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Comparative Evaluation of Variation in Heart Rate Variability with Change in Posture in Young Adult Indian Males and Females

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Abstract

Context: *An important component of Cardiovascular Adaptation is the ability of the cardiovascular system to adapt to physiological changes caused by physical challenges such as change in posture, gender etc, causing its adaptation response. If these parameters remain within sub- normal range for a long duration, then this could mean a sign of cardiovascular dysfunction, which may point toward poor physical health or onset of a cardiovascular disorder. Heart rate variability (HRV) is an important and widely-used measure of autonomic functioning, especially to assess cardiac activity. Few studies have focused on the impact of change in posture and gender on cardiac autonomic modulation in Indian context, so the rationale behind the present study was to systematically investigate the effect of postural change and gender on various HRV parameters using frequency domain measures of HRV in healthy young adult Indian population.*

Aim: *To record, compare and evaluate HRV in different postures in young adult Indian males and females.*

Settings and Design: *The study was conducted on 100 young adults (50 males and 50 females).*

Methods and Material: Their Height, Weight, Pulse rate & Blood Pressure were noted.HRV was recorded with the help of Anu photo rheograph using frequency domain method in supine, sitting and standing postures.

Statistical analysis used: *The data was analysed using SPSS 17.0 statistical package. Comparison between groups (supine, sitting and standing) was done using one way ANOVA followed by Tuckey's POST HOC test and Independent t-test. The statistical significance level was established at 5% ($P < 0.05$) and 1% ($P < 0.01$).*

Results:

The present study shows that, HRV parameters, such as TP, VLF and LF were higher in males, which *reflect sympathetic dominance in males. HF was significantly higher in females, which demonstrates parasympathetic dominance in females. Mean RR interval was significantly higher in males than females in lying and standing position but not in sitting position. With changes in posture (lying-sitting-standing), mean RR interval decreased. Both genders demonstrated significant decrease of mean RR interval with change of posture from sitting to standing, but it was not significant from lying to sitting, which may be explained by increased sympathetic tone with change in posture from sitting to standing.*

TP decreased with postural changes in males and females but not significantly. Significant difference in TP between males and females in sitting and standing positions could be explained on the basis of greater parasympathetic dominance in females and greater sympathetic dominance in males. In our study no significant difference in VLF could be observed either with change in posture, or between genders.VLF indicates influence of long-term regulatory mechanisms. So, our study which consisted of short time recordings does not reflect the influence of such mechanisms.

The difference in LF was significant in lying position only. In both genders, there was a significant increase of LF with change in posture from lying to sitting. But with change of posture from sitting to standing, LF decreased not significantly. These findings can be explained by increase of sympathetic tone with lying-sitting change in posture. And decrease of sympathetic influence with sitting-standing change in posture could be related to recovery process trying to find a balance in a new standing condition. The difference in HF between males and females was significant in supine and sitting postures but not in standing position. When postures were changing from lying to sitting and to standing, HF decreased in both sexes. It correlates with decreased parasympathetic and increased sympathetic tone with postural changes from lying to sitting and to standing.

Keywords- *heart rate variability, change in posture, gender, young adult Indian males and females, comparison*

INTRODUCTION

Heart rate variability (HRV) is a valuable and extensively used tool to assess autonomic functioning, especially cardiac health. HRV is the variation in beat-to-beat intervals of the human heart that allows the organ to react to stimuli. (1) A plethora of studies indicate that increased variability in the heart’s interbeat interval is physiologically desirable. (2)

A depressed HRV usually points towards an underlying pathology such as coronary artery disease, heart failure, diabetes and hypertension. HRV is also a predictor of left ventricular dysfunction following myocardial infarction and is a risk factor for morbidity and mortality. (1)

Apart from the autonomic nervous system (ANS), the external factors, like body posture also change the spectral characteristics of HRV. In the supine posture, the parasympathetic influence is dominant resulting in stronger high-frequency heartbeat fluctuations. In contrast, decreased parasympathetic function occurs in the standing position. (3) Postural effects have been attributed to hydrostatic influences affecting the amount of blood in the splanchnic area, the blood pressure in the head and different amounts of static muscular contraction needed to maintain the different postures. A few reports on gender-related differences in cardiac autonomic modulation reveal that, in normal population, parasympathetic tone dominates over sympathetic in women and vice versa in men. (4) Gender differences in the ANS may be present because of developmental variations or due to the effect of varied concentrations of male and/or female sex hormones. (5)

One of the best ways to assess the autonomic function is HRV analysis. The HRV analysis is non invasive, powerful, very accurate, reliable, reproducible, yet simple to do. (6)

HRV can be assessed by time domain or frequency domain indices. Frequency domain measures of HRV provide information on the frequency distribution of the components of HRV using power spectral density analysis. (2)

Spectral analysis of HRV is characterized by four main components:

Total power - a power spectrum of RR intervals calculated for a frequency range from 0.0033 Hz to 0.4 Hz. It represents effect of the autonomic regulation on cardiovascular function.

The high frequency (HF) component (0.15Hz -0.40 Hz) measures the influence of the vagus nerve in modulating the sinoatrial node and the inspiratory inhibition of the vagal tone.

The low frequency (LF) component (0.04Hz-0.15 Hz) - influenced by baroreceptor-mediated regulation of blood pressure and reflect predominantly sympathetic activity.

The very low frequency (VLF) component (0.003Hz -0.04 Hz) reflects the influence of several factors on the heart, including chemoreceptors, thermoreceptors, the renin-angiotensin system, and other non-regular factors.

The purpose of the present study was to systematically investigate the effect of gender and different postural changes in both a healthy female and a male population using frequency domain measures of HRV.

SUBJECTS AND METHODS

A total of 100 healthy young adults (50 males and 50 females) were included in this study with age range from 18 to 25 years.

The study was conducted in the Department of Physiology at a Medical College.

The non smoker, non alcoholic, non diabetic, having normal pulse rate, blood pressure, normal heart sounds and having no evidence of illness and having perfect physical, mental and psychological well being were included in the study.

A brief history was taken and general physical examination of all the volunteers was done with main emphasis on cardiovascular diseases, renal diseases. None of the subjects took any medication at the time of study. All the tests were carried out between 11 am to 4 pm. The procedure was explained and informed consent was obtained after the subjects had read a description of the experimental protocol, which was approved by the ethical committee of the college. The height, weight and blood pressure of the subject was measured with measuring tape, weighing machine and sphygmomanometer respectively. On auscultation, the heart sounds were found to be normal.

The experiment consisted of 3 recordings and each performed in a sequence: lying position, sitting position and standing position. During the data collection, the volunteers were instructed not to speak or move. To evaluate the autonomic HR modulation response in relation to the supine, standing and sitting postures, data were recorded for a 5-minute period at rest for each condition respectively, with spontaneous breathing. Initially the subject was asked to lie down over a bench in horizontal supine position and relax. The probe of pulse oxymeter was clipped to the subject's index finger and care was taken that subject did not move his hand. The probe was connected to the Anu-photo-rheograph which was in turn connected to personal computer with application software (Variability Analyzer 2008). Record in lying position was taken.

After the first record, the subject was asked to get up and sit in a chair with hands placed on the bench at the level of her thorax and the probe of pulse oxymeter was attached to the index finger. Subject was asked to relax and record in sitting position was taken. At last the subject was asked to stand up with hands by the side of the body and the record was taken in standing position.

The recorded HRV raw data was analyzed in the frequency domain to get HRV graph and FFT power spectrum. Very low frequency (VLF), low frequency (LF), high frequency (HF) spectral powers were determined by integrating power spectrum between 0.00-0.04 Hz, 0.04-0.15 Hz and 0.15-0.4 Hz respectively and expressed in normalized units (nu). Total power was calculated between 0.00-0.5 Hz and expressed in absolute unit of millisecond squared.

The statistical analysis of the significance on the data was done using one way ANOVA followed by Tuckey's POST HOC test and independent t-test. The statistical significance level was established at 5% ($p < 0.05$) and 1% ($p < 0.01$).

RESULTS

Table 1. Physical Characteristics of Male and Female Subjects

Physical Characteristics				
Gender	Statistics	Parameter		
		Age	Height	Weight
	Mean	20.08	165.36	63.94
Male	Std. Deviation	2.89	7.29	7.13
Female	Mean	19.12	156.21	54.86
	Std. Deviation	2.04	22.71	7.00

Table 2. Descriptive Statistics and One Way Anova (In Males)

Parameter	Posture	Mean	Standard Deviation	F-stat	DF	P value
Mean RR Interval	Lying	0.82	0.15	14.748	2,147	0.00*
	Sitting	0.78	0.12			
	Standing	0.69	0.10			
Total Power	Lying	2264.80	2381.18	0.519	2,147	0.596
	Sitting	2253.74	2385.17			
	Standing	1891.84	1285.78			
Very Low Frequency	Lying	19.04	11.16	0.187	2,147	0.83
	Sitting	19.32	9.20			
	Standing	20.18	8.72			
Low Frequency	Lying	27.76	8.40	6.894	2,147	0.001#
	Sitting	34.28	9.08			
	Standing	30.73	8.87			
High Frequency	Lying	20..00	11.30	7.66	2,147	0.001#
	Sitting	14.20	8.76			
	Standing	13.32	7.31			

Table 3. Multiple Comparisons (Tucky's HSD) (In Males)

#: Statistically significant at 5%level of significance i.e. P-value < 0.05

*: Statistically significant at 1%level of significance i.e. P-value < 0.01

Parameter	Posture	Posture	Mean Difference	P- value
Mean RR Interval	Lying	Sitting	0.04840	0.131
		Standing	0.13380	0.000*
	Sitting	Lying	-0.0480	0.131
		Standing	0.08540	0.002*
	Standing	Lying	-0.13380	0.000*
		Sitting	-0.08540	0.002*
Total Power	Lying	Sitting	11.06000	1.000
		Standing	372.96000	0.644
	Sitting	Lying	11.06000-	1.000
		Standing	361.90000	0.661
	Standing	Lying	-372.96000	0.644
		Sitting	-361.90000	0.661
Very Low Frequency	Lying	Sitting	-0.28188	0.989
		Standing	-1.14480	0.827
	Sitting	Lying	0.28188	0.989
		Standing	-0.86292	0.898
	Standing	Lying	1.14480	0.827
		Sitting	0.86292	0.898

Low Frequency	Lying	Sitting	-6.51986	0.001*
		Standing	-2.97252	0.212
	Sitting	Lying	6.51986	0.001*
		Standing	3.54734	0.112
	Standing	Lying	-2.97252	0.212
		Sitting	-3.54734	0.112
High Frequency	Lying	Sitting	5.79444	0.006*
		Standing	6.68042	0.001*
	Sitting	Lying	-5.79444	0.006*
		Standing	0.88598	0.882
	Standing	Lying	-6.68042	0.001*
		Sitting	-0.88598	0.882

#: Statistically significant at 5%level of significance i.e. P-value < 0.05

*: Statistically significant at 1%level of significance i.e. P-value <0.01

Table 4. Descriptive Statistics and One Way Anova (In Females)

Parameter	Posture	Mean	Standard Deviation	F-stat	DF	P value
Mean RR Interval	Lying	0.75	0.13	12.983	2,147	0.000*
	Sitting	0.74	0.11			
	Standing	0.66	0.08			
Total Power	Lying	1483.00	1759.75	0.562	2,147	0.571
	Sitting	1360.63	684.34			
	Standing	1235.69	746.22			
Very Low Frequency	Lying	18.20	13.79	0.269	2,147	0.764
	Sitting	18.06	7.79			
	Standing	16.83	8.41			
Low Frequency	Lying	20.20	8.37	15.480	2,147	0.000*
	Sitting	31.11	9.59			
	Standing	28.44	12.19			
High Frequency	Lying	26.46	16.59	12.470	2,147	0.000*
	Sitting	21.25	8.21			
	Standing	14.89	8.11			

*: Statistically significant at 1%level of significance i.e. P-value < 0.01

Table 5. Multiple Comparisons (Tucky's HSD) (In Females)

Parameter	Posture	Posture	Mean Difference	P- value
Mean RR Interval	Lying	Sitting	0.01361	0.795
		Standing	0.09810*	0.000*
	Sitting	Lying	-0.01361	0.795
		Standing	0.08449*	0.000*
	Standing	Lying	-0.09810*	0.000*
		Sitting	-0.08449*	0.000*
	Lying	Sitting	122.36735	0.862

Total Power		Standing	247.31373	0.540
	Sitting	Lying	-122.36735	0.862
		Standing	124.94638	0.855
	Standing	Lying	-247.31373	0.540
		Sitting	-124.94638	0.855
Very Low Frequency	Lying	Sitting	0.14319	0.997
		Standing	1.37482	0.783
	Sitting	Lying	-0.14319	0.997
		Standing	1.23163	0.823
	Standing	Lying	-1.37482	0.783
		Sitting	-1.23163	0.823
Low Frequency	Lying	Sitting	-10.90886*	0.000*
		Standing	-8.24299*	0.000*
	Sitting	Lying	10.90886*	0.000*
		Standing	2.66587	0.393
	Standing	Lying	8.24299*	0.000*
		Sitting	-2.66587	0.393
High Frequency	Lying	Sitting	5.20641	0.071
		Standing	11.57180*	0.000*
	Sitting	Lying	-5.20641	0.071
		Standing	6.36539#	0.019
	Standing	Lying	-11.57180*	0.000*
		Sitting	-6.36539#	0.019

#: Statistically significant at 5%level of significance i.e. P-value < 0.05

*: Statistically significant at 1%level of significance i.e. P-value <0.01

Table 6

Descriptive Statistics and Independent Sample t-test							
Position - Lying							
Parameter	Gender	Mean	Std. Deviation	Mean Difference	t-stat	DF	p-value
Mean R-R Interval	M F	0.82 0.75	0.15 0.13	0.0716#	2.57	98	0.012#
Total Power	M F	2264.80 1483.00	2381.18 1759.75	781.8000	1.87	98	0.065
VLF	M F	19.04 18.20	11.16 13.79	0.8353	0.33	98	0.740
LF	M F	27.76 20.20	8.40 8.37	7.5580*	4.51	98	0.000*
HF	M F	20.00 26.46	11.30 16.59	-6.4616#	- 2.27	98	0.025#

#: Statistically significant at 5% level of significance i.e. p-value < 0.05.

*: Statistically significant at 1% level of significance i.e. p-value < 0.01.

Table7.

Descriptive statistics and independent sample t-test							
Position: Sitting							
Parameter	Gender	Mean	Std. Deviation	Mean Difference	t-stat	DF	p-value
Mean RR Interval	Male Female	0.776 0.740	0.120 0.108	0.037	1.611	98	0.110
Total Power	Male Female	2253.740 1360.633	2385.174 684.341	902.720#	2.573	98	0.012#
Very low frequency	Male Female	19.321 18.061	9.202 7.793	1.518	0.884	98	0.379
Low Frequency	Male Female	34.279 31.110	9.083 9.585	3.471	1.845	98	0.068
High Frequency	Male Female	14.205 21.254	8.758 8.208	-6.994*	-4.138	98	0.000*

#: Statistically significant at 5% level of significance i.e. p-value < 0.05.

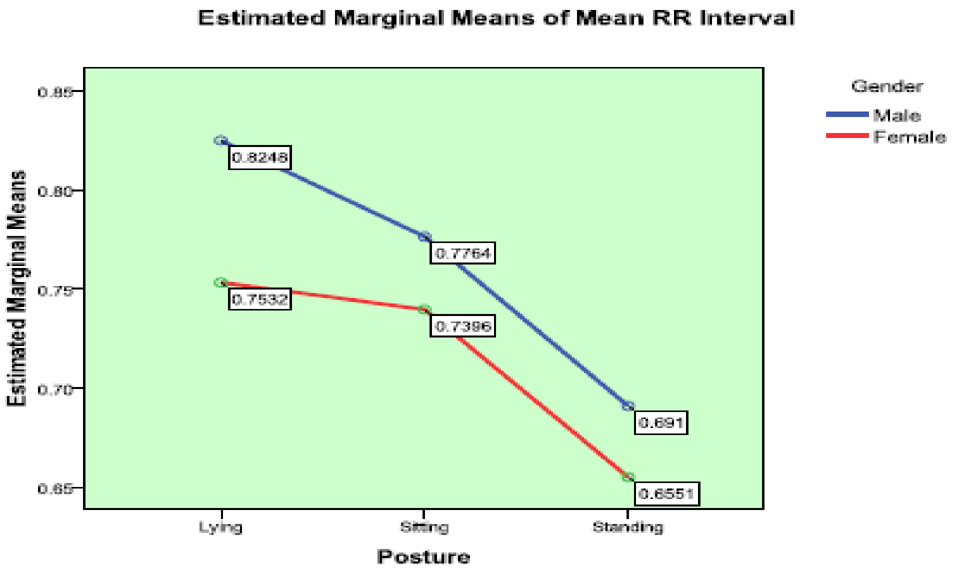
*: Statistically significant at 1% level of significance i.e. p-value < 0.01.

Table 8.

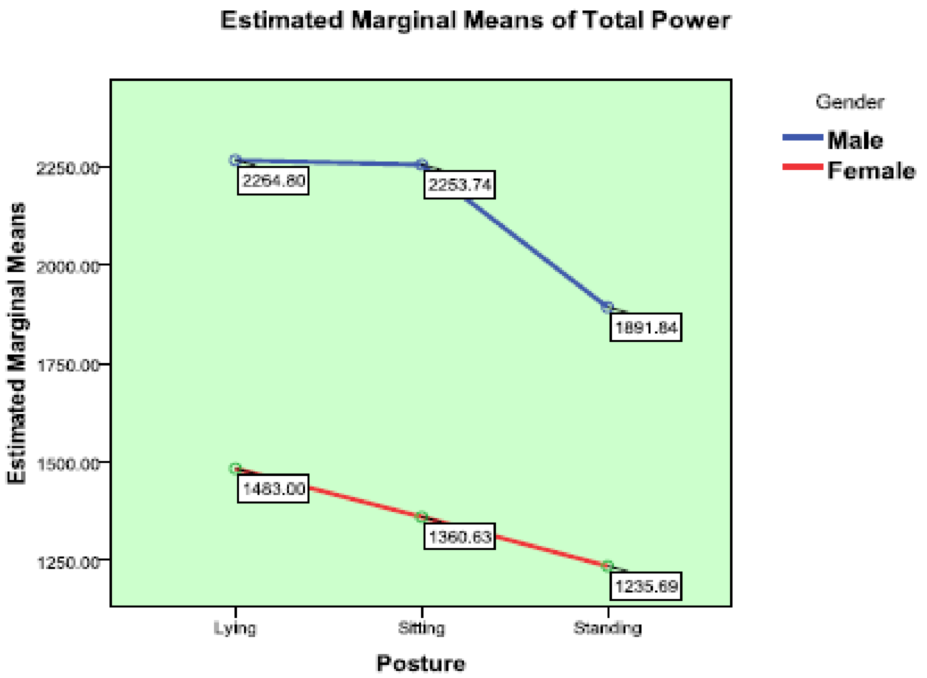
Descriptive statistics and independent sample t-test							
Position: Standing							
Parameter	Gender	Mean	Std. Deviation	Mean Difference	t-stat	DF	p-value
Mean RR Interval	Male Female	0.691 0.653	0.096 0.075	0.038	2.19	98	0.031#
Total Power	Male Female	1891.84 1242.80	1285.78 752.047	649.04	3.08	98	0.003*
Very low frequency	Male Female	20.184 17.062	8.717 8.324	3.1217	1.83	98	0.070
Low Frequency	Male Female	30.731 28.694	8.871 12.186	2.038	0.96	98	0.341
High Frequency	Male Female	13.319 14.817	7.313 8.177	-1.498	- 0.966	98	0.337

#: Statistically significant at 5% level of significance i.e. p-value < 0.05.
*: Statistically significant at 1% level of significance i.e. p-value < 0.01.

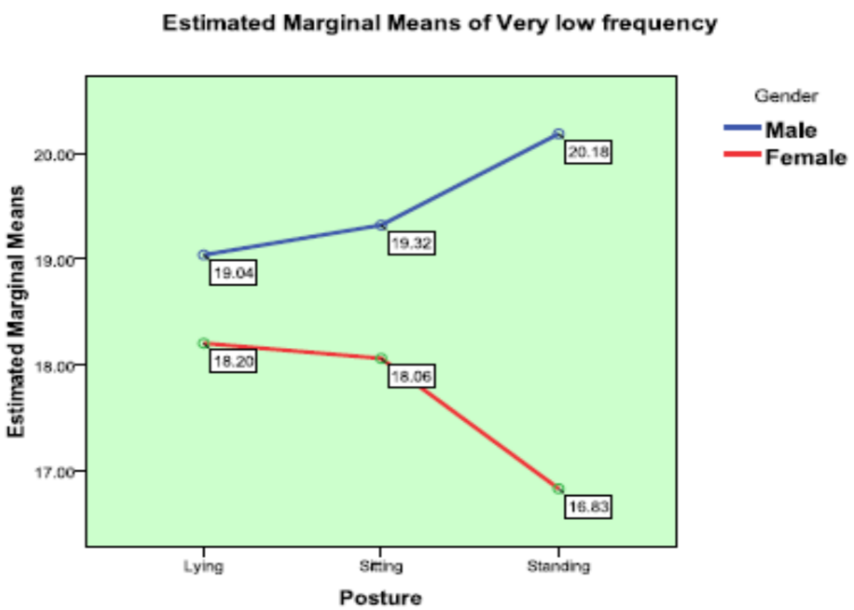
Graph 1.



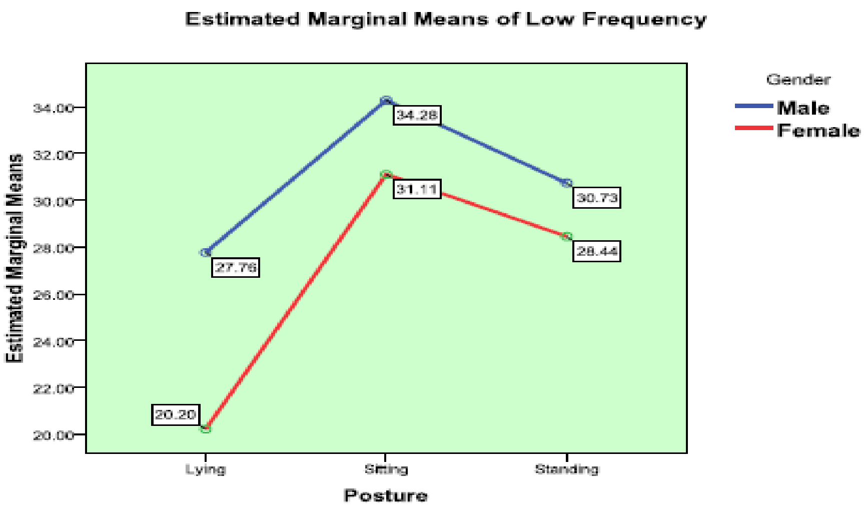
Graph 2.



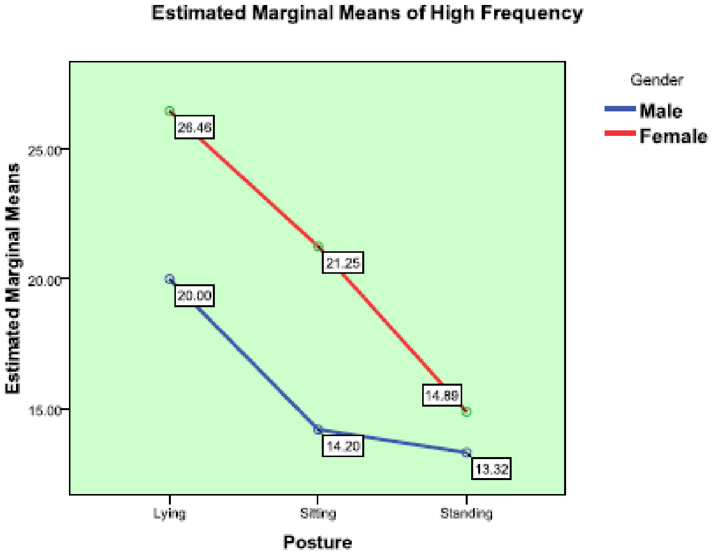
Graph 3.



Graph 4.



Graph 5.



ANALYSIS OF RESULTS:

The mean RR Interval for males in lying, sitting and standing positions was 0.82 ± 0.15, 0.78 ± 0.12 and 0.69 ± 0.10 respectively. The result shows that the mean RR interval for males in three postures was significantly different (F (2,147) = 14.748, p < 0.05). The mean total power (TP) for males in lying, sitting and standing positions was 2264.80 ± 2381.18, 2253.74 ± 2385.17 and 1891.84 ± 1285.78 respectively. The result shows that the mean total power for males in three postures was not significantly different (F (2,147) = 0.519, p> 0.05).

The mean very low frequency (VLF) for males in lying, sitting and standing positions was found to be 19.04 ± 11.16, 19.32 ± 9.20 and 20.18 ± 8.72 respectively. The mean VLF for males in three postures was not significantly different (F (2,147) = 0,187, p > 0.05).

The mean very low frequency (VLF) for males in lying, sitting and standing positions was found to be 19.04 ± 11.16, 19.32 ± 9.20 and 20.18 ± 8.72 respectively. The mean VLF for males in three postures was not significantly different (F (2,147) = 0,187, p > 0.05).

The mean low frequency (LF) for males in lying, sitting and standing positions was found to be 27.76 ± 8.40, 34.28 ± 9.08 and 30.73 ± 8.87 respectively. The mean LF for males in three postures was significantly different (F (2,147) = 6,894, p < 0.05). The mean high frequency (HF) for males in lying, sitting and standing positions was found to be 20.00 ± 11.30, 14.20 ± 8.76 and 13.32 ± 7.31 respectively. The mean HF for males in three postures was significantly different (F (2,147) = 7.66, p < 0.05). The mean difference in RR Interval for males between lying and sitting positions was 0.0484 [not significantly different (p > 0.05)]. The mean difference in RR Interval for males between lying and standing and sitting and standing was 0.1338 and 0.0854 [significantly different ($p < 0.05$)].

The mean difference in TP for males between lying and sitting, lying and standing and sitting and standing was 11.06, 372.96 and 361.90 respectively [not significantly different ($p > 0.05$)].

The mean difference in VLF for males between lying and sitting, lying and standing and sitting and standing was -0.28188, -1.1448 and -0.86292 respectively [not significantly different ($p > 0.05$).

The mean difference in LF for males between lying and sitting was found to be -6.51986 which is significantly different ($p < 0.05$). The mean difference in LF for males between lying and standing, and sitting and standing was -2.97252 and 3.54764 respectively [not significantly different ($p>0.05$)].

The mean difference in HF for males between lying and sitting, lying and standing and sitting and standing was 5.79444, 6.68042 and 0.88598 respectively, which is significantly different ($p < 0.05$).

The mean RR Interval for females in lying, sitting and standing was 0.75 ± 0.13, 0.74 ± 0.11 and 0.66 ± 0.08 respectively. The result shows that the mean RR interval for females in three postures was significantly different ($F (2,147) = 12.983$, $p < 0.01$).

The mean total power (TP) for females in lying, sitting and standing positions was 1483.00 ± 1759.75, 1360.63 ± 684.34 and 1235.69 ± 476.22 respectively. The result shows that the mean total power for females in three postures was not significantly different ($F (2,147) = 0.562$, $p> 0.05$).

The mean very low frequency (VLF) for males in lying, sitting and standing positions was 18.20 ± 13.79, 18.06 ± 7.79 and 16.83 ± 8.41 respectively. The mean VLF for males in three postures was not significantly different (F (2,147) = 0,269, $p > 0.05$).

The mean LF for females in lying, sitting and standing was 20.20 ± 8.37, 31.11 ± 9.59 and 28.44 ± 12.19 respectively. The mean LF for females in three postures was significantly different ($F (2,147) = 15.480$, $p < 0.01$).

The mean HF for females in lying, sitting and standing was 26.46 ± 16.59, 21.25 ± 8.21 and 14.89 ± 8.11 respectively. The mean HF for females in three postures was significantly different ($F (2,147) = 12.470$, $p < 0.01$).

The mean difference in RR Interval for females between lying and sitting was 0.01361 which is not significantly different ($p > 0.05$). The mean difference in RR Interval for females between lying and standing and between sitting and standing was 0.0.9810 and 0.08449 which is significantly different ($p < 0.01$).

The mean difference in TP for females between lying and sitting, lying and standing and sitting and standing was 122.36735, 247.31373 and 124.94638 respectively [not significantly different ($p > 0.05$)].

The mean difference in VLF for females between lying and sitting, lying and standing and sitting and standing was -0.14319, 1.37482 and 1.23163 [not significantly different ($p > 0.05$)].

The mean difference in LF for females between lying and sitting, lying and standing was 10.90886, -8.24299 [significantly different ($p < 0.01$)]. But that between sitting and standing was 2.66587 [not significantly different ($p > 0.05$)].

The mean difference in HF for females between lying and sitting was 5.20641 [not significantly different ($p > 0.05$)]. The mean difference in HF for females between lying and standing and sitting and standing was 11.57180 and 6.36539 which is significantly different ($p<0.01$).

The mean RR interval in lying position for males was found to be 0.82 ± 0.15, and for females it was 0.75 ± 0.13. The mean difference in mean RR interval between males and females in lying position was 0.0716 which is significant at 5% level of significance ($t (98) = 2.57$, $p < 0.05$). The result is shown in graph 1.

The mean TP in lying position for males was found to be 2264.80 ± 2381.18, and for females it was 1483.00 ± 1759.75. The mean difference in mean TP between males and females was 781.8 which is not significant statistically ($t (98) = 1.87$, $p > 0.05$). The result is shown in graph 2.

The mean VLF in lying position for males was found to be 19.04 ± 11.16, and for females it was 18.20 ± 13.79. The mean difference in mean VLF between males and females was 0.8353 which is not significant statistically ($t (98) = 0.33$, $p > 0.05$). The result is shown in graph 3.

The mean LF in lying position for males was 27.76 ± 8.40, and for females it was 20.20 ± 8.37. The mean difference in mean LF between males and females in lying position was 7.558 which is significant at 1% level of significance ($t (98) = 4.51$, $p < 0.01$). The result is shown in graph 4.

The mean HF in lying position for males was found to be 20.00 ± 11.30, and for females it was 26.46 ± 16.59. The mean difference in mean HF between males and females in lying position was -6.4616 which is significant at 5% level of significance ($t(98) = -2.277$, $p < 0.05$). The result is shown in graph 5.

The mean RR interval in sitting position for males was found to be 0.776 ± 0.12, and for females it was 0.74 ± 0.108. The mean difference in mean RR interval between males and females in sitting position was 0.037 which is significant at 5% level of significance ($t (98) = 1.611$, $p < 0.05$). The result is shown in graph 1.

The mean TP in sitting position for males was found to be 2253.74 ± 2385.174, and for females it was 1360.633 ± 684.341. The mean difference in mean TP between males and females was 902.72 which is significant at 5% level of significance (t (98) = 2.573, $p < 0.05$). The result is shown in graph 2.

The mean VLF in sitting position for males was found to be 19.321 ± 9.202, and for females it was 18.061 ± 7.793. The mean difference in mean VLF between males and females was 1.518 which is not significant statistically (t (98) = 0.884, $p > 0.05$). The result is shown in graph 3.

The mean LF in sitting position for males was 34.279 ± 9.083, and for females it was 31.110 ± 9.585. The mean difference in mean LF between males and females in sitting position was 3.471 which is not significant statistically (t (98) = 1.845, $p > 0.05$). The result is shown in graph 4.

The mean HF in sitting position for males was found to be 14.205 ± 8.758, and for females it was 21.254 ± 8.208. The mean difference in mean HF between males and females in sitting position was -6.994 which is significant at 1% level of significance (t (98) = -4.138, $p < 0.01$). The result is shown in graph 5.

The mean RR interval in standing position for males was found to be 0.691 ± 0.096, and for females it was 0.653 ± 0.075. The mean difference in mean RR interval between males and females in standing position was 0.0378 which is significant at 5% level of significance (t (98) = 2.19, $p < 0.05$). The result is shown in graph 1.

The mean TP in standing position for males was found to be 1891.84 ± 1285.78, and for females it was 1242.80 ± 752.05. The mean difference in mean TP between males and females was 649.04 which is significant at 1% level of significance (t (98) = 3.08, $p < 0.01$). The result is shown in graph 2.

The mean VLF in standing position for males was found to be 20.184 ± 8.717, and for females it was 17.062 ± 8.324. The mean difference in mean VLF between males and females was 3.1217 which is not significant statistically (t (98) = 1.83, $p > 0.05$). The result is shown in graph 3.

The mean LF in standing position for males was 30.731 ± 8.871, and for females it was 28.694 ± 12.186. The mean difference in mean LF between males and females in standing position was 2.0377 which is not significant statistically (t (98) = 0.96, $p > 0.05$). The result is shown in graph 4.

The mean HF in standing position for males was found to be 13.319 ± 7.313, and for females it was 14.817 ± 8.177. The mean difference in mean HF between males and females in standing position was -1.498 which is not significant statistically (t (98) = -0.966, $p > 0.05$). The result is shown in graph 5.

Mean RR interval was significantly higher in males than females in lying and standing position but not in sitting position. With changes in posture (lying-sitting-standing), decrease of mean RR interval was observed. Both genders demonstrated significant decrease of mean RR interval with change of posture from sitting to standing, but it was not significant from lying to sitting. This finding is explained by increase in sympathetic tone with postural changes.

HRV parameters, such as TP, VLF and LF were higher in males, which reflect sympathetic dominance in males. HF was significantly higher in females, which demonstrates parasympathetic dominance in females.

TP decreased with postural changes in males and females but not significantly. Significant difference in TP between males and females in sitting and standing positions could be explained on the basis of greater parasympathetic dominance in females and greater sympathetic dominance in males. In our study no significant difference in VLF could be observed either with change in posture, or between two genders. VLF indicates influence of long-term regulatory mechanisms. So, our study which consisted of short time recordings does not reflect the influence of such mechanisms.

LF was higher in males than females due to greater sympathetic tone in males. This difference was significant in lying position only, in sitting and standing postures LF was not significantly higher in males. In both genders, there was a significant increase of LF with change in posture from lying to sitting. But with change of posture from sitting to standing, LF decreased not significantly. These findings can be explained by increase of sympathetic tone with lying-sitting change in posture. And decrease of sympathetic influence with sitting-standing change in posture could be related to recovery process trying to find a balance in a new standing condition.

HF was higher in females than males; it proves parasympathetic dominance in females. This difference was significant in supine and sitting postures but not in standing position. When postures were changing from lying to sitting and to standing there was decrease of HF in males and females. This correlates with decreased parasympathetic and increased sympathetic influence with postural changes from lying to sitting to standing positions.

DISCUSSION

Genetic characteristics, anthropometrics (body mass and height), age, gender, hormonal and emotional factors, status of physical and mental health are some of the factors that influence HRV at rest. The analysis of HRV through postural tests can be studied to observe the impact of such factors. (8)

Influence of postural changes on HRV parameters in males and females –

1] Response of R-R interval to postural changes -

In present study, mean RR interval decreases with change in posture in both, males and females (Table 2, 4, graph 1). In both genders, decrease of RR interval with change in posture from lying to sitting is not significant statistically; but when posture changes from sitting to standing, decrease of RR interval is significant in both (Table 3, 5).

In this study, the basal recording showed that mean RR interval was higher in males in all three postures. The difference in mean RR interval between males and females was statistically significant in lying and standing but not in sitting posture. (Table 6, 7, 8)

It has been reported in the literature that adjustments in Heart Rate modulation from supine to sitting and standing posture are due to hydrostatic deviations caused by the displacement of blood from the central region to the lower regions, which decreases the cardiac output, systemic arterial pressure and activation of the arterial and cardiopulmonary receptors.

Similar results were obtained in a study by Zuttin R. S. et al. Their results of analysis of RR interval showed that heart rate was greater in the sitting posture than in the supine posture (7).

The results of the study by Joyce M. Evans showed that men and women demonstrated statistically significant differences in indexes of sympathetic and parasympathetic autonomic activity with men showing greater sympathetic influence whereas women showing parasympathetic preponderance. (8)

The mechanisms of the differences in RR interval dynamics due to gender variation are not known. Possible effects of sex hormones and differences in baseline variables, such as blood pressure have been speculated. It was suggested that the mechanisms behind gender-related differences in autonomic modulation of heart rate are probably more closely related to hormonal or genetic factors.

However, there were no significant differences between genders in mean heart rate in the study by Ryan A.D. et al (9).

2] Total power response to postural changes -

HRV analysis of this study showed that the total power for males in three postures was not significantly different (Table 2, 3, graph 2). Similarly for females, the total power in three postures was not significantly different (Table 4, 5, graph 2).

The basal level of TP was higher in males than in females (Graph 2). TP was significantly higher in males in sitting and standing posture. In supine position, difference in TP between males and females was not statistically significant. (Table 6, 7, 8)

The results on total power are even more varied; from a decrease with tilt (Pagani et al.) through no difference with tilt (Vybiral *et al.* 1989) to an increase with tilt (Lipsitz et al.). (1, 10, 11)

Total power reflects overall influence of parasympathetic and sympathetic effect on cardiac function. (6)

Significant difference in TP between males and females in sitting and standing positions could be explained on the basis of greater parasympathetic dominance in females and greater sympathetic dominance in males.

3] Very low frequency response to postural changes -

In males VLF was slightly increasing with changes in posture but it was not significantly different in all three postures (Table 2, 3, graph 3). In females, VLF was slightly decreasing with changes in posture but difference in VLF in three positions was not significant statistically (Table 4, 5, graph 3).

Mean VLF was higher in males than females but in all three postures difference in VLF between males and females was not significant statistically (Table 6, 7, 8).

The result of our study was similar to the result of study by Ryan AD et al. They did not observe any significant differences between genders in total power or distribution of power of very low frequency bands. At the same time, they did observe a significant difference in the distribution of power between males and females (LF and HF), with significantly less high-frequency power (parasympathetic activity) in males (9).

In contrast, in the study by Shemalia Saleem et al (12), the frequency domain indices like TP and VLF were found attenuated in females as compared to the males, but the difference was not statistically significant.

VLF component of HRV analysis reflects the influence of several factors on the heart, such as chemoreceptors, thermoreceptors, the renin-angiotensin system, and other non-regular factors. The physiological interpretation of VLF has still not been universally accepted. With longer recordings, it is considered to represent sympathetic tone as well as slower hormonal and thermoregulatory effects (4).

There are some findings indicating that in shorter recordings VLF has fair representation of various mental stress factors (negative emotions, worries, rumination etc.

In our study no significant difference in VLF component could be observed either with change in posture, or between males and females. The factors described above influence the cardiac function as long-term regulatory mechanisms. So, the present study which consists of three recordings of 5 minutes each (total 15 minutes) hence does not reflect the influence of above mentioned factors.

4] Low frequency response to postural changes -

In present study, in males mean LF increases significantly with change in posture from lying to sitting. When males changed posture from sitting to standing, there was decrease of LF band of power spectra but not significant statistically. In males, LF was higher in standing position than in supine, but difference was not significant statistically. (Table 2, 3, graph 4)

Similarly in females, mean LF increases significantly with change in posture from lying to sitting. Then when posture changed from sitting to standing, there was decrease of LF but it was not significant statistically. Females demonstrated higher LF in standing position than in lying and difference is significant statistically. (Table 4, 5, graph 4)

The base line of LF was higher in males than in females in all three postures (Graph 4), but there was statistically significant difference in LF between males and females in supine posture only. LF was not significantly different between genders in sitting position and standing position. (Table 6, 7, 8)

The results of the present study match with results of study by Zuttin RS et al. They observed that for the supine posture in relation to the sitting posture, the HF was greater, the LF was lower and the LF/HF ratio was lower. This reflected the finding that the HRV decreased significantly from the supine posture to the sitting posture (7).

The results of study by Sirkku Pikkujamsa et al (10) also indicate that there are sex-related differences in cardiovascular autonomic regulation. The heart rate response to an abrupt rise in blood pressure and the LF are lower in women than in men, whereas the HF is higher in women.

In contrast to our study, Ryan A.D. et al (9) did not observe significant differences between genders in mean heart rate, respiratory frequency, total power or distribution of power in low and very low frequency bands. They examined the effect of changing body position on HRV in 24 subjects and did observe a significant difference in high-frequency power between males and females.

Results of our study correlate with a study by Ramaekers D. et al (13). They noted a highly significant gender difference in heart rate and heart rate variability. Heart rate variability indices, denoting vagal activity, were not significantly different between men and women, whereas the spectral indices such as LF and LF/HF ratio were significantly higher in men. These findings may reflect a higher sympathetic activity in men compared to women.

In another study by Pomeranz B. et al (14) it was found that low-frequency fluctuations (below 0.12Hz) are increased by standing and are jointly mediated by the sympathetic and parasympathetic nervous systems. Higher-frequency fluctuations are decreased by standing and are mediated solely by the parasympathetic system.

Changing a body posture from lying position to sitting or standing position causes blood mass to rush down to lower extremities due to gravitational pull. This causes an increase in arterial and venous pressure in the lower body and decrease in blood mass returned to the heart. Therefore the central venous pressure drops causing decrease in stroke volume and cardiac output. In response to decreased blood pressure in large arteries, an internal regulatory mechanism turns on to avoid dizziness or even passing out due to a limited blood supply of the brain. (6)

The sitting-lying difference is due to hydrostatic influence acting mainly, if not wholly, through the carotid sinus reflex. (15)

Once mean pressure drops due to standing up, stimulation of baroreceptors increases, so they begin sending signals to vasomotor center located in the brainstem. Increased stimulation of this center causes immediate drop in parasympathetic tone and rapid increase in sympathetic tone.

A combination of decreased parasympathetic tone and increased sympathetic tone causes rapid increase in heart rate, contractility of the heart muscle and peripheral arterial vasoconstriction. This all leads to increase in the stroke volume, cardiac output and mean arterial pressure. Thus the body achieves compensation of the cardiovascular deficiency caused by standup maneuver. (6)

Analysis of results of present study shows that LF component of HRV, which is associated with sympathetic tone, is higher in males than females. With a change of posture from lying to sitting, there is an increase of sympathetic effect on HRV in both, males and females.

In present study, the sitting-standing difference in males and females is characterized by decreasing influence of sympathetic tone. Once the compensation has been achieved, the body begins a recovery process trying to find a balance in a new standing condition. The organism tries to gradually find a new equilibrium, lowering heart rate, stroke volume and arterial blood pressure without compromising on adequate blood supply to the vital organs.

The decreased level of mean arterial pressure lowers stimulation of baroreceptors, which reduces stimulation of vasomotor center in the brainstem and causes decrease in sympathetic activity. This finally leads to gradual decrease of heart rate and contractility, which reduces stroke volume, cardiac output and mean arterial pressure to the level adequate to new body condition. (6)

5] High frequency response to postural changes -

In present study, in males mean HF decreases significantly with change in posture from lying to sitting. Decrease of mean HF in males from sitting position to standing is not significant statistically. (Table 2, 3, graph 5)

In females, mean HF also decreases with change in posture from lying to sitting but decrease is not significant. Decrease of mean HF in females from sitting to standing is significant statistically. (Table 4, 5, graph 5)

In our study, the base line of mean HF is higher in females, in contrast to other parameters, which are higher in males. (Graph 5)

In lying and sitting position, the difference of HF between males and females is significant statistically. In standing position, HF is higher in females than males but not significantly. (Table 6, 7, 8)

In contrast to our study, results of the study by Shemalia Saleem et al (14) demonstrate that in healthy Pakistani population, heart rate variability is low in women than men. It reflects sympathetic dominance in women in the population.

Various combinations of vagal and sympathetic activation are characteristic for different body postures. Cacioppo et al. have suggested that vagal activity is the highest and sympathetic activity is the lowest in the supine posture. The reverse occurs in the standing posture, and a combination is characteristic for the sitting posture. (16)

CONCLUSIONS

This study shows that, change in body posture changes the spectral characteristics of HRV. The parasympathetic activity decreases and sympathetic dominance increases with posture change from supine to sitting to standing in both genders. Males show sympathetic dominance whereas females show parasympathetic dominance. Lower sympathetic activity may be the reason behind lower cardiovascular risk in females, in premenopausal age group.

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