Frequency Domain Analysis of Persons Retired from Competitive Sports Recorded with Selected Recording Durations

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Abstract

The term heart rate variability (HRV) has become widely accepted though in practice, one usually measures the variation in the beat-to-beat interval rather than the variation in the instantaneous heart rate. HRV may be broken into the frequency components that compose the overall variability. Components of HRV in the frequency domain analyzed were LF (Normalized Power), HF(Normalized Power), LF/HF Ratio, LF(Absolute Power), HF(Absolute Power), Total Power(Absolute Power).Thirty male veteran sportsperson who had withdrawn from the competitive sports were **tested and evaluated** for time domain analysis variables. **Ages** of the sample ranged from 30 to 35 years were recorded. Recording protocols were a) recorded for 15 minutes, b) twice recorded for 10 minutes, c) thrice recorded for 5 minutes of ECG (electrocardiogram). The ECG analog were **quantified** using Fast Fourier Transform with 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. Collected data was computed with Mean, SD, 'F' ratio (ANOVA) and LSD post-hoc comparisons. The **finding** suggests that 1) LF(Normalized Power), 2) HF(Normalized Power), 3) LF/HF, 4) LF(Absolute Power), 5) HF(Absolute Power), 6) Total Power (Absolute Power) were insignificantly different among the selected recording durations. Comparison among six sets of recording protocols are not significantly different in regard to variables namely LF(Normalized Power), HF(Normalized Power), LF/HF, LF(Absolute Power) ,HF(Absolute Power), Total Power (Absolute Power).

KEYWORDS:HRV, Autonomic, Frequency Domain Analysis, Electrocardiogram

INTRODUCTION

Heart rate variability (HRV) is a measure of variation in heart rate. This term has become widely accepted though in practice, one usually measures the variation in the beat-to-beat interval rather than the variation in the instantaneous heart rate. However, because HRV is a cardiac measure derived from the ECG, it is not possible to distinguish reduced *central* vagal activity (in the vagal centers of the brain) from reduced peripheral activity (the contribution of the target organ -- the sinus node -- or the afferent/efferent pathways conducting the neural impulses to/from the brain) [1]. Additional insight into the nature of HR fluctuations may be gained by analyzing the fluctuations in the frequency domain. By analogy, one learns only about the overall power of a star by measuring the intensity of light emanating from it, but by separating the light into its component colors with a prism, one may learn about the composition of chemical reactions within the star. HRV may similarly be broken into the frequency components that compose the overall variability[2]. 'Heart Rate Variability' has become the conventionally accepted term to

describe variations of both instantaneous heart rate and RR intervals. In order to describe oscillation in consecutive cardiac cycles, other terms have been used in the literature, for example cycle length variability, heart period variability, RR variability and RR interval tachogram, and they more appropriately emphasize the fact that it is the interval between consecutive beats that is being analysed rather than the heart rate per se. However, these terms have not gained as wide acceptance as HRV, thus we will use the term HRV in this document [3].

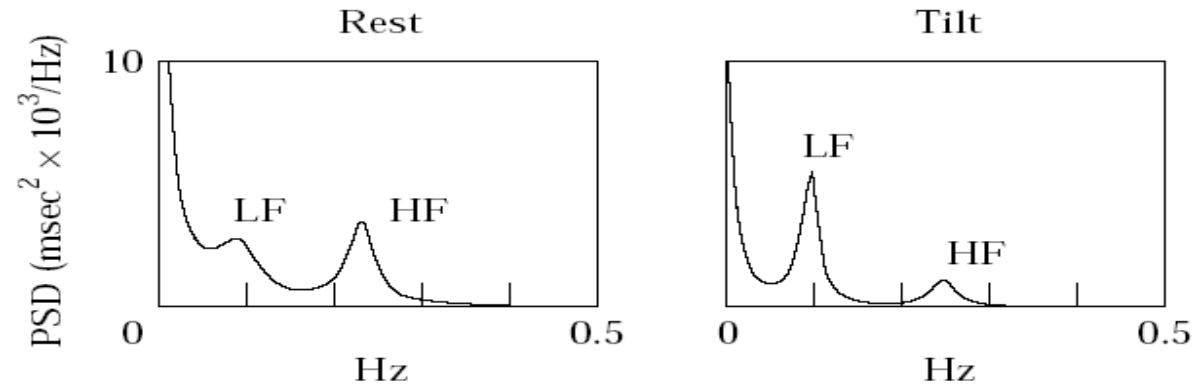
Frequency Domain Analysis

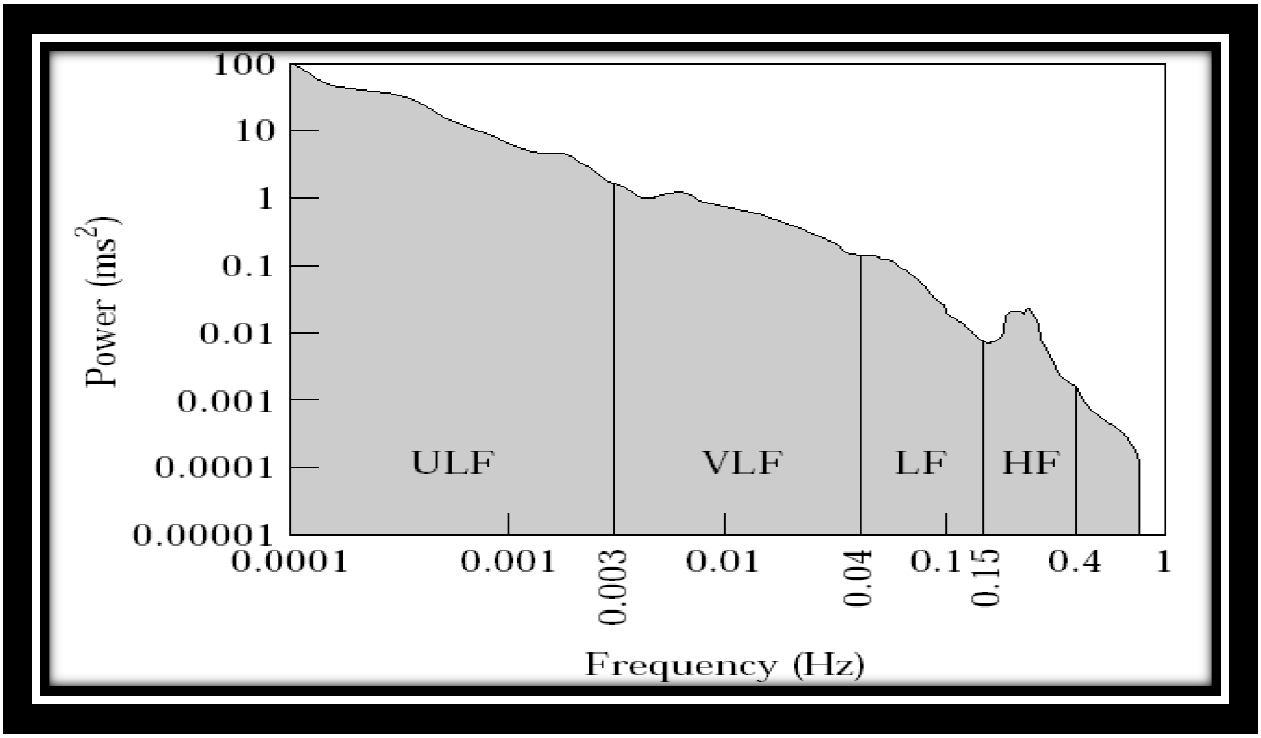
Several methods are available. Power spectral density, using parametric or nonparametric methods, provides basic information of the power (variation) distribution across frequencies. One of the most commonly used PSD methods is the Fast Fourier transform. Several frequency bands of interest have been defined in humans[4].

- High Frequency band (HF) between 0.15 and 0.4 Hz. HF is driven by respiration and appears to derive mainly from vagal activity (parasympathetic nervous system).
- Low Frequency band (LF) between 0.04 and 0.15 Hz. LF derives from both parasympathetic and sympathetic activity and has been hypothesized to reflect the delay in the baroreceptor loop.
- Very Low Frequency band (VLF) band between 0.0033 and 0.04 Hz. The origin of VLF is not well known.
- Ultra Low Frequency (ULF) band between 0 and 0.0033 Hz. The major background of ULF is day–night variation and therefore is only expressed in 24-hour recordings.
- The ratio of low-to-high frequency spectra power(LF/HF) is has been proposed as an index of sympathetic to parasympathetic balance of heart rate fluctuation, but this is controversial because of the lack of understanding of the mechanisms for the LF component.

Selected frequency domain measures of HRV[4]

Variable	Units	Description	Frequency range
• 5 min total power	ms^2	The variance of NN intervals over the temporal segment	approx. 0·4 Hz
• LF	ms^2	Power in low frequency range	0·04–0·15 Hz
• LF norm	n.u.	LF power in normalized units LF/(Total Power–VLF)x100	
• HF	ms2	Power in high frequency range	0·15–0·4 Hz
• HF norm	n.u.	HF power in normalized units HF/(Total Power–VLF) x100	
• LF/HF		Ratio LF [ms2]/HF [ms2]	





Example of an estimate of power spectral density obtained from the entire 24-h interval of a long term Holter recording. Only the LF and HF components correspond to peaks of the spectrum while the VLF and ULF can be approximated by a line in this plot with logarithmic scales on both axes. The slope of such a line is the · measure of HRV[6].

OBJECTIVE

Objective of the study is to comparefrequency domain analysis of retired sportsperson recorded with selected recording durations.

HYPOTHESIS OF THE STUDY

It was hypothesized that frequency domain analysis (selected variables)insignificantly different in regard to recorded durations.

SAMPLE FOR THE STUDY

The study was conducted on 30 males retired sports males. Ages of the sample ranged from 30 to 35 years.

STATISTICS

Collected data was computed with Mean, SD, 'F' ratio (ANOVA) and LSD post-hoc comparisons at 0.05 level of significance

FINDINGS

Table: 1

Descriptive Statistics of Selected Variables

Variable	DR	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound
LF(Normarlized Power)	1	30	50.8450	12.92932	2.36056	46.0171	55.6729
	2	30	52.0607	12.90981	2.35700	47.2401	56.8813
	3	30	48.8723	13.43826	2.45348	43.8544	53.8903
	4	30	51.0110	14.90471	2.72122	45.4455	56.5765
	5	30	52.8620	13.96210	2.54912	47.6485	58.0755
	6	30	49.3823	14.32997	2.61628	44.0314	54.7332
	Total	180	50.8389	13.64288	1.01688	48.8323	52.8455
HF(Normarlized Power)	1	30	49.1550	12.92932	2.36056	44.3271	53.9829
	2	30	47.9393	12.90981	2.35700	43.1187	52.7599
	3	30	51.1277	13.43826	2.45348	46.1097	56.1456
	4	30	48.9890	14.90471	2.72122	43.4235	54.5545
	5	30	47.1380	13.96210	2.54912	41.9245	52.3515
	6	30	50.6177	14.32997	2.61628	45.2668	55.9686
	Total	180	49.1611	13.64288	1.01688	47.1545	51.1677
LF/HF Ratio	1	30	1.1907	.65150	.11895	.9474	1.4339
	2	30	1.2393	.61897	.11301	1.0082	1.4705
	3	30	1.1080	.63995	.11684	.8690	1.3470
	4	30	1.2760	.90241	.16476	.9390	1.6130
	5	30	1.3087	.68075	.12429	1.0545	1.5629
	6	30	1.1357	.62205	.11357	.9034	1.3679
	Total	180	1.2097	.68711	.05121	1.1087	1.3108
LF(Absolute Power)	1	30	9.9265	651.50817	1.18949	749.3752	1235.9295
	2	30	9.9694	663.69738	1.21174	749.1117	1244.7690

	3	30	9.4492	645.23658	1.17804	703.9894	1185.8600
	4	30	8.6323	662.45192	1.20947	615.8617	1110.5889
	5	30	9.9309	576.21607	1.05202	777.9317	1208.2570
	6	30	1.0171	1049.63943	1.91637	625.1579	1409.0415
	Total	180	9.6799	716.69211	53.4190	862.5773	1073.4016
HF(Absolute Power)	1	30	1.2201	1324.54719	2.41828	725.5516	1714.7397
	2	30	1.2278	1480.79825	2.70356	674.8758	1780.7542
	3	30	1.2045	1259.80218	2.3000	734.1028	1674.9385
	4	30	1.1001	1757.80062	3.20929	443.7011	1756.4482
	5	30	1.1089	1027.17364	1.87535	725.3547	1492.4606
	6	30	1.1647	1360.33022	2.48361	656.7530	1672.6643
	Total	180	1.1710	1367.69012	1.01942	969.8668	1372.1906
Total Power(Absolute Power)	1	30	3.6372	2643.08926	4.82560	2650.2399	4624.1314
	2	30	3.4895	2692.52214	4.91585	2484.0624	4494.8710
	3	30	3.6548	2933.07087	5.35503	2559.5587	4750.0120
	4	30	3.0087	2883.68628	5.26487	1931.9555	4085.5278
	5	30	3.3083	2400.62010	4.38291	2411.9231	4204.7356
	6	30	3.6918	4290.65031	7.83362	2089.6715	5293.9818
	Total	180	3.4651	3003.71308	2.23884	3023.2653	3906.8465

Note: DR= Duration of Recording

Table 2
ANOVA of Selected Variables

Variable		Sum of Squares	df	Mean Square	F	Sig.
LF(Normalized Power)	Between Groups	348.128	5	69.626	.367	.870
	Within Groups	32968.829	174	189.476		
	Total	33316.957	179			
HF(Normalized Power)	Between Groups	348.128	5	69.626	.367	.870
	Within Groups	32968.829	174	189.476		
	Total	33316.957	179			
LF/HF Ratio	Between Groups	.938	5	.188	.390	.855
	Within Groups	83.572	174	.480		
	Total	84.510	179			
LF(Absolute Power)	Between Groups	479879.531	5	95975.906	.183	.969
	Within Groups	9.146	174	525649.634		
	Total	9.194	179			
HF(Absolute Power)	Between Groups	470769.377	5	94153.875	.049	.999
	Within Groups	3.344	174	1921622.876		
	Total	3.348	179			
Total Power(Absolute Power)	Between Groups	1.051	5	2102596.061	.228	.950
	Within Groups	1.604	174	9221134.089		
	Total	1.615	179			

The analysis of data in table-2 illustrate insignificant difference in LF (Normalized Power) (‘F’=.367); HF (Normalized Power) (‘F’=.367); LF/HF Ratio (‘F’=.390); LF (Absolute Power) (‘F’=.183); HF (Absolute Power) (‘F’=.049) and Total Power (Absolute Power) (‘F’=.228). Hence, this shows that all variables wiz. LF (Normalized Power), HF (Normalized Power), LF/HF Ratio, RMSSD, HF (Absolute Power) and Power (Absolute Power)can be recorded either for 15minutes, 10 minutes, and 5 minutes recording durations.

Table: 3

Multiple Comparisons (LSD) of LF (Normalized Power)of Variables Recording Durations

Dependent Variable	(I) DR	(J) DR	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
LF(Normalized Power)	1	2	-1.21567	3.55412	.733	-8.2304	5.7991
		3	1.97267	3.55412	.580	-5.0421	8.9874
		4	-.16600	3.55412	.963	-7.1807	6.8487
		5	-2.01700	3.55412	.571	-9.0317	4.9977
		6	1.46267	3.55412	.681	-5.5521	8.4774
	2	3	3.18833	3.55412	.371	-3.8264	10.2031
		4	1.04967	3.55412	.768	-5.9651	8.0644
		5	-.80133	3.55412	.822	-7.8161	6.2134
		6	2.67833	3.55412	.452	-4.3364	9.6931
	3	4	-2.13867	3.55412	.548	-9.1534	4.8761
		5	-3.98967	3.55412	.263	-11.0044	3.0251
		6	-.51000	3.55412	.886	-7.5247	6.5047
	4	5	-1.85100	3.55412	.603	-8.8657	5.1637
		6	1.62867	3.55412	.647	-5.3861	8.6434
	5	6	3.47967	3.55412	.329	-3.5351	10.4944

*. The mean difference is significant at the 0.05 level.

Note: DR= Duration of Recording; DR1= 30 samples recorded for 15minutes; DR2= 30 samples recorded for 10minutes; DR3= 30 samples recorded for next 10minutes; DR4= 30 samples recorded for 5minutes; DR5= 30 samples recorded for next 5minutes; DR6= 30 samples recorded for next 5minutes

The analysis of data in table- 3 demonstrated insignificant differences between all the recording durations wiz DR1, DR2, DR3, DR4, DR5, DR6 in regard to NN50 count at 0.05 level of significance.

Table: 4

Multiple comparisons (LSD) of HF(Normalized Power)of variables recording durations

Dependent Variable	(I) DR	(J) DR	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
HF(Normalized Power)	1	2	1.21567	3.55412	.733	-5.7991	8.2304
		3	-1.97267	3.55412	.580	-8.9874	5.0421

		4	.16600	3.55412	.963	-6.8487	7.1807
		5	2.01700	3.55412	.571	-4.9977	9.0317
		6	-1.46267	3.55412	.681	-8.4774	5.5521
	2	3	-3.18833	3.55412	.371	-10.2031	3.8264
		4	-1.04967	3.55412	.768	-8.0644	5.9651
		5	.80133	3.55412	.822	-6.2134	7.8161
		6	-2.67833	3.55412	.452	-9.6931	4.3364
	3	4	2.13867	3.55412	.548	-4.8761	9.1534
		5	3.98967	3.55412	.263	-3.0251	11.0044
		6	.51000	3.55412	.886	-6.5047	7.5247
	4	5	1.85100	3.55412	.603	-5.1637	8.8657
		6	-1.62867	3.55412	.647	-8.6434	5.3861
	5	6	-3.47967	3.55412	.329	-10.4944	3.5351

*. The mean difference is significant at the 0.05 level.
Note: DR= Duration of Recording; DR1= 30 samples recorded for 15minutes; DR2= 30 samples recorded for 10minutes; DR3= 30 samples recorded for next 10minutes; DR4= 30 samples recorded for 5minutes; DR5= 30 samples recorded for next 5minutes; DR6= 30 samples recorded for next 5minutes

The analysis of data in table- 4 demonstrated insignificant differences between all the recording durations wiz DR1, DR2, DR3, DR4, DR5, DR6 in regard to HF (Normalized Power) at 0.05 level of significance.

Table: 5

Multiple comparisons (LSD) of LF/HF Ratio of variables recording durations

Dependent Variable	(I) DR	(J) DR	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
LF/HF Ratio	1	2	-.04867	.17894	.786	-.4018	.3045
		3	.08267	.17894	.645	-.2705	.4358
		4	-.08533	.17894	.634	-.4385	.2678
		5	-.11800	.17894	.510	-.4712	.2352
		6	.05500	.17894	.759	-.2982	.4082
	2	3	.13133	.17894	.464	-.2218	.4845
		4	-.03667	.17894	.838	-.3898	.3165
		5	-.06933	.17894	.699	-.4225	.2838

	6	.10367	.17894	.563	-.2495	.4568
3	4	-.16800	.17894	.349	-.5212	.1852
	5	-.20067	.17894	.264	-.5538	.1525
	6	-.02767	.17894	.877	-.3808	.3255
4	5	-.03267	.17894	.855	-.3858	.3205
	6	.14033	.17894	.434	-.2128	.4935
5	6	.17300	.17894	.335	-.1802	.5262

*. The mean difference is significant at the 0.05 level.
Note: DR= Duration of Recording; DR1= 30 samples recorded for 15minutes; DR2= 30 samples recorded for 10minutes; DR3= 30 samples recorded for next 10minutes; DR4= 30 samples recorded for 5minutes; DR5= 30 samples recorded for next 5minutes; DR6= 30 samples recorded for next 5minutes

The analysis of data in table- 5 demonstrated insignificant differences between all the recording durations wiz DR1, DR2, DR3, DR4, DR5, DR6 in regard to LF/HF Ratio at 0.05 level of significance.

Table: 6

Multiple comparisons (LSD) of LF (Absolute Power) of variables recording durations

Dependent Variable	(I) DR	(J) DR	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
LF(Absolute Power)	1	2	-4.28800	1.87199E2	.982	-373.7602	365.1842
		3	47.72767	1.87199E2	.799	-321.7446	417.1999
		4	129.42700	1.87199E2	.490	-240.0452	498.8992
		5	-.44200	1.87199E2	.998	-369.9142	369.0302
		6	-24.44733	1.87199E2	.896	-393.9196	345.0249
	2	3	52.01567	1.87199E2	.781	-317.4566	421.4879
		4	133.71500	1.87199E2	.476	-235.7572	503.1872
		5	3.84600	1.87199E2	.984	-365.6262	373.3182
		6	-20.15933	1.87199E2	.914	-389.6316	349.3129

	3	4	81.69933	1.87199E2	.663	-287.7729	451.1716
		5	-48.16967	1.87199E2	.797	-417.6419	321.3026
		6	-72.17500	1.87199E2	.700	-441.6472	297.2972
	4	5	-129.86900	1.87199E2	.489	-499.3412	239.6032
		6	-153.87433	1.87199E2	.412	-523.3466	215.5979
	5	6	-24.00533	1.87199E2	.898	-393.4776	345.4669

*. The mean difference is significant at the 0.05 level.
Note: DR= Duration of Recording; DR1= 30 samples recorded for 15minutes; DR2= 30 samples recorded for 10minutes; DR3= 30 samples recorded for next 10minutes; DR4= 30 samples recorded for 5minutes; DR5= 30 samples recorded for next 5minutes; DR6= 30 samples recorded for next 5minutes

The analysis of data in table- 6 demonstrated insignificant differences between all the recording durations wiz DR1, DR2, DR3, DR4, DR5, DR6 in regard to LF(Absolute Power) at 0.05 level of significance.

Table: 7

Multiple Comparisons (LSD) of HF (Absolute Power) of Variables Recording Durations

Dependent Variable	(I) DR	(J) DR	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
HF(Absolute Power)	1	2	-7.66933	3.57922E2	.983	-714.0970	698.7583
		3	15.62500	3.57922E2	.965	-690.8027	722.0527
		4	120.07100	3.57922E2	.738	-586.3567	826.4987
		5	111.23800	3.57922E2	.756	-595.1897	817.6657
		6	55.43700	3.57922E2	.877	-650.9907	761.8647
	2	3	23.29433	3.57922E2	.948	-683.1333	729.7220

	4	127.74033	3.57922E2	.722	-578.6873	834.1680
	5	118.90733	3.57922E2	.740	-587.5203	825.3350
	6	63.10633	3.57922E2	.860	-643.3213	769.5340
3	4	104.44600	3.57922E2	.771	-601.9817	810.8737
	5	95.61300	3.57922E2	.790	-610.8147	802.0407
	6	39.81200	3.57922E2	.912	-666.6157	746.2397
4	5	-8.83300	3.57922E2	.980	-715.2607	697.5947
	6	-64.63400	3.57922E2	.857	-771.0617	641.7937
5	6	-55.80100	3.57922E2	.876	-762.2287	650.6267

*. The mean difference is significant at the 0.05 level.
Note: DR= Duration of Recording; DR1= 30 samples recorded for 15minutes; DR2= 30 samples recorded for 10minutes; DR3= 30 samples recorded for next 10minutes; DR4= 30 samples recorded for 5minutes; DR5= 30 samples recorded for next 5minutes; DR6= 30 samples recorded for next 5minutes

The analysis of data in table- 7 demonstrated insignificant differences between all the recording durations wiz DR1, DR2, DR3, DR4, DR5, DR6 in regard to HF(Absolute Power) at 0.05 level of significance.

Table: 8

Multiple comparisons (LSD) of Total Power (Absolute Power)of variables recording durations

Dependent Variable	(I) DR	(J) DR	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Total Power(Absolute Power)	1	2	147.71900	7.84055E2	.851	-1399.7637	1695.2017
		3	-17.59967	7.84055E2	.982	-1565.0823	1529.8830
		4	628.44400	7.84055E2	.424	-919.0387	2175.9267

		5	328.85633	7.84055E2	.675	-1218.6263	1876.3390
		6	-54.64100	7.84055E2	.945	-1602.1237	1492.8417
	2	3	-165.31867	7.84055E2	.833	-1712.8013	1382.1640
		4	480.72500	7.84055E2	.541	-1066.7577	2028.2077
		5	181.13733	7.84055E2	.818	-1366.3453	1728.6200
		6	-202.36000	7.84055E2	.797	-1749.8427	1345.1227
	3	4	646.04367	7.84055E2	.411	-901.4390	2193.5263
		5	346.45600	7.84055E2	.659	-1201.0267	1893.9387
		6	-37.04133	7.84055E2	.962	-1584.5240	1510.4413
	4	5	-299.58767	7.84055E2	.703	-1847.0703	1247.8950
		6	-683.08500	7.84055E2	.385	-2230.5677	864.3977
	5	6	-383.49733	7.84055E2	.625	-1930.9800	1163.9853

*. The mean difference is significant at the 0.05 level.

Note: DR= Duration of Recording; DR1= 30 samples recorded for 15minutes; DR2= 30 samples recorded for 10minutes; DR3= 30 samples recorded for next 10minutes; DR4= 30 samples recorded for 5minutes; DR5= 30 samples recorded for next 5minutes; DR6= 30 samples recorded for next 5minutes

The analysis of data in table- 8 demonstrated insignificant differences between all the recording durations wiz DR1, DR2, DR3, DR4, DR5, DR6 in regard to Total Power (Absolute Power) at 0.05 level of significance.

DISCUSSION

In the present study we compared all the selected variables of frequency domain analysis and analyzed that LF (Normalized Power), HF (Normalized Power), LF/HF Ratio, RMSSD, HF (Absolute Power) and Power (Absolute Power) can be recorded either for 15minutes, 10 minutes, or 5 minutes recording durations. All selected variables of frequency domain are insignificantly different in respect to variable duration recording. This shows that frequency domain analysis is not dependant on duration recording.

CONCLUSION

The recording of 15 minutes, 10 minutes successively and 5 minutes successively are not different in respect to LF (Normalized Power), HF (Normalized Power), LF/HF Ratio, RMSSD, HF (Absolute Power) and Power (Absolute Power)duration recordings.

RECOMMENDATION

It is recommended that for selected recording durations, same duration must be followed in further experiments/research

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