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Original Research Article

Effect of Meditation on Time and Frequency Domain Parameters of Heart Rate Variability

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ABSTRACT

Introduction: The Advanced meditation program provides optimal conditions for going deep within, quieting our mental chatter, and experiencing profound rest and inner silence. The goal of present study was to evaluate effects of Advanced Meditation Program on Linear parameters-time domain and frequency domain of heart rate variability.

Method: The study was conducted in Department of physiology, Rajasthan University of Health Sciences, Jaipur in association with art of living organization. Advance meditation program is conducted by art of living organization. Subjects who voluntarily enrolled in meditation and healthy controls were assessed, after taking written consent. A detailed history was taken and detailed general physical examination and Anthropometric measurements along with baseline ECG was recorded for 5 minutes. Participants were divided in three groups. Linear parameters of Heart Rate Variability were assessed in Physiology Research lab before advanced meditation program and after Completion of advanced meditation program.

Results: In this study, an attempt has been made to evaluated the linear dynamics of HRV – specifically time domain and Frequency domain in advanced meditation program and compare and correlate them. In reference to time domain and frequency domain parameters of HRV, individuals practicing meditation had increased pRR50 (68.65 ± 3.45) and RMSSD (64.55 ± 3.75), increased HF (58.42 ± 1.28), and decreased LF (26.78 ± 1.26), decreased LF/HF ratio less than one (0.650± .15) in comparison to subjects who was not practicing meditation regularly significant differences exist in HRV parameters (RMSSD, pNN50, HF, LF, LF/HF) b/w subjects practicing meditation results was statistical highly significant (P value = <0.0001).

Conclusion: Results of this study show that, if meditation practiced regularly can emerge as one of the important non-pharmacological tool for primary prevention of cardiovascular disease and restoring sympathovagal balance and also evaluate linear parameters time domain and frequency domain and compare & correlate these parameters.

Keywords: Heart Rate Variability, Advanced Meditation Program, Autonomic Nervous System, Time Domain and Frequency Domain.

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INTRODUCTION

Meditation refers to the practices that focus on training to internalized attention under greater voluntary control, thereby foster specific mental capacities such as relaxation and even complete quiescence. It involves various practicing techniques and different meditative phases. Since meditation has been found related to relaxation, the changes in Sympathovagal balance are expected. Heart rate variability (HRV) has been a technique widely used to measure the status of autonomic nervous system.

Heart rate variability can be easily measured noninvasively, making it an attractive signal to use in the study of human physiological response to different stimuli.[1-2] Heart rate variability (HRV) is the change in the time interval between heartbeats. It is controlled by the autonomic nervous system, which also controls many other vital functions of the body. Heart rate variability (HRV) has been used as a noninvasive marker of cardiac autonomic activity and cardiovascular risk stratification.[2] This system has two

important components, the sympathetic and the parasympathetic systems. The sympathetic component, in a simplified sense, increases heart rate and the parasympathetic component decreases heart rate. Thus, the observed heart rate variability is an indicator of the dynamic interaction and balance between these two components of the system.[3]

HRV analyzes the characteristics of normal-normal (NN) intervals. Linear parameters in HRV are divided into two categories: time and frequency domains. HRV parameters of time domain includes root-mean-square of the successive differences of NNs (RMSSD) and the number of pairs of successive NNs that differ by more than 50 ms divided by total number of NNs (pNN50); while those of frequency domain includes spectral power of NNs in high frequency (HF, 0.15-0.4Hz) reflecting parasympathetic activity, low frequency (LF, 0.04-0.15Hz) indicating sympathetic function, and low frequency-to-high frequency ratio (LF/HF) as an index of autonomic balance.[4]

Sympathovagal balance is the ratio of absolute LF to absolute HF power, or LF/HF. Change of either the numerator or the denominator must change the fraction. Thus, a reduction of LF with no change of HF will reduce the fraction, and a reduction of HF with no change of LF will increase the fraction. According to published precedents,[5-6] the former change would be interpreted as a shift of sympathovagal balance toward vagal predominance and the latter as a shift of sympathovagal balance toward sympathetic predominance.

ADVANCED MEDITATION PROGRAM

Art of Living Course Part II, duration of course is four days. Designed by art of living organization comprises of- Rejuvenating yoga-pranayama, basic asans, Two to three days of guided silence practice, Sudarshan Kriya, Unique guided meditations., Seva, Satsang.[7-9]

Benefits of meditation program

- Meditation reduces stress, improves concentration and memory.
- It encourages a healthy lifestyle, increases self-awareness, happiness, acceptance
- It slows aging, practice benefits cardiovascular and immune health.
- The practice of silence – of consciously withdrawing our energy and attention from outer distractions has been used in different ways throughout time as a pathway to physical, mental, and spiritual renewal.[8-9]

However, studies on linear component of HRV in advanced meditation program are not well documented. Therefore, in this study, an attempt has been made to assess specifically the linear dynamics of HRV time domain and frequency domain in advanced meditation program and compare and correlate them.

MATERIALS AND METHODS

Aims: The present study was designed to study the effect of meditation on beat-to-beat heart rate dynamics by assessing the time and frequency domain components of HRV in subject practicing meditation regularly, the purpose of this study was to assess specifically the linear dynamics time domain and frequency domain of HRV in advanced meditation program and compare and correlate b/w time domain and frequency domain them The Advanced meditation program designed by art of living organization comprised of padmasans, sudharshan kriya and meditation effective than practicing only meditation for sympathovagal balance and also to compare and correlate linear parameters of heart rate variability. Hence aim of present study was to assess the effects of program on sympathovagal balance by assessing linear components of HRV-time and frequency domain parameters.

Study design

The study was designed as a cross sectional pilot study, conducted in Research Lab Department of physiology, Rajasthan University of Health Sciences, Jaipur in association with art of living organization. Subjects who voluntarily enrolled in meditation program and healthy controls were included in study.

Happiness program: During this course, using both theory and practice, people learn different kinds of prānāyāma: the three-part breathing yogic technique, the bhastrika, and the Sudarshan Kriya.[8-9]

Participants

In the age range of 18 to 40 yrs.& Cohens perceived stress score of 17 or higher were included in study, participants of the program who were suffering from any kind of chronic disease or who were any kind of meditation were not included, after taking written consent from subjects they were communicated to fill stress questionnaire. A detailed history was taken and general physical examination was done. Anthropometric measurements were taken and baseline ECG was recorded for 5 minutes. Participants were divided in three groups of 10 subjects , Group A,B,C , Group A- Comprises of subjects who have never participated in any meditation program ,Group B- Comprises of subjects who participated in advanced meditation program first time and have not meditated earlier , Group C -Comprises of subjects who are actively doing meditation since two years and have participated in 3 or more meditation program .Heart Rate Variability was assessed in physiology lab before advanced meditation program and after Completion of advanced meditation program and results were compared.

Interventions

Advance meditation program, comprises of a session of yoga in the morning (padamasadhana) followed by sudarshan kriya and after that different types of guided meditation.

Analysis of heart rate variability: ECG signals were recorded by a digital physiograph AD instruments. The signals were filtered digitally and processed to extract QRS peaks which determine the R-R intervals. These QRS peaks were automatically detected and were reviewed visually for R-wave determination and ectopic beats. Areas of ECG in which identification of beats was poor or ectopic beats were present were excluded. The time and frequency domain indices were computed from 5-minute segments

LINEAR DYNAMICS

Time domain analysis

The time domain indices computed using statistical methods on RR tachogram, included mean-RR (mean of RR interval), SDNN (standard deviation [SD] of RR interval), RMSSD (the square root of the mean of the sum of the squares of the differences between adjacent RR intervals), RR 50 (the number of pairs of adjacent RR intervals differing by >50 ms in the entire recording) and pRR50 (the percentage of RR 50 counts, given by RR 50 count divided by

total number of all RR intervals).Among these indices from linear dynamics of short-term HRV SDNN, RMSSD, NN50 and PNN50 indices represent the cardiac parasympathetic drive (vagal tone).[10,11]

Frequency domain analysis

Frequency domain analysis was done by power spectral analysis using fast Fourier transformation. The frequency domain indices included low frequency (LF; 0.04-0.15 Hz), high frequency (HF; 0.15-0.4 Hz), total power (TP), LF in normalized units (LFnu), HF in normalized units (HFnu) and the ratio of LF to HF (LF-HF ratio). The LF and LFnu represent sympathetic tone. The LF-HF ratio depicts the sympathovagal balance.[10,11]

Fig 1: **Group A; Comprising of subjects who have never participated in any meditation program**

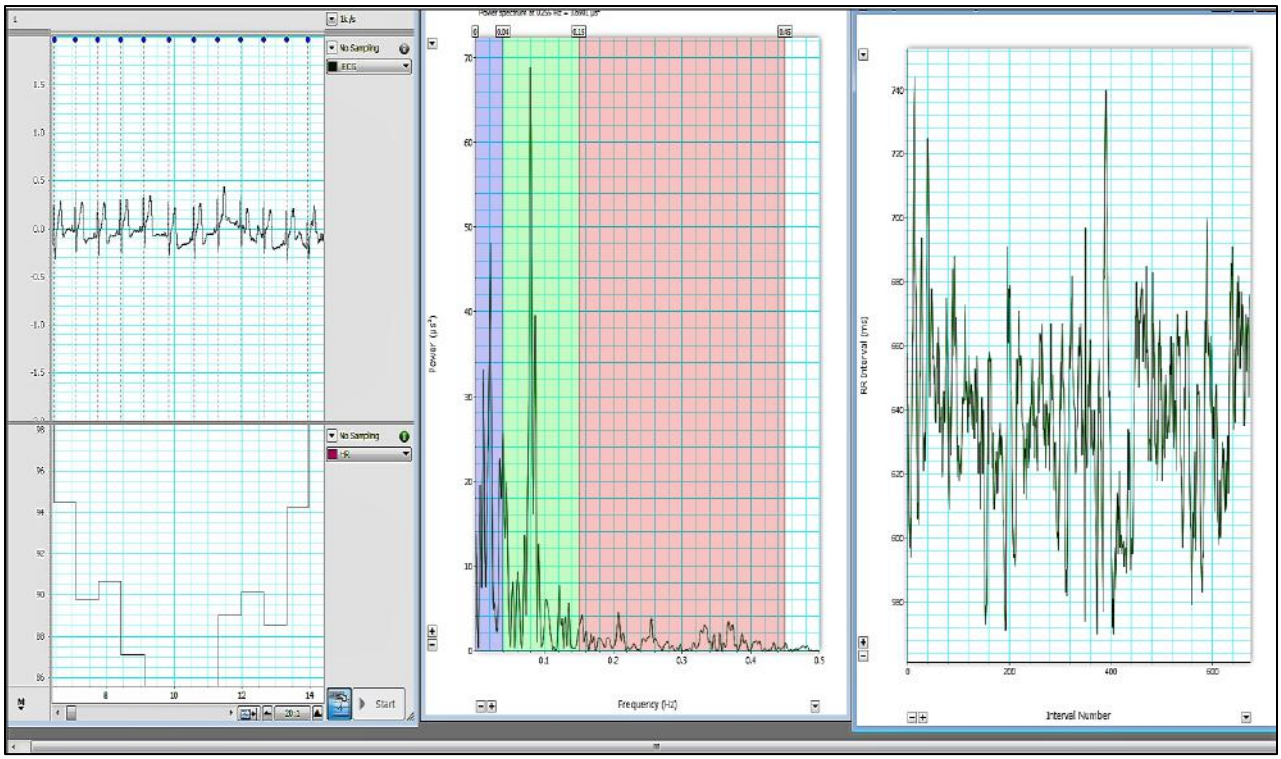


Chart view **Power spectrum density** **Tachogram**

Power spectrum graph of subjects who have never participated in any meditation program. The frequency variation is only in the range of low frequency. This indicates the variation in frequency is less and nonconsistent inn subjects.

Report view

GENERAL

Analysis Start	Block: 1, 0 s
Analysis End	Block: 1, 6:28.288
Total Included Beats	524
Included Normal Beats	524
Included Ectopic Beats	0

TIME-DOMAIN

Average RR	734.3 ms
Median RR	738 ms
SDRR	39.29 ms
SDARR	0 s
CVRR	0.05351
Average Rate	81.96 BPM
SD Rate	4.716 BPM
SDSD	21.66 ms
RMSSD	21.64 ms
pRR50	2.29 %

FREQUENCY-DOMAIN

VLF Band	0 - 0.04 Hz
LF Band	0.04 - 0.15 Hz
HF Band	0.15 - 0.45 Hz

Band	Power(µs²)	Power(%)	Power(nu)
Total	897.3		
VLF	413	46.03	
LF	395.9	44.12	81.74
HF	84.81	9.452	17.51
LF/HF		4.667	

NONLINEAR

SD1	15.32 ms
SD2	53.41 ms

Fig 2: Group B; Comprising of subjects who participated in Advanced meditation program for first time.

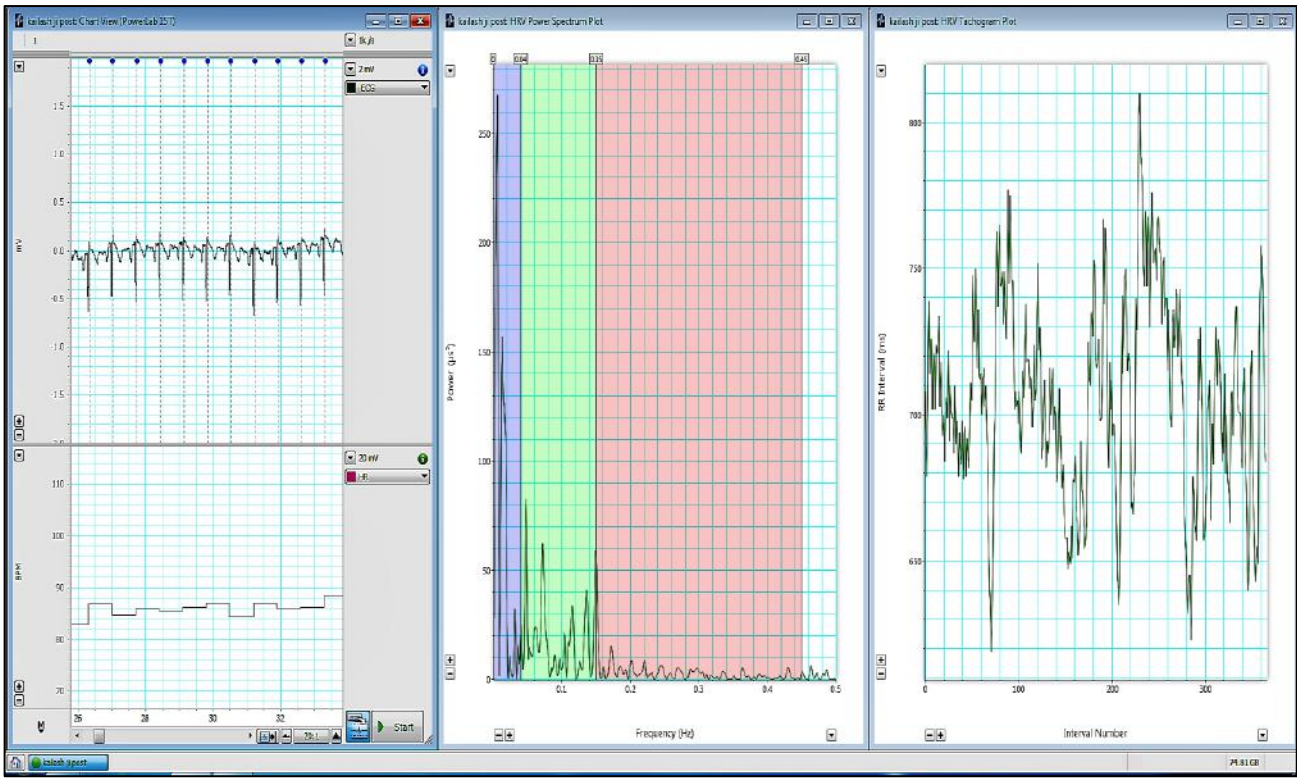


Chart view **Power spectral graph** **Tachogram**

Figure 2 shows power spectrum plot of subjects who have participated in Advanced meditation program for first time. The frequency variation is in the range of low frequency component and less in high frequency component. This indicates the variation in frequency is more than in those subjects who have never participated in any meditation program.

Report view

GENERAL

Analysis Start	Block: 1, 0 s
Analysis End	Block: 1, 6:36.638
Total Included Beats	366
Included Normal Beats	366
Included Ectopic Beats	0

TIME-DOMAIN

Average RR	705.9 ms
Median RR	706 ms
SDRR	34.11 ms
SDARR	0 s
CVRR	0.04831
Average Rate	85.19 BPM
SD Rate	4.136 BPM
SDSD	30.75 ms
RMSSD	33.59 ms
pRR50	17.49 %

FREQUENCY-DOMAIN

VLF Band	0 - 0.04 Hz
LF Band	0.04 - 0.15 Hz
HF Band	0.15 - 0.45 Hz

Band	Power(μs²)	Power(%)	Power(nu)
Total	2167		
VLF	1013	46.72	
LF	795.5	36.71	68.9
HF	359.6	16.59	31.14
LF/HF		2.212	

NONLINEAR

SD1	21.75 ms
SD2	43.06 ms

Fig 3: Group C; Comprising of subjects who are actively doing meditation for two years and have participated in 3 or more meditation program.

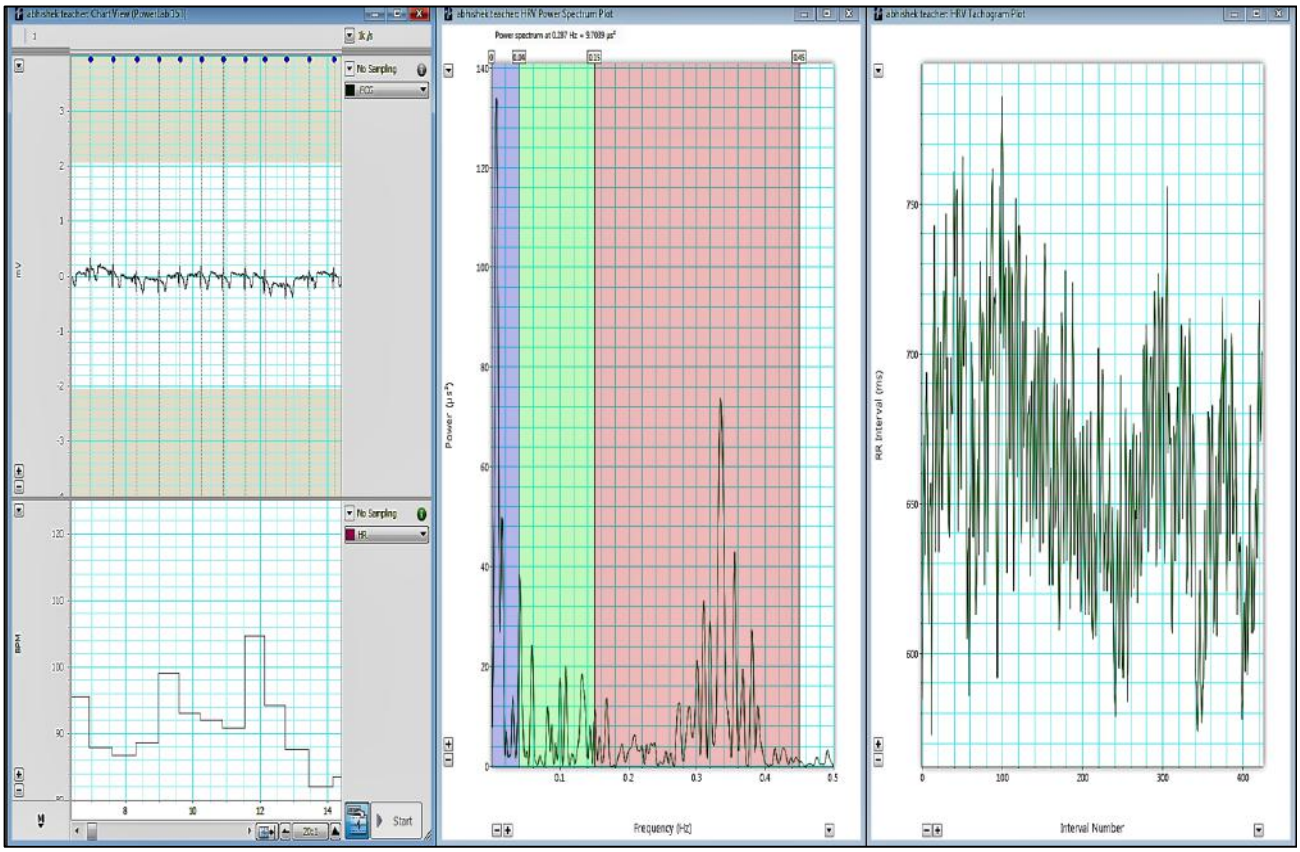


Chart view **Power spectrum Graph** **Tachogram**

Figure 3 shows subjects who have actively doing meditation for two years and have participated in 3 or more meditation program. . The frequency variation in the range of high frequency components.

Report view

GENERAL

Analysis Start	Block: 1, 0 s
Analysis End	Block: 1, 6:32.838
Total Included Beats	15
Included Normal Beats	15
Included Ectopic Beats	0

TIME-DOMAIN

Average RR	699.8 ms
Median RR	695 ms
SDRR	46.37 ms
SDARR	0 s
CVRR	0.06627
Average Rate	86.09 BPM
SD Rate	5.702 BPM
SDSD	35.82 ms
RMSSD	65.37 ms
pRR50	66.67 %

FREQUENCY-DOMAIN

VLF Band	0 - 0.04 Hz
LF Band	0.04 - 0.15 Hz
HF Band	0.15 - 0.45 Hz

Band	Power(μs²)	Power(%)	Power(nu)
Total	5.375e+004		
VLF	8809	16.39	
LF	1.468e+004	27.32	32.68
HF	2.673e+004	49.73	59.47
LF/HF		0.5495	

NONLINEAR

SD1	25.33 ms
SD2	60.49 ms

Statistical analysis: Statistical analysis was done using SPSS software, Version 19. For data analysis, all values were expressed as mean ± SD. P < .05 was considered statistically significant.

RESULTS

Group A: Comprises of subjects who have never participated in any meditation program

Group B: Comprises of subjects who participated in Advanced meditation program for first time.

Group C: Comprises of subjects who are actively doing meditation for two years and have participated in 3 or more meditation program.

Table 2, Group A, B, C mean LF, HF, LF/HF Ratio pre-and post-meditation group was 77.69, 66.07,31.02, 16.72, 25.81, 55.61, 4.604, 2.85, 0.715, 77.69, 60.35, 26.78.650 In post group C HF component is high, and LF component, LF/HF ratio is low as compared to post group B and A and p value between pre-and post-group is highly significant (<0.0001)

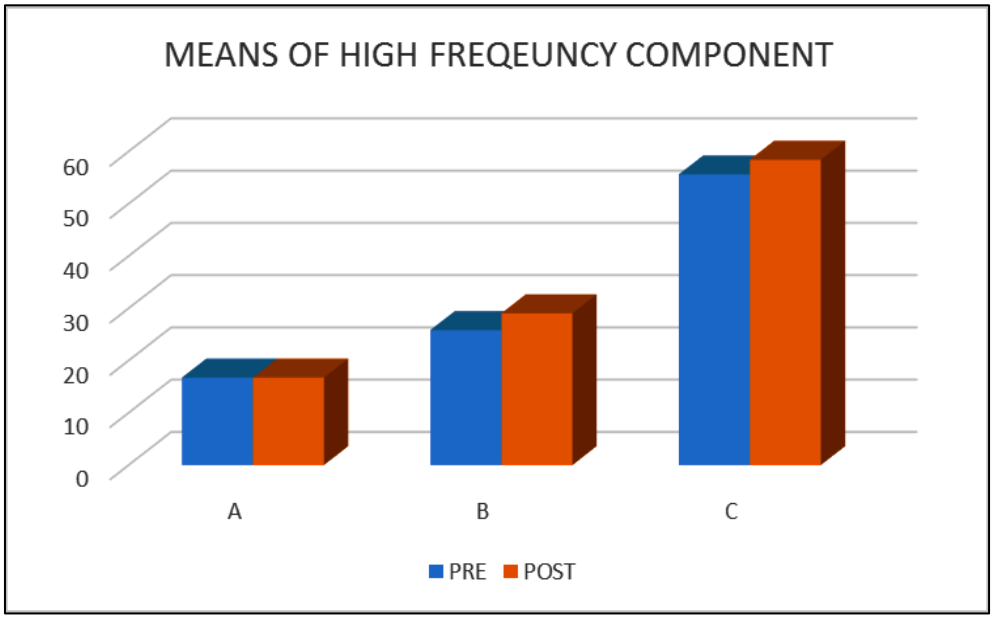
Table 1: Comparison of demographic parameters amongst three groups.

Demographic parameters	Group A Mean ±SD	Group B Mean ±SD	Group C Mean ±SD
Age (years)	25.1±4.4	26.1±4.2	27.1±4.2
Height (cm)	166±7.7	167.8±5.1	168.8±5.1
Weight (kg)	63.6±7.6	62.8±7.8	62.8±7.8
Body mass index (Kg /m2)	24.2±2.8	22.5±3.1	22.5±3.1

Table 2: Frequency domain analysis- Comparison of Mean Power spectral indexes (LF, HF, LF/HF) amongst three groups.

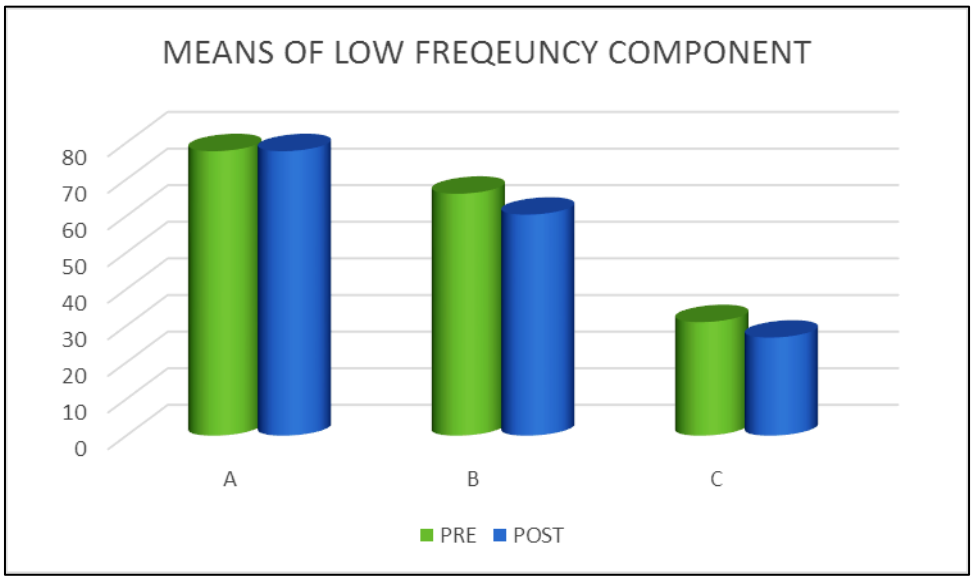
Parameters	Group A		Group B		Group C	
	Pre	post	pre	post	pre	post
LF	77.69±2.20	77.69±2.20	66.07±1.72	60.35±1.72	31.02±.95	26.78±1.26
P value			.0000004		.0000001	
HF	16.72±1.01	16.72±1.01	25.81±1.77	29.03±1.76	55.61±1.40	58.42±1.28
P value			0.00035039		0.00008985	
LF/HF Ratio	4.604± .704	4.604±.704	2.85±.233	1.85±.233	.715±.193	.650±.15
P value			<.0001		<.0001	

Pre-and post-meditation recordings of group A, B, C; LF-Low frequency component, HF-High frequency component, LF/HF-Low frequency to high frequency ratio, SD-Standard deviation.

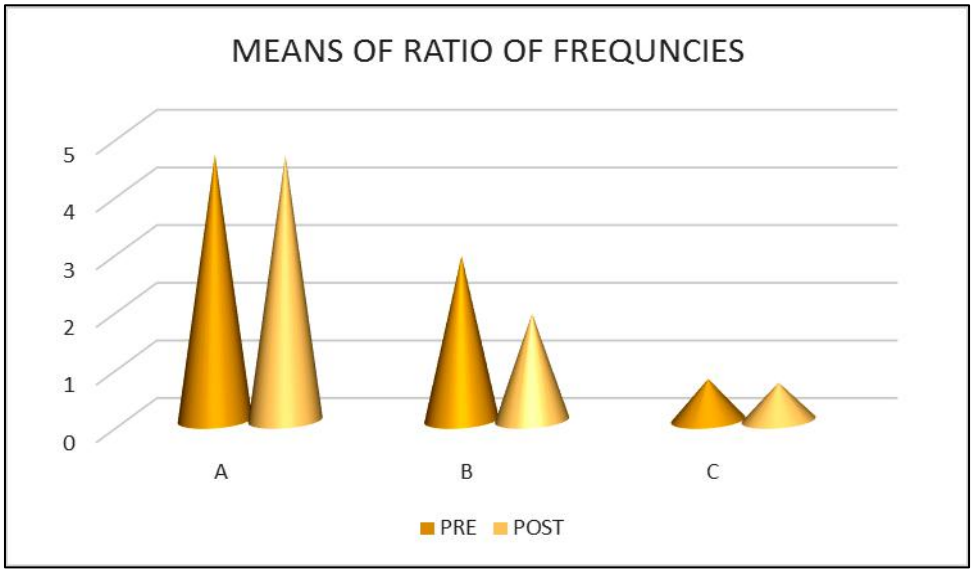


Graph 1: Bar graph on effects of meditation program compared b/w Group A, B, C

HF component was high in Group C compare to A & B.



Graph 2: Bar graph on effects of meditation program compared b/w Group A, B and C. LF component was high in Group A, compared to B & C.



Graph 3: Bar graph on effects of Meditation program compared with Group A, B, C. Ratio of frequencies of HR variability was high in Group A, compared to B, C.

Table 3: One way analysis of variance for high frequency component for post group

Variation	Sum of Squares	Degrees of Freedom	Mean Sum of Squares	F Ratio	P Value	Inference
Between Groups	9180.793	2	4590.397	2398.591	<0.0001	HS
Within Groups	51.67229	27	1.913789			
Total	9232.465	29				

Table 4: One way analysis of variance for low frequency component for post group

Variation	Sum of Squares	Degrees of Freedom	Mean Sum of Squares	F Ratio	P Value	Inference
Between Groups	13399.98	2	6699.991	1646.755	<0.0001	HS
Within Groups	109.8522	27	4.068601			
Total	13509.83	29				

Table 5: One way analysis of variance for ratio of frequencies for post group

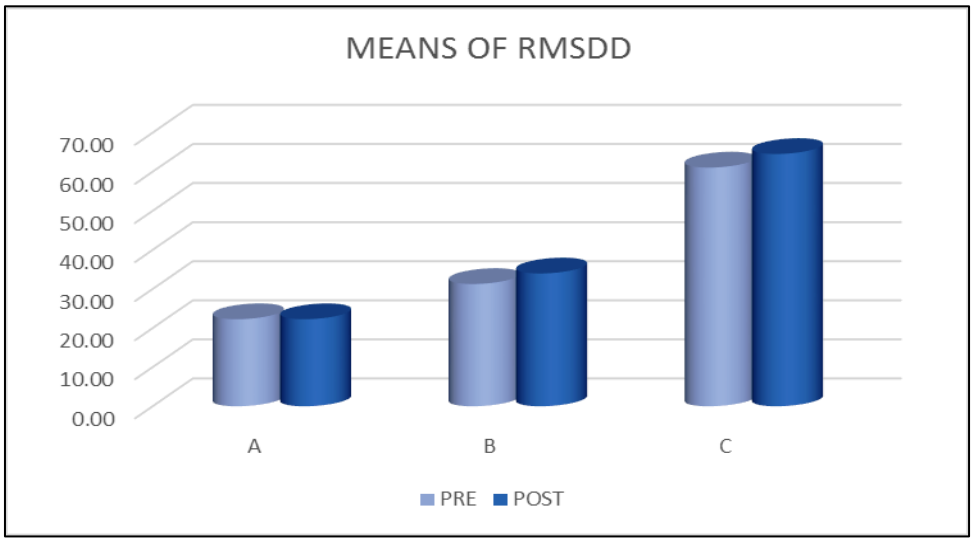
Variation	Sum of Squares	Degrees of Freedom	Mean Sum of Squares	F Ratio	P Value	Inference
Between Groups	82.1982	2	41.0991	215.347	<0.0001	HS
Within Groups	5.15297	27	0.19085			
Total	87.3512	29				

Table 6: Time domain analysis- Comparison of Mean Time domain indexes (RMSDD, pRR50)

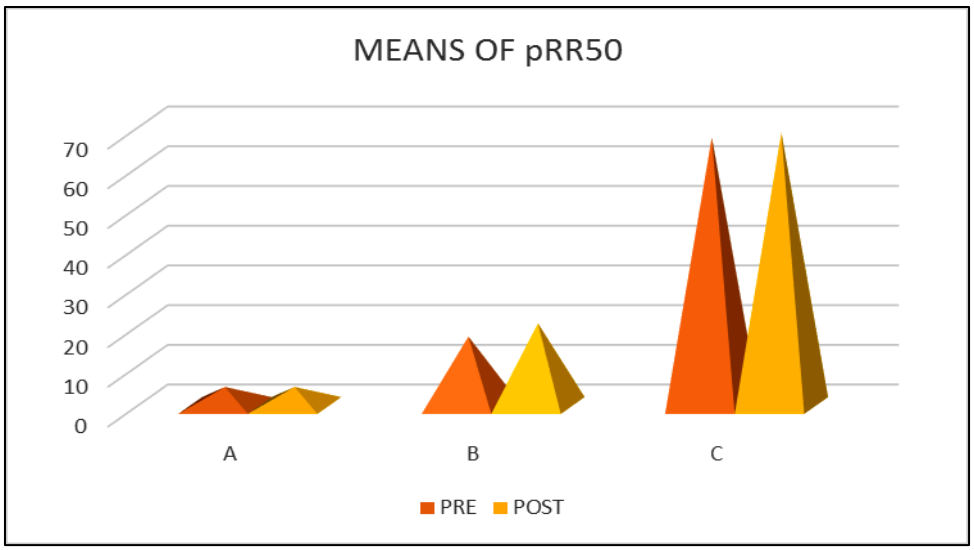
Parameters	Group A		Group B		Group c	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**
RMSDD	22.27±2.95	22.27±2.95	31.28±2.88	33.98±2.91	61.07±4.38	64.55±3.75
p value			.0258		.0361	
PRR50	4.67±1.76	4.67±1.76	17.36±2.25	20.67±2.61	67.53±4.19	68.65±3.45
p value			.00354		.2610	

RMSDD-Root mean standard deviation, pRR50-probability of RR interval at 50 ms

Table-6, show that in Pre-and post-Group A, B and C the values of RMSDD and PRR50 22.27, 31.28, 61.07, 4.67, 17.36, 67.53, 22.27, 33.98, 64.55, 4.67 20.67, 68.65 mean in post group C RMSDD and PRR50 component is highest compared to post group B and A (also shown in bar graph 4,5) and p value between pre-and post-group is significant. (<.05)



Graph 4: Bar graph on effects of meditation program compared with group A, B, C. Mean of RMSDD of heart rate variability was high in Group C, compared to A& B groups.



Graph 5: Bar graph on effects of advance meditation program compared with Group A, B, C. pRR50 component of HR variability was high in Group C, compared to A& B groups.

Table 7: One way analysis of variance for RMSDD for post group

Variation	Sum of Squares	Degrees of Freedom	Mean Sum of Squares	F Ratio	P Value	Inference
Between Groups	9530.84	2	4765.42	457.366	<0.0001	HS
Within Groups	281.32	27	10.4193			
Total	9812.16	29				

Table 8: One way analysis of variance for pRR50 for post group

Variation	Sum of Squares	Degrees of Freedom	Mean Sum of Squares	F Ratio	p Value	Inference
Between Groups	22173.23	2	11086.61	1521.538	<0.0001	HS
Within Groups	196.7342	27	7.286454			
Total	22369.96	29				

Karl Pearson's correlation coefficient (post groups)

Table 9: Correlation between HF component and pRR50 for Group A, B, C

BETWEEN	GROUP	r VALUE	p VALUE	INFERENCE
High freq comp and pRR50	**A**	-0.2145	0.1590	NS
	B	-0.1508	0.3121	NS
	C	-0.1119	0.4491	NS

Table 10: Correlation between HF component and RMSDD for Group A, B, C

BETWEEN	GROUP	r VALUE	p VALUE	INFERENCE
High free comp and RMSDD	**A**	0.1826	0.2254	NS
	B	0.6836	0.0002	VS
	C	0.9962	<0.0001	HS

Table 11: Correlation between LF component and pRR50 for Group A, B, C

BETWEEN	GROUP	r VALUE	p VALUE	INFERENCE
Low freq comp and pRR50	**A**	-0.3786	0.0201	S
	B	-0.5464	0.0017	VS
	C	0.3244	0.0415	S

Table 12: Correlation between low frequency component and RMSDD for Group A, B, C

BETWEEN	GROUP	r VALUE	p VALUE	INFERENCE
Low freq comp and RMSDD	**A**	-0.0273	0.8516	NS
	B	0.0744	0.6121	NS
	C	-0.1878	0.2133	NS

Table 13: Correlation between Ratio of frequencies and pRR50 for Group A, B, C

BETWEEN	GROUP	r VALUE	p VALUE	INFERENCE
Ratio of freq and pRR50	**A**	-0.0855	0.5607	NS
	B	0.0880	0.5497	NS
	C	0.003	0.9836	NS

Table 14: Correlation between Ratio of frequencies and RMSDD for Group A, B, C

BETWEEN	GROUP	r VALUE	p VALUE	INFERENCE
Ratio of freq and RMSDD	**A**	0.6808	<0.0001	HS
	B	-0.5116	0.0030	VS
	C	0.0867	0.5556	NS

DISCUSSION

Studies on linear components of HRV in advanced meditation program are not well documented. Hence, in this study, an attempt has been made to assess linear parameters- time domain and frequency domains, and to establish correlation between time and frequency domain parameters of Heart Rate Variability.

The Power Spectral Density recordings reveal the relative strengths of frequency components of the signal [12]Frequencies in the range 0.0033 to 0.04 Hz (VLF) are associated with parasympathetic activity; frequencies from 0.15 to 0.4 Hz (HF) are associated with sympathetic activity. The intervening band (LF) is a mixture of the two influences.[13] The HF reflects parasympathetic activity, the LF reflects the sympathetic modulation, and LF/HF ratio indicates sympathovagal balance.[14-15]

In our study on effect of advanced meditation program in pre and post meditation recordings it was observed that in the spectral analysis in Group A, B and C as shown in Table 2, mean LF, HF, LF/HF Ratio in post meditation recordings of group CHF component is high and LF component, LF/HF ratio is low (Bar graph 1,2,3) as compared to post meditation recordings in group B and A (Bar graph 1,2,3) and p value between pre and post group is highly significant which is suggests that para sympathetic activity is increased after meditation and is highest in group C subjects ,who are regularly doing meditation since last two years as compared to group B and A with concomitant sympathetic withdrawal, the outcome of study has been found similar to studies undertaken after meditation.by Murata et al.[16,] Takahashi et al [17.]

In previous studies, it has been reported that Increased normalized unit of HF (nuHF)[16-19] decreased normalized unit of LF (nuLF)[16,18,20] and decreased LF/HF[16,18,20] in HRV have been found during various forms of meditation.

The Power Spectral Density plots are applied widely to monitor the sympathovagal change.[21] The significance of all the HRV measurements has been verified under the correlation with various physiological variables which reflect the changing of autonomic balance.[22]

Table-6, shows that in Pre-and post-meditation recordings in Group A, B and C, the values of mean RMSDD and PRR50 is highest compared to post meditation recordings in group B and A (also shown in bar graph 4,5) and p value between pre-and post-group is significant (<.05). As far as the HRV parameters in time domain are concerned RMSDD and PRR50 shows para sympathetic activity which is high in group C (Bar graph 4,5) i.e. subjects who are actively doing meditation for two years as compared to groups B and A. Previous studies by An H et al.[18] on meditation found increased PRR50 and RMSSD similar to the findings of present study.

Tells et al.[22] compared changes in HRV during the first four meditative states, cancalata (random thinking), ekagrata (nonmeditative focusing), dharana (meditative focusing), and dhyana (effortless meditation) and it was observed that during dhyana, in which effortless meditation was exercised, there was significant increase in pNN50 and RMSDD. The results of the present study show that time domain parameters exhibited significant difference on comparison in pre-and post-meditation group. Since the meditation technique employed in our study is similar to meditative focusing, our results are concordant with the part dhyana.[22]

In our study, we also evaluated Karl Pearson correlation coefficient between high frequency and pRR50 (Table 9) in post meditative readings of group A, B and C but the findings were not significant. The correlation between high frequency and RMSDD (Table 10) in group A was not significant, in group B very significant & in group C highly significant. The correlation between low frequency & pRR50 (Table 11) in group A was found to be significant, in group B very significant and in group C was found to be significant. The correlation between low frequency component of frequency domain and RMSDD component of time domain (Table 12) no significant correlation was observed in post meditative findings of all the three groups. The ratio of frequency (low frequency and high frequency) and pRR50 (Table 13) for Group A, Group B and Group C was not significant and correlation between ratio of frequency and RMSDD (Table 14) for Group A was found to be highly significant, in Group B very significant and in Group C not significant.

In our study one way analysis of variance in post meditative group for high frequencies, low frequencies, ratio of low to high frequencies, pRR50, RMSDD (Table 3,4,5,7,8) was highly significant.

LIMITATIONS OF THE STUDY

The sample size in each group in the present study was modest and study was at a point of time. Therefore, we could not perform logistic regression analysis to assess the contribution of linear parameters to autonomic function and its predictive role in the assessment CV risks. Studies should be conducted in larger sample size and multicentral to further establish the predictive and investigative importance of linear parameters in meditation group.

CONCLUSION

Results of this study show that, if meditation practiced regularly can emerge as one of the important non-pharmacological tool for primary prevention of cardiovascular disease and restoring sympathovagal balance. We have measured and compared HRV parameters from pre-and post-group after meditation in different groups. The results show after meditation, significant differences exist between different groups in terms of HRV parameters.

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