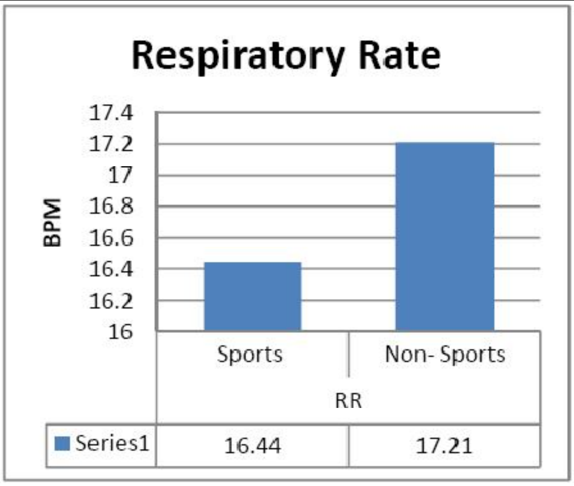


Table- 3
ANOVA on Frequency Domain Analysis of Selected Heart Rate Variability (HRV) Variables of Male Sports Students and Non-Sports Students from Science Stream Background

Variables	Mean Square	F	Significance
LF	16443.03	0.01	0.91
HF	10240	0.02	0.9
TOTAL Power(Absolute Power)	4102403	0.82	0.37
LF:HF	0.51	0.63	0.43
LFNU	264.71	1.51	0.23
HFNU	263.17	1.5	0.23

N= 40; significance at .05 level of significance; LF- Low Frequency; HF- High Frequency; NU – Normalized unit

The analysis of data in table- 3, regarding the comparison between the selected heart rate variability (HRV) variables of male sports students and non-sports students from science stream background LF having mean square= 16443.03, which having insignificant 'F' ratio .01 likely HF having mean square= 10240, which having 'F' ratio .02, Total Power having mean square= 4102403, which having 'F' ratio .82, LF:HF having mean square= .51, which having 'F' ratio .63, LFNU having mean square= 264.71, which having 'F' ratio 1.51, and HFNU having mean square= 263.17, which having 'F' ratio 1.5 were insignificant at .05 level of significance.

Table- 4
ANOVA on Frequency Variables of Male Sports Students and Non-Sports Students from Science Stream Background

Variables	Mean Square	F	Significance
VC	1.47	2.54	0.12
RR	104.26	3.76	0.04*

N= 40; *- significance at .05 level of significance; VC- Vital Capacity; RR- Respiratory Rate

The analysis of data in table- 4, regarding the comparison between the selected respiratory variables of male sports students and non-sports students from science stream background VC having mean square= 1.47, which having insignificant 'F' ratio .2.54 likely RR having mean square= 104.26, which was having significant 'F' ratio 3.76 at .05 level of significance.

VII. INTERPRETATION

- Mean projections are optimistic for heart rate variability when compared for sports and non-sports students. The projections are positive and as per the desired/expected data viz. frequency is decreasing in sports, which is positive.
- Mean and standard deviation shows a positive vital capacity in science sports person.
- The data of sports person of our college seems to be suggestive that our students although involved in sports are not purely sports students since, they are not regular in sports. This is attributed to the fact that the sample comprises of science students and such students are always under stress of academics etc.
- Respiratory rate showed significant difference between the sports students and non- sports students.

DISCUSSION

Long-term intensive sports training, employed by regional class runners preparing for competitions, changes the autonomic profile, promoting parasympathetic dominance. This may be an important argument to encourage many young and healthy people to engage in endurance sports at such intensity[16].

Our experimental data indicate that sports activity has positive effect on heart rate and respiratory activity. This has been demonstrated through Frequency Domain Analysis. Though the statistical analysis of the data suggested that results related to low frequency, high frequency and total power (Absolute Power) of heart rate variability and vital capacity are significant 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 respiratory rate. This suggests that mild and intermediate sports activities are sufficient to have positive effect on respiratory rate.

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