Original article

Effect of Advance Meditation Program on Poincare plot of Heart Rate Variability in young population

[1]Dr.Sudhanshu Kacker , [2]Dr.Neha Saboo , [3]Dr.Mahima Sharma , [4]Dr.Mohit Sharma , [5]Dr.Sonali Sharma, [6] Jitendra

[1]Professor and Head, Department of Physiology, RUHS College of Medical Sciences, Jaipur
[2]Assistant Professor, Department of Physiology, RUHS College of Medical Sciences, Jaipur
[3]Senior Demonstrator , Department of Physiology, RUHS College of Medical Sciences,Jaipur
[4]Assistant Professor, CTVS department,SMS Medical college and associated group of hospital ,Jaipur
[5]Professor and Head ,Department of Biochemistry , RUHS College of Medical Sciences,Jaipur
[6]M.Sc. student,RUHS College of Medical Sciences, Jaipur
Corresponding author: Dr.Neha Saboo, Assistant Professor, Department of Physiology, RUHS College of Medical Sciences, Jaipur

Abstract

Introduction- Meditation leads to experience of complete quiescence, absence of self-boundaries, blissful feeling, and inner light. The goal of present study was to evaluate effects of Advanced Meditation Program on heart rate , ECG and 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 was done and Anthropometric measurements along with baseline ECG were recorded for 5 minutes. Participants were divided in Three groups. Heart Rate Variability was assessed in Physiology Research lab before advanced meditation program and after Completion of advanced meditation program .

Result-In this study, an attempt has been made to assess specifically the nonlinear dynamics of HRV using Poincare plot in advanced meditation program and compare it with that of the HRV assessed by linear measures. Linear and non linear parameters of heart rate variability , frequency domain and Poincare plot were evaluated.. Then linear parameter , frequency domain and non linear parameters were compared. The LF power and the SD2 of the Poincaré plot decreased in subjects who were meditating. Additionally, a significant correlations were found between LF and SD2, HF and SD1 ($p < 0.05$), and LF/HF and SD2/SD1 ($p < 0.01$).However, the LF, SD2 and LF/HF decreased; the HF, SD1 and SD1/SD2 ratio increased after meditation.

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. Poincare plot analysis is easier and more sensitive in evaluating the sympathovagal balance and observing the beat to beat HRV.

Keywords: Heart rate variability, Advanced Meditation Program, Poincare plot, Autonomic Nervous System.

Introduction-

The advanced stage of meditation leads one to experience complete quiescence, the absence of self boundaries, blissful feeling, and inner light.Meditation refers to the practices that focus on training internalized attention under greater voluntary control, and thereby foster specific mental capacities such as relaxation and even complete quiescence.

Happiness Program

The central - piece of the Art of living Happiness program is a unique and profound breathing technique. A practical tool that restores body, mind and spirit into its natural rhythm of being, the SudarshanKriya has positively transformed millions and millions of lives. Its uniqueness is not only in its performance, but also in its formation as his Holiness Along with SudarshanKriya, other powerful breathing techniques, yoga and meditation

It involves in various practicing techniques and different meditative phases - SudarshanKriya, other powerful breathing techniques, yoga and meditation . Since meditation has been found related to relaxation, the changes in autonomic nervous system (ANS) of subjects are likely to be affected.

Heart rate variability (HRV) has been used as a noninvasive marker of cardiac autonomic activity and cardiovascular risk stratification.[1]HRV is an index of vagal tone and reflects the balance between parasympathetic and sympathetic system .

Sympathetic nervous system activation accelerates heart rate (HR) thereby decreasing HRV, whereas parasympathetic nervous system activation decelerates HRand increases HRV.[2]Conventionally, there are two main approaches to HRV analysis, the time domain analysis using the various statistical measures and the frequency domain analysis using the spectral analysis by Fast Fourier transformation. Both of these measures are linear models of HRV analysis. However, time and frequency domain methods have got some technical limitations such as stationary requirement and the linear assumptions in which these techniques are based, and in some cases these methods are insensitive and more susceptible to interference by ectopic rhythm.

The analysis of Poincare plots or sections of RR intervals is an emerging method of nonlinear dynamics applied in HRV analysis.[3]

The Poincaré plot analysis is a geometrical and nonlinear method to assess the dynamics of HRV.[3] It is a plot in which each R-R interval is marked as a function of the previous R-R interval where the values of each pair of successive R-R interval define a point in the plot. Poincaré plots have been evaluated in a qualitative way using their visual pattern whereby the shape of the plot is categorized into functional classes that have prognostic value in various disease and can be evaluated quantitatively through the computation of the SD indexes of the plot[4]. The plot provides summary information as well as detailed beat-to-beat information on the behavior of the heart.[5] Hence Poincare plot analysis may be a better way to monitor the dynamic change of autonomic function during meditation. Genesis of HRV also involves the nonlinear phenomena, which are determined by complex interactions of hemodynamic, electrophysiological and humoral variables, as well as by autonomic and central nervous regulations.[1] Hence, the analysis of the nonlinear dynamics of HRV would enable a better physiological interpretation of the HRV.[1]

Poincare plot of RR intervals is a useful visual tool, which is capable of summarizing an entire RR time series derived from an electrocardiogram (ECG) in

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one picture, and a quantitative technique which gives information on the long- and short-term HRV.[6]

Howeverstudies on nonlinear component of HRV in advanced meditation program are not well documented.Therefore, in this study, an attempt has been made to assess specifically the nonlinear dynamics of HRV using Poincare plot in advanced meditation programand compare it with that of the HRV assessed by linear measures. Using Poincare plot analysis may be a better way to asses dynamic changes of autonomic functions during meditation.

Materials and Methods:-

Aims-

The purpose of this study was to assess specifically the nonlinear dynamics of HRV using Poincare plot in advanced meditation program and compare it with that of the HRV assessed by linear measures.. Our goal was to assess if Advanced meditation program which includes padmasans,sudharshan kriya and different phases of meditation is more effective than practising only meditation for sympathovagal balance and also to compare linear and non linear parameters of heart rate variability.

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 and healthy controlswere included in study. Advance meditation program is conducted by art of living organization. and eligibility to participate in this course is participant must have participated in at least one happiness program.

Inclusion criteria:

- age between 18 and 40 years
- Cohen perceived stress score of 17 or higher (PSS; Cohen et al. 1983).
- participant must have participated in at least one happiness program

Exclusion criteria:

- Cohen perceived stress score of 17 or less (PSS; Cohen et al. 1983)
- Subjects on any kind of meditation
- Subjects suffering from any kind of Chronic diseases like hypertension, diabetes etc.

Participants:

After taking written consent from subjects they were communicated to fill stress questionnaire (Cohen perceived stress scale.. A detailed history was taken and detailed general physical examination was conducted. 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 neve 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.

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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 geometric and frequency domain indices were computed from 5-minute segments

Linear dynamics--

Frequency domain analysis

Frequency domain analysis of 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).

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, the HF, HFnu, TP, SDNN, RMSSD, NN50 and PNN50 of HRV indices represent the cardiac parasympathetic drive (vagal tone). The LF and LFnu represent sympathetic tone. The LF-HF ratio depicts the sympathovagal balance.[1]

Nonlinear dynamics: Using Poincare plot

These have been derived from the 5-minute Poincaré plot representing a diagram in which each R-R interval of tachogram is plotted against the previous R-R interval.

It is a two-dimensional graphic representation of the correlation between consecutive RR intervals, in which each interval is plotted against the following interval and its analysis can be done in a qualitative way, by assessing the shape formed by its attractor, which shows the degree of complexity of RR intervals, or in a quantitative way. The quantitative analysis is done by fitting an ellipse to the shape formed by the plot and measure the dispersion along the major and minor axis of the ellipse.[7,8]

There are two standard descriptors of Poincare plot namely:

Standard deviation 1

- The length of the transverse line is defined as the SD1 of the plot data in perpendicular direction.
- It is the standard deviation (SD) of the instantaneous (short-term) beat-to-beat R-R interval variability (minor axis of the ellipse or SD1).

Standard deviation 2

- The length of the longitudinal line is defined as the SD2 of the plot data
- It is the SD of the long-term R-R interval variability (major axis of the ellipse or SD2).[7,8]

Furthermore, additional parameters were computed which included:

Area of the ellipse (S)

- It is given as the amount of area covered by the ellipse

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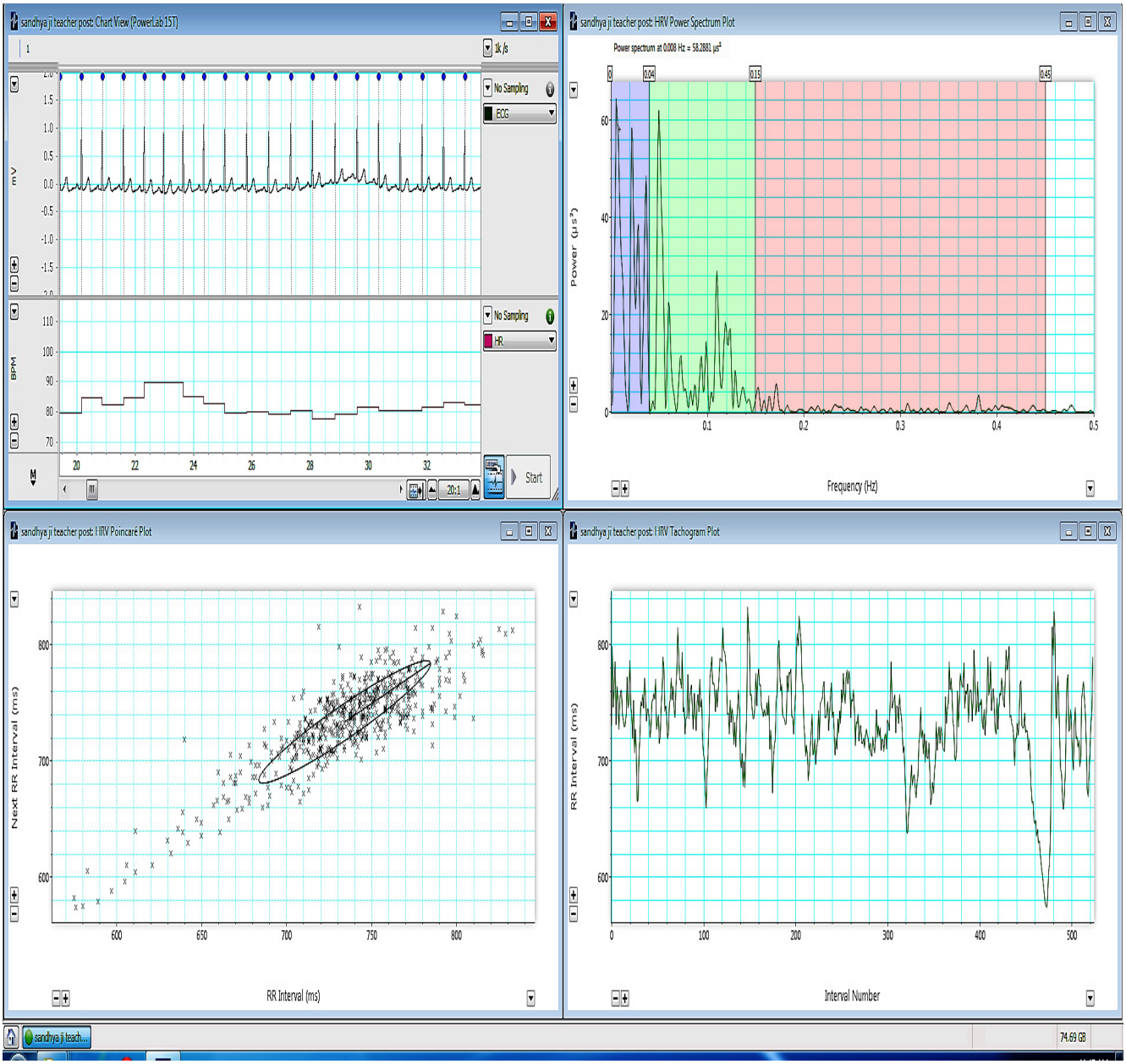
- It is calculated by doing the product of π, SD1, and SD2.
- It represents total HRV.[9]

A normal configuration of the plot was defined as a fan or comet shape. Abnormal forms were a random pattern characterized by asymmetrical RR-interval clusters; a torpedo-shaped pattern with narrow configuration that lacked RR-interval dispersion.[9]

Figure-1

Group A- Comprising of subjects who have never participated in any meditation program



2.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

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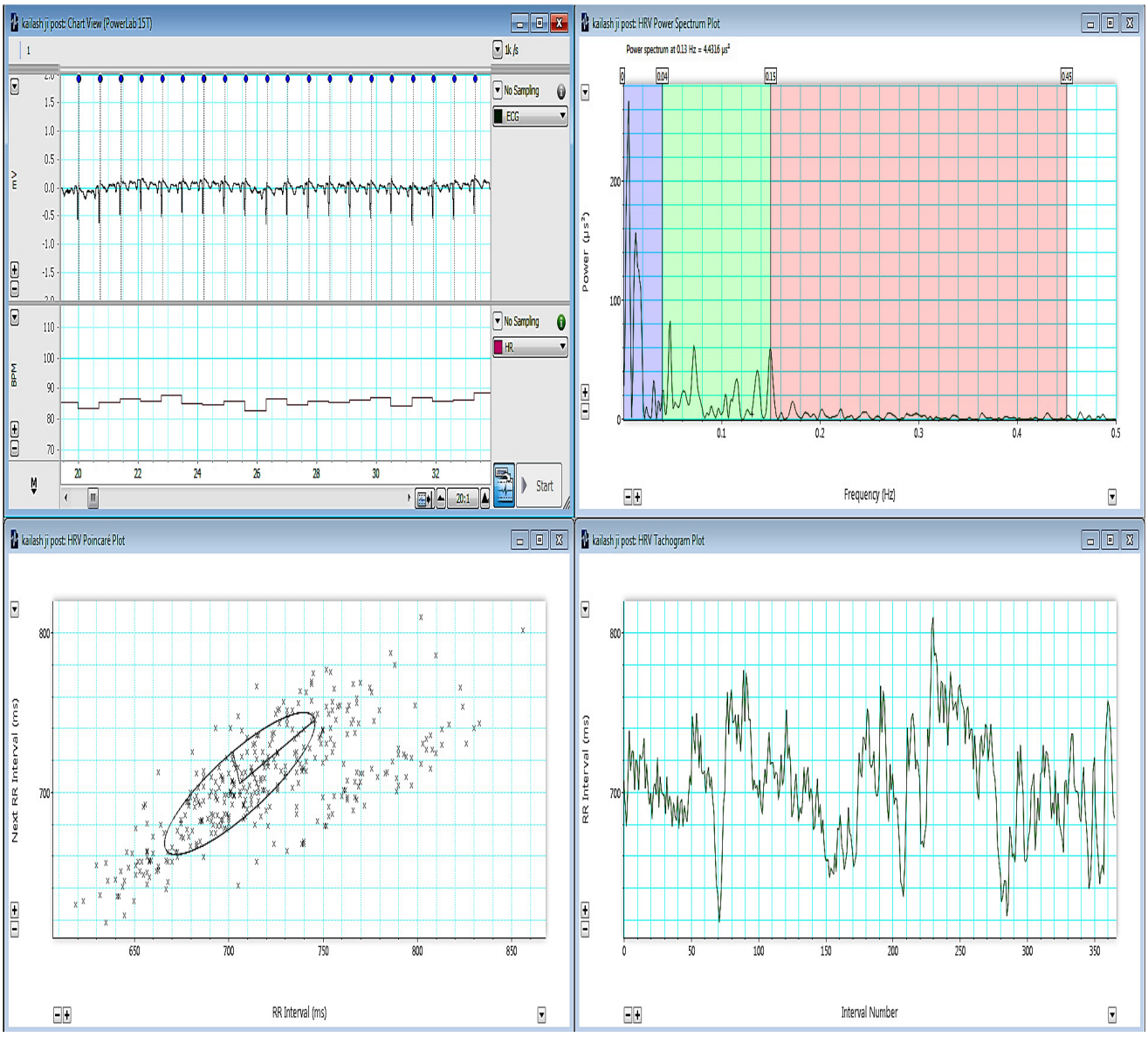
Figure-3

Group B-Comprising of subjects who participated in Advanced meditation program for first time.



4.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

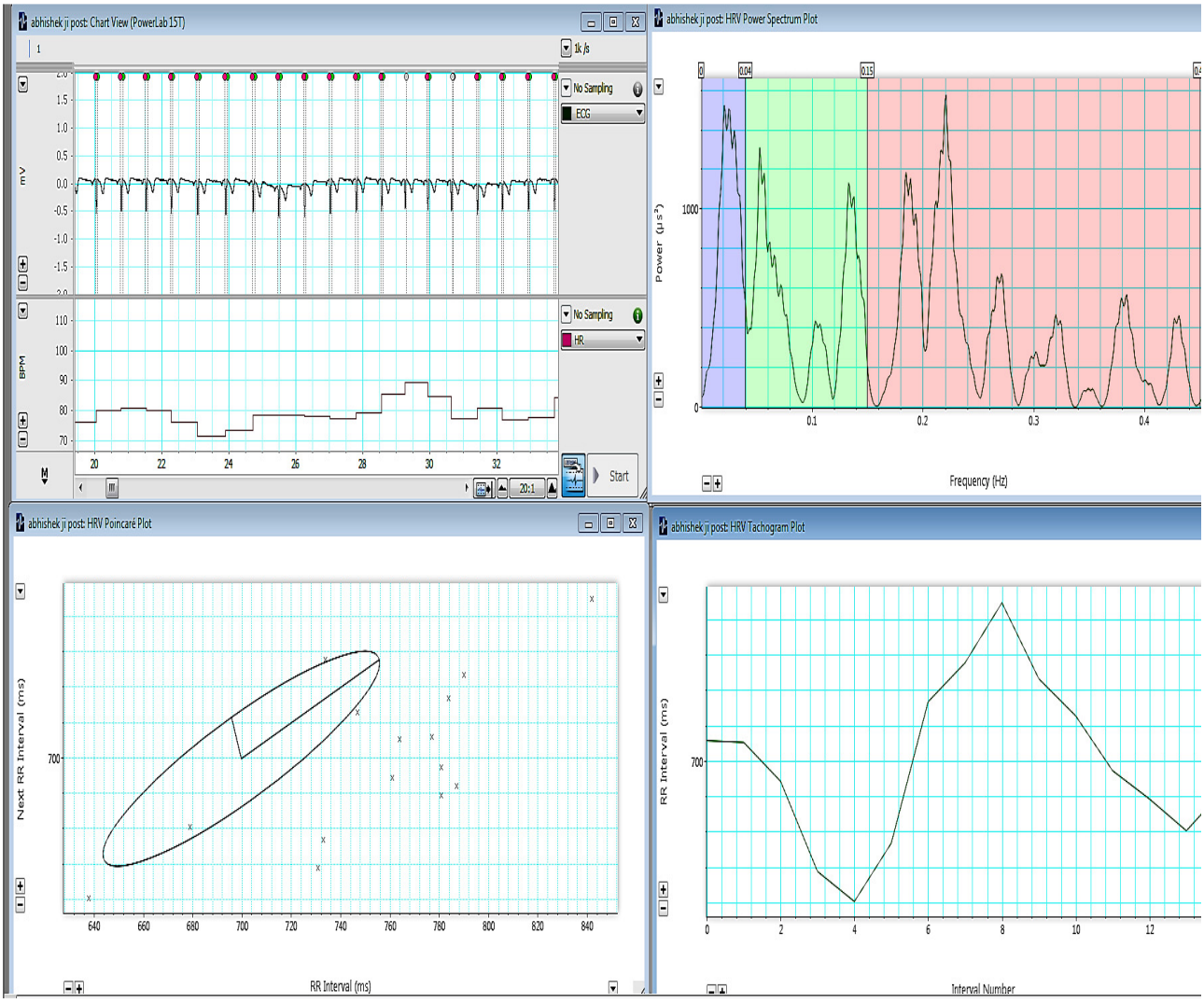
Band	Power(μs²)	Power(%)	Power(nu)
Total	2167		
VLF	1013	46.72	
LF	795.5	36.71	68.9
HF	359.6	16.59	31.14
LF/HF		2.212	

NONLINEAR

SD1	21.75 ms
SD2	43.06 ms

Figure-5

Group C -Comprising of subjects who are actively doing meditation since two years and have participated in 3 or more meditation program.



6..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

Poincare plots-

In the Poincare plots, after the meditation , the plots show an oval and fan shaped (Fig 8 & 9) and non meditation group the plots turned into a torpedo shape(Fig 7)

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Figure-7

Group A-Comprises of subjects who have never participated any meditation.(Torpedo shaped)

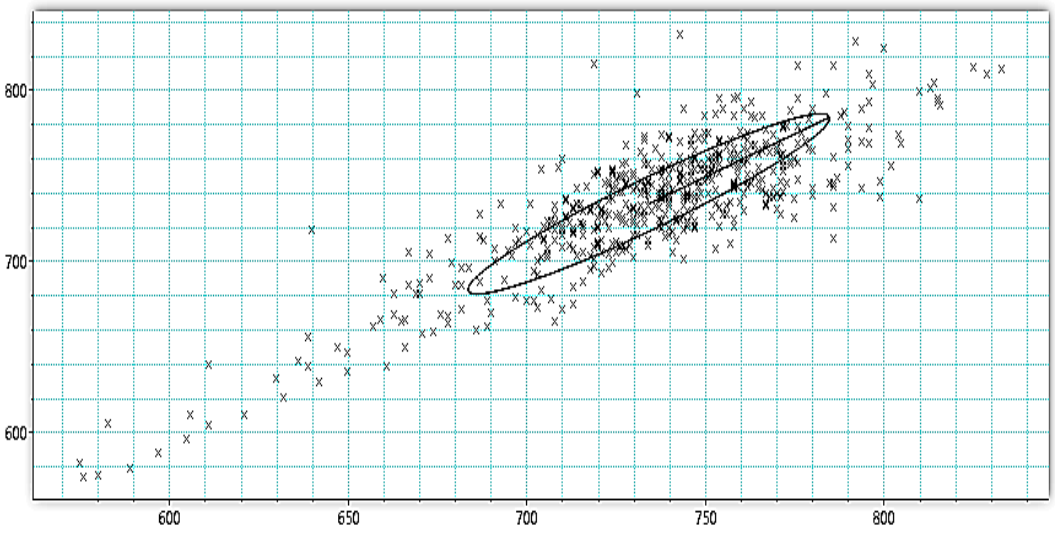


Figure 8-

Group B-Comprises of subjects who participated in Advanced meditation program for first time and have not meditated earlier.(Oval orFan shaped)

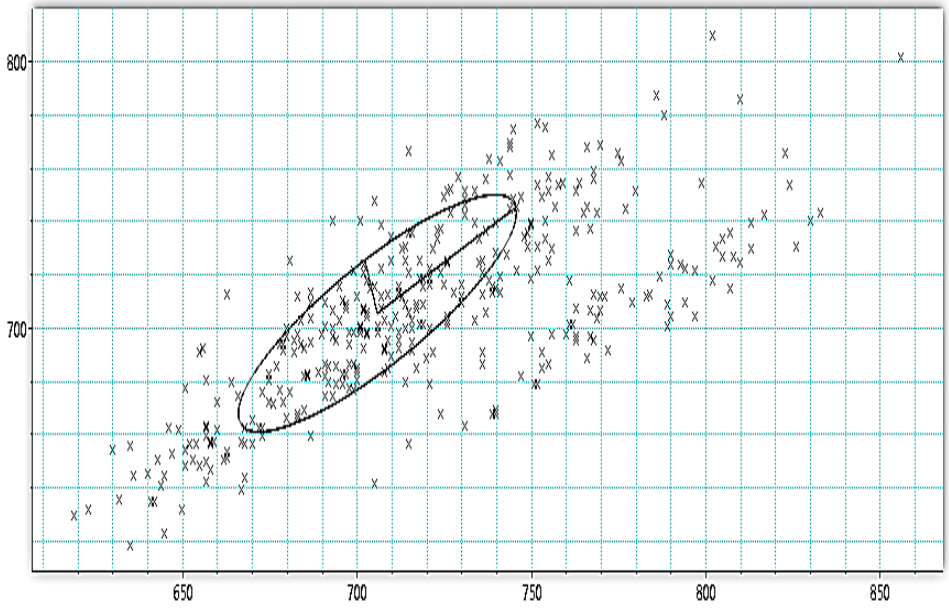
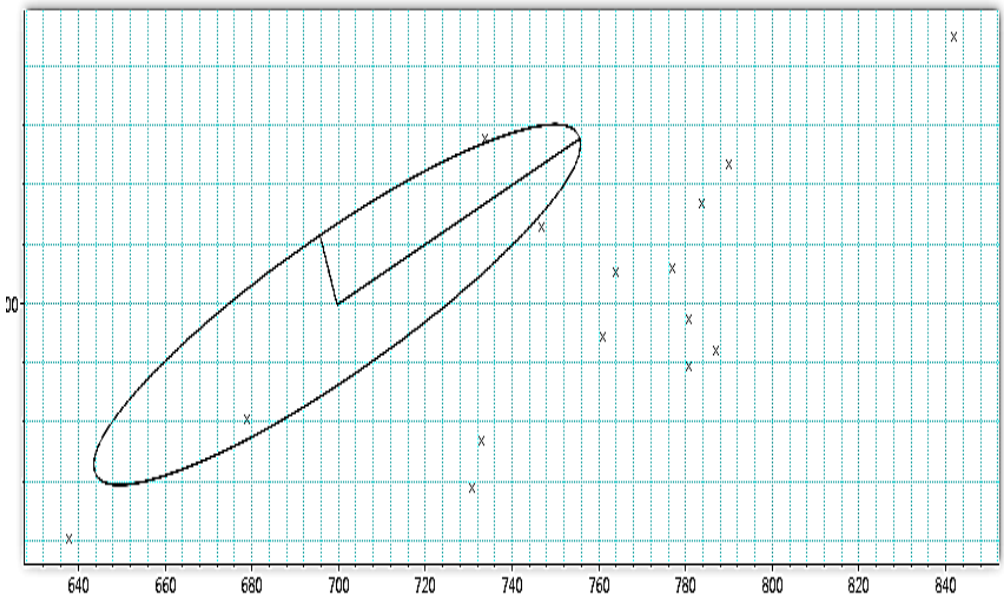


Figure- 9 -Group C -Comprises of subjects who are actively doing meditation since two years and have participated in 3 or more meditation program (More oval or fan shaped plot)



Statistical analysis of data

Statistical analysis was done using SPSS Statistics software, Version 19 . For data analysis, all values were expressed as mean ± SD. $P < 0.05$ 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 since two years and have participated in 3 or more meditation program

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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

The demographic profile shown in Table 1 subjects were of either sex with age 25.1 ± 4.4 years, height 166 ± 7.7 cm, and weight 63.6 ± 7.6 kg, BMI 24.2± 2.8 kg/m^2

Table- 2

Mean Power spectral indexes (LF, HF, LF/HF)

Groups	LF	SD	HF	SD	LF/HF Ratio	SD
Group A	77.69	2.20	16.92	1.15	4.60	.70
Group B	66.07	1.72	29.52	1.05	1.85	.23
Group C	31.02	.95	58.16	1.34	.65	.15

LF-Low frequency component

HF-High frequency component

LF/HF-Low frequency to high frequency ratio

SD-Standard deviation

Results show that in Group A,B,C mean LF ,HF , LF/HF Ratio 77.69, 66.07,31.02, 16.92,29.52,58.16 ,4.6,1.85,.65 .In Group C HF component is highest,and LF component , LF/HF ratio is lowest as compared to B and A,

Table -3

LOW FREQUENCY COMPONENT

LOW FREQUENCY COMPONENT		
GROUP A	GROUP B	GROUP C
77.694	66.07	31.018

Results shows that low frequency component is highest in Group A ,compare to B & C.

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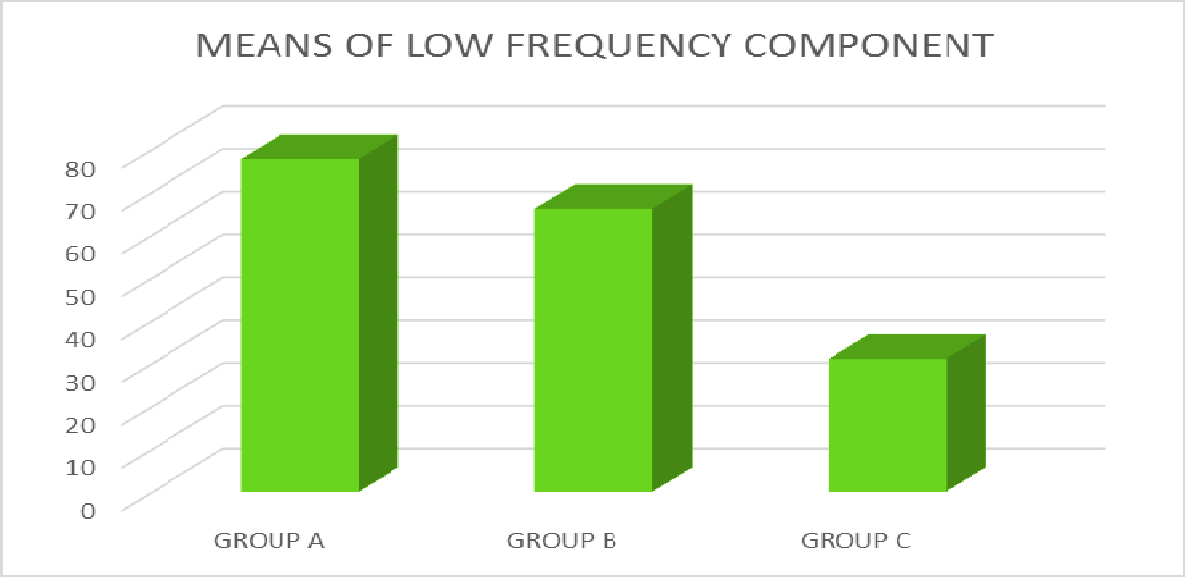
Bar Graph



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

Table -4ONE WAY ANALYSIS OF VARIANCE FOR LOW FREQUENCY COMPONENT

TABLE OF ONE WAY ANALYSIS OF VARIANCE FOR LOW FREQUENCY COMPONENT						
	Sum of	**Degrees of**	**Mean Sum**			
Variation	**Squares**	**Freedom**	**of Squares**	**F Ratio**	**P Value**	**Inference**
Between Groups	11808.03	2	5904.01509	2032.197	<0.0001	HS
Within Groups	78.4414	27	2.90523704			
Total	11886.47	29				

The p value indicates that there is no homogeneity in heart rate variability parameters in different groups.

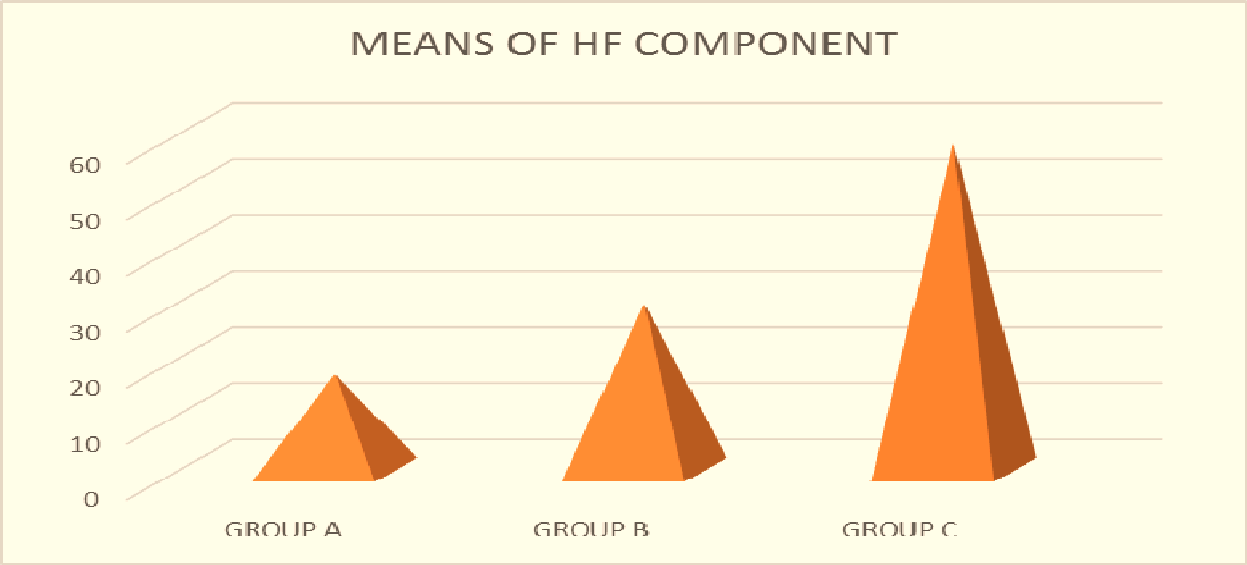
When pairwise comparison is done, it is found that in each pair there is highly significant difference (p<0.0001)

Table-5

HF component

HF COMPONENT		
GROUP A	GROUP B	GROUP C
16.921	29.524	58.162

Bar Graph-



Bar graph on effects of advance meditation program compared b/w Group A, B, CHF component was highest in Group C compare to A& B.

Table -6ONE WAY ANALYSIS OF VARIANCE FOR HF COMPONENT

TABLE OF ONE WAY ANALYSIS OF VARIANCE FOR HF COMPONENT						
	Sum of	**Degrees of**	**Mean Sum**			
Variation	**Squares**	**Freedom**	**of Squares**	**F Ratio**	**P Value**	**Inference**
Between Groups	8932.636	2	4466.31789	3174.899	<0.0001	HS
Within Groups	37.98249	27	1.40675889			
Total	8970.618	29				

The p value indicates that there is no homogeneity in heart ratevariability parameters in different groups.

When pairwise comparison is done, it is found that in each pair there is highly significant difference (p<0.0001)

Table -7

Mean Poincaré plot indexes (SD1, SD2, SD1/SD2)

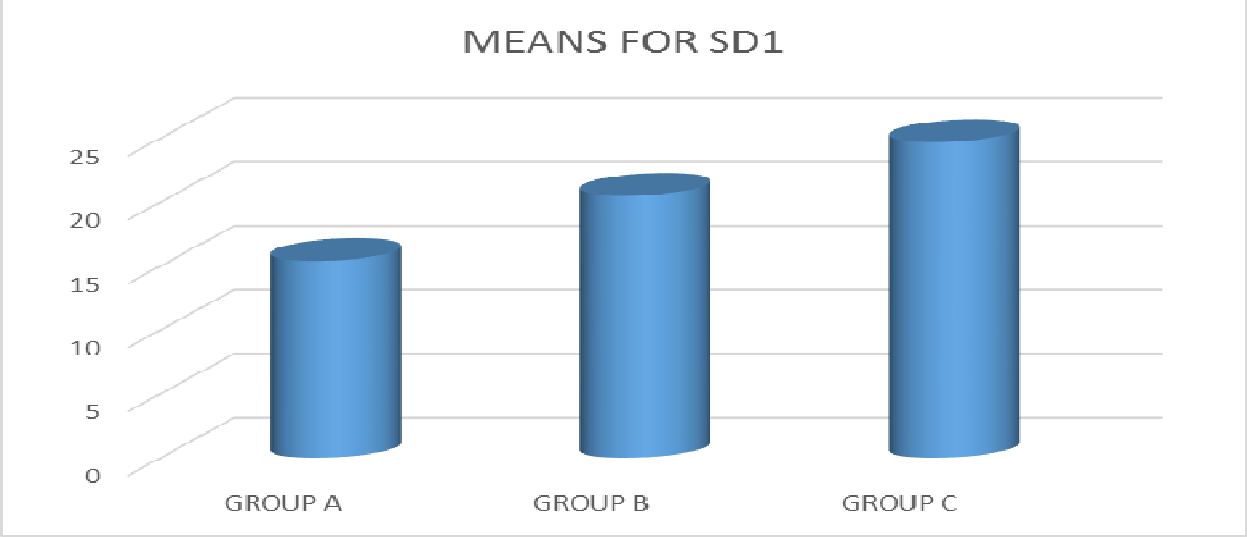
Groups	SD1	SD	SD2	SD	SD1/SD2
Group A	16.92	1.15	57.99	1.58	.286
Group B	29.52	1.05	50.78	1.45	.505
Group C	58.16	1.34	43.14	1.37	.4187

Results shows that in Group A ,B,C mean SD1 ,SD2 Ratio SD1/SD2 16.92,29.52,58.16 . In Group C SD1 component is highest ,and SD2 component , SD2 /SD1 ratio is lowest as compare to B and A groups,

Table-8-Mean Poincaré plot indexes SD1(Standard deviation 1 of poine care plot)

GROUP A	GROUP B	GROUP C
15.393	20.499	24.683

Bar Graph-



Bar graph on effects of advance meditation program compared with GroupA,B,C.
SD1 component of HR variability was highest in Group C,compared to A& B groups.

Table- 9

TABLE OF ONE WAY ANALYSIS OF VARIACE FOR SD1

Variation	**Sum of Squares**	**Degrees of Freedom**	**Mean Sum of Squares**	**F Ratio**	**P Value**	**Inference**
Between Groups	432.937	2	216.46865	109.682	<0.0001	HS
Within Groups	53.2871	27	1.9735967			
Total	486.224	29				

The p value indicates that there is no homogeneity in heart rate variability parameters in different groups.
When pairwise comparison is done, it is found that in eah pair there is highly significant difference (p<0.0001)

Table-10-

Mean Poincaré plot indexes SD2 (Standard deviation 2 of Poincare plot)

SD2		
GROUP A	**GROUP B**	**GROUP C**
57.993	**43.136**	**50.781**

Bar Graph-

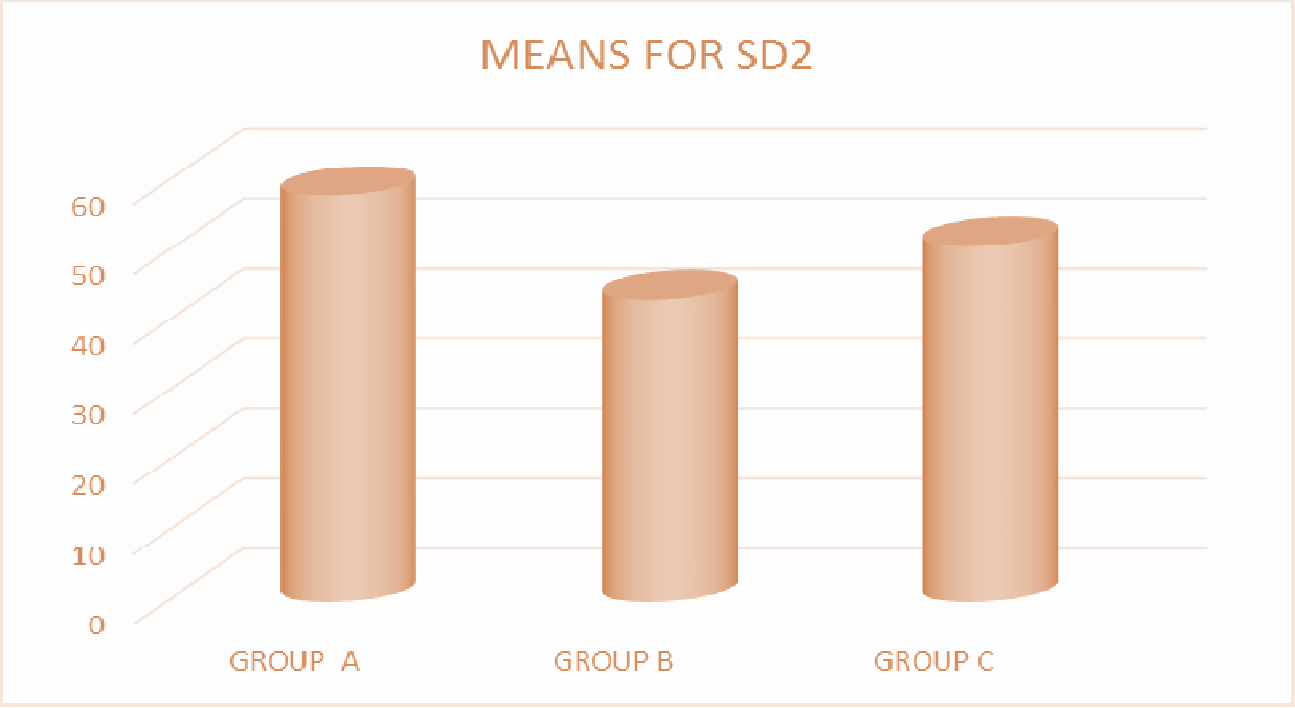


Table-11

TABLE OF ONE WAY ANALYSIS OF VARIANCE FOR SD2						
	Sum of	**Degrees of**	**Mean Sum**			
Variation	**Squares**	**Freedom**	**of Squares**	**F Ratio**	**P Value**	**Inference**
Between Groups	1103.965	2	551.982363	255.4399	<0.0001	HS
Within Groups	58.34454	27	2.16090889			
Total	1162.309	29				

The p value indicates that there is no homogeneity in heart rate variability parameters in different groups.

When pairwise comparison is done, it is found that in each pair there is highly significant difference ($p<0.0001$)

In the Poincare plots, after the meditation , the plots show an oval and fan shaped (Fig 8 & 9) and non meditation group the plots turned into a torpedo shape(Fig 7)

Table-12

Comparison of Mean Power spectral indexes (LF, HF, LF/HF) and Mean Poincare plot indexes (SD1, SD2, SD1/SD2) in different groups

Groups	LF	HF	LF/HF	SD1	SD2	SD1/SD2	P value
Group A	77.69	16.92	4.60	16.92	57.99	.286	<.0001
Group B	66.07	29.52	1.85	29.52	43.14	.505	<.0001
Group C	31.02	58.16	.65	58.16	50.78	.4187	<.0001

The p value indicates that there is no homogeneity in heart rate variability parameters in different groups.

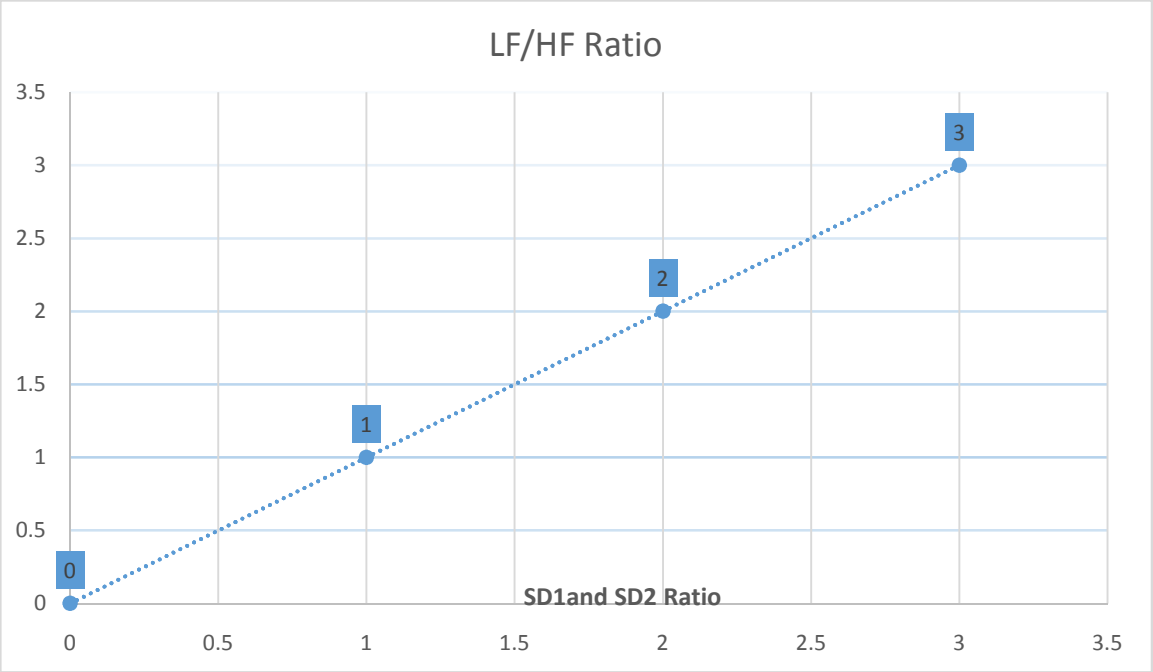
When pairwise comparison is done, it is found that in each pair there is highly significant difference ($p<0.0001$)

Table-13

Correlation of power spectral indexes (LF, HF, LF/HF) and Poincare plot indexes (SD1, SD2, SD1/SD2) during meditation.

	LF	HF	LF/HF Ratio	SD1	SD2	SD2/SD1
LF	1.00	0.686*	0.507*	0.129*	0.561*	0.448
HF		1.00	−0.24	.626	-.484	-.295
LF/HF			1.00	.108	.674	.811
SD2				1.0	1.0	.074
SD1						-.653
SD2/SD1						1.0

Results show there is strong correlation b/w LF and SD2 ,HF and SD1 and LF/HF ratio and SD2/SD1.



Discussion-

Studies on linear and nonlinear components of HRV in advanced meditation program are not well documented. Hence, in this study, an attempt has been made to assess linear and non linear parameters and compare nonlinear dynamics of HRV using Poincare plot in advanced meditation program.

The HF reflects parasympathetic activity, the LF reflects the sympathetic modulation, and LF/HF ratio indicates sympathovagal balance.[11,12]

In our study it was observed that in the spectral analysis, after advanced meditation program Table 2,3,4,5,6 Results show that in Group A,B and C mean LF ,HF , LF/HF Ratio observed was 77.69, 66.07,31.02, 16.92,29.52,58.16 ,4.6,1.85,.65 respectively. In Group C HF component is highest ,and LF component , LF/HF ratio is lowest as compared to B and A, which is show para sympathetic activity is stimulated after meditation with concomitant sympathetic withdrawal the outcome of study has been found similar to studies undertaken after meditation.[26]

However, the Poincare plots have more advantages; they can offer an instant and visually appreciable change of sympathovagal balance. In the Poincaré plots, after the meditation the SD1 increases, the SD2 decreases, and SD1/SD2 ratio increases instantly after the parasympathetic stimulation with a concurrent change of shape. The plot changes for a narrower torpedo-like shape to fan shape in the Poincare plot analysis , After the advanced meditation program Table 7,8,9,10,11,12 results show that in Group A ,B,C mean SD1 ,SD2 Ratio SD1/SD2 are 16.92,29.52,58.16 . In Group C SD1 component is highest ,and SD2 component , SD2 /SD1 ratio is lowest as compared to B and A, Results of the present study are in concurrence to studies done earlier on other meditation techniques .[11,12]

The spectral and Poincaré plot analysis of HRV are applied widely to monitor the sympathovagal change.'[13] The significance of all the HRV measurements has been verified under the correlation with various physiological variables which reflect the changing of autonomic balance.[14]

The Poincaré plot is a geometrical representation that permits the visual identification of the presence of non-linear HRV components.[15] In the Poincaré plots, the SD1 width reflects the parasympathetic activity; and the SD2 length reflects the sympathetic modulation.[16] The shape of Poincaré plot can be used to visually evaluate the sympathovagal activity. An elongated, torpedo-like shape with decreased SD1/SD2 ratio is associated with elevated sympathetic tone, and a more oval, fan-shaped configuration resulting from increased SD1/SD2 ratio indicates less sympathetic tone.[4,17]The points get more scattered when vagal activity increases, or the sympathetic activity decreases. Result of our study show in the Poincare plots, after the meditation , the plots show an oval and fan shaped (Fig 8 & 9) and non meditation group the plots turned into a torpedo shape(Fig 7).

After advanced meditation program the autonomic activity increased which results in increased SD1, SD2, and dispersed Poincaré plots. Moreover, the width of SD1 and SD2 can be used to quantify the vagal modulation of the heart rate.[5,18].

The Poincaré plot may identify abnormalities that are not easily detectable with traditional time and frequency domain measures.[19] In clinical settings, Poincaré plot analysis of R-R intervals provides prognostic information in various cardiovascular diseases..[2,3] It has been shown that during accentuated sympathovagal activation the heart rate behavior becomes remarkably unstable. These features of heart rate dynamics can be better identified by dynamic analysis of Poincaré plot than by traditional analysis techniques of HRV.[3] The Poincaré plots which use the unfiltered data have a relatively high intra-individual reproducibility than other measures of HRV.It has an advantage of being able to identify beat-to-beat cycles and patterns in the data.[20] Moreover , the Poincaré plot may be better in the use of dynamic analysis than spectral analysis.[4]

The spectral measures and Poincaré plots are fundamentally based on the measurement of the magnitude of HRV, even though the computation and analysis are different. Therefore, it is not surprising that Poincaré plot analysis and spectral measures have a relatively strong correlation with each other. In our study, Table 12,13 show that a good correlation between spectral and Poincaré analysis. The LF/HF has a good correlation with the SD2/SD1 ratio. The relations (SD1, HF), (SD2, LF) and (LF/HF, SD2/SD1) are mathematically equivalent measures.[21] Like HF/LF ratio, the SD1/SD2 ratio can reflect the sympathovagal balance; moreover, it offers better discrimination capability among the maneuvers of different vagal activity and can even discern the nonlinear information of HRV which is not evident in the linear analysis.[20]

Hence, we observed that, the findings of the nonlinear dynamics of HRV are corroborative with the observations from linear dynamics. Information about HRV has been commonly obtained using linear methods.[1] However, RR intervals fluctuate in a more complex pattern exhibiting patterns suggestive of nonlinear processes. Visual inspection of the Poincare plot has been largely used in the analysis of HRV. [11]It is capable of summarizing an entire RR time series derived from an ECG in one picture, and a quantitative technique, which gives information on

the long- and short-term HRV.[23]The nonlinear analysis offers the advantage of not requiring any preprocessing or stationarity of the data, which is needed in linear analysis.[24] Nonlinear methods such as the Poincaré plot, detrended fluctuation analysis (DFA), tone/entropy analysis and HR complexity analysis are newly developed tools used for identifying nonlinear patterns within ECG data. [25]Our study not only evaluated linear parameters Time domain and Frequency domain and non linear parameters Poine care plot but also compare linear and non linear parameters.

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 Poincare plot indices to autonomic function and its predictive role in the assessment CV risks. Studies should be conducted in larger sample size and multicentric to further establish the predictive and investigative importance of Poincare plot analysis in meditation group.

Conclusion-

In conclusion, we readily detect the sympathovagal changes through the change of shapes in the plots especially after the advanced meditation course in the different groups . The Poincaré plot is visually more discernible to detect this autonomic change, showing the potential to evaluate the dynamic change associated with meditation. For a better dynamic monitoring during the meditation course, the Poincaré plot provides a qualitatively and quantitatively a visual measure of autonomic nervous system activity.

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References-

1. Heart rate variability: Standards of measurement, physiological interpretation and clinical use. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. Circulation 1996;93:1043-65.
2. Sudhanshu Kacker ,Neha Saboo Indian Journal of Basic and Applied Medical Research; September 2016: Vol.-5, Issue- 4, P. 42-48.
3. Tulppo MP, Makikallio TH, Takala TES, Seppanen T, Huikuri HV. Quantitative beat-to-beat analysis of heart rate dynamics during exercise. Am J Physiol 1996;271:244e52.
4. Woo MA, Stevenson WG, Moser DK, Trelease RB, Harper RH. Patterns of beat-to-beat heart rate variability in advanced heart failure. Am Heart J 1992; 123:704e10.
5. Kamen PW, Krum H, Tonkin AM. Poincaré plot of heart rate variability allows quantitative display of parasympathetic nervous activity. Clin Sci 1996;91: 201e8.
6. Piskorski J, Guzik P. Geometry of the Poincaré plot of RR intervals and its asymmetry in healthy adults. Physiol Meas 2007;28:287-300.
7. Stein PK, Reddy A. Non-linear heart rate variability and risk stratification in cardiovascular disease. Indian Pacing Electrophysiol J 2005;5:210-20.
8. Karmakar CK, Khandoker AH, Voss A, Palaniswami M. Sensitivity of temporal heart rate variability in Poincaré plot to changes in parasympathetic nervous system activity. Biomed Eng Online 2011;10:17.

9. Guzik P, Bychowiec B, Piskorski J, Wegrzynowski A, Krauze T, Schneider R, et al. Heart rate variability by Poincaré plot and spectral analysis in young healthy subjects and patients with type 1 diabetes. Folia Cardiol 2005;12 Suppl D: 64-7.

10. Schubert, A., Palazzolo, J.A., Brum, J.M., Ribeiro, M.P., and Tan, M. Heart rate, heart rate variability, and blood pressure during perioperative stressor events in abdominal surgery. J Clin Anesthesia. 1997; 9: 52–60

11. Kamen, P.W., Krum, H., and Tonkin, A.M. Poincaré plot of heart rate variability allows quantitative display of parasympathetic nervous activity. Clin Sci. 1996; 91: 201–208

12. Bootsma, M., Swenne, C.A., Van Bolhuis, H.H., Chang, P.C., Cats, V.M., and Bruschke, A.V.G. Heart rate and heart rate variability as indexes of sympathovagal balance. Am J Physiol. 1994; 266: 1565–1571

13. Silke, B. and Riddell, J.G. Heart rate variability effects of an agonist or antagonists of the beta-adrenoceptor assessed with scatterplot and sequence analysis. Clin Autonomic Res. 1998; 8: 145–153

14. Carrasco, S., Gaitan, M.J., Gonzalez, R., and Yanez, O. Correlation among Poincaré plot indexes and time and frequency domain measures of heart rate variability. J Med Eng Technol. 2001; 25: 240–248

15. Michaels, D.C., Chialvo, D.R., Matyas, E.P., and Jalife, J. Chaotic activity in a mathematic model of the vagally driven sinoatrial node. Circ Res. 1989; 65: 1350–1360

16. Brennan, M., Palaniswami, M., and Kamen, P. Poincaré plot interpretation using a physiological model of HRV based on a network of oscillators. Am J Physiol. 2002; 283: 1873–1886

17. Brennan, M., Palaniswami, M., and Kamen, P. Do existing measures of Poincaré plot geometry reflect nonlinear features of heart rate variability?. IEEE Trans Biomed Eng. 2001; 48: 1342–1347

18. Kamen, P.W. Heart rate variability. Aust Family Physician. 1996; 25: 1087–1094

19. Laitio, T.T., Huikuri, H.V., Kentala, S.H., Makikallio, T.H., and Jalonen, R. Correlation properties and complexity of perioperative RR-interval dynamics in coronary artery bypass surgery patients.Anesthesiol. 2000; 93: 69–80

20. Ziegler, D., Piolot, R., Straburger, K., Lambeck, H., and Dannehl, K. Normal ranges and reproducibility of statistical, geometric, frequency domain, and non-linear measures of 24-hour heart rate variability.Horm Metab Res. 1999; 31: 672–679

21. Otzenberger, H., Gronfier, C., Simon, C., Charloux, A., Ehrhart, J., Piquard, F. et al. Dynamic heart rate variability: a tool for exploring sympathovagal balance continuously during sleep in men. Am J Physiol. 1998; 275: 946–950

22. Mourot L, Bouhaddi M, Perrey S, Rouillon JD, Regnard J. Quantitative Poincaré plot analysis of heart rate variability: Effect of endurance training. Eur J Appl Physiol 2004;91:79-87.

23. Tulppo MP, Mäkikallio TH, Takala TE, Seppänen T, Huikuri HV. Quantitative beat-to-beat analysis of heart rate dynamics during exercise. Am J Physiol 1996;271:H244-52.

24. Voss A, Kurths J, Kleiner HJ, Witt A, Wessel N. Improved analysis of heart rate variability by methods of nonlinear dynamics. J Electrocardiol 1995;28 Suppl: 81-8.

25. 5. Lerma C, Infante O, Perez-Grovas H, Jose MV. Poincaré plot indexes of heart rate variability capture dynamic adaptations after haemodialysis in chronic renal failure patients. Clin Physiol Funct Imaging. 2003;23(2):72–80

26. Burr, Robert L. "Interpretation of Normalized Spectral Heart Rate Variability Indices In Sleep Research: A Critical Review." Sleep 30.7 (2007): 913–919. Print.