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Use of HRV as a Tool to Study Cardiovascular Autonomic Responses to Postural Stress in Males

Authors
***Malini D[1], Kalpana M[2]**
[1]Department of Physiology, Apollo Institute of Medical Sciences & Research, Hyderabad, Telangana
[2]Department of Physiology, Kamineni Academy of Medical Sciences & Research, Hyderabad, Telangana
Corresponding Author
Malini Dutta
Associate Professor, Department of Physiology, Apollo Institute of Medical Sciences & Research,
Jubilee Hills, Hyderabad -96, Telangana, India
Email: *duttamalini@gmail.com*

ABSTRACT
Control of autonomic response due to change in posture is mediated mostly by baroreflexes. The baroreflex function is influenced by many factors. Autonomic responses due to change in posture are mediated by both cardiopulmonary and arterial mechanisms and this can be demonstrated by changes in frequency components (High frequency for parasympathetic and low frequency for sympathetic) of heart rate variability (HRV). Autonomic dysfunction due to postural changes can be found out by conducting autonomic function test which are helpful when physical examinations are inconclusive. The tilt table test can be performed to find the mixed autonomic response to postural stress by studying the changes in frequency components of HRV in different tilt angles. The present study is being done to find the cardiovascular autonomic adjustments to postural stress by doing gradual head up tilt and head down tilt test.

Keywords – *Heart rate variability (HRV), High frequency (HF), Low frequency LF) , Head up tilt (HUT), Head down tilt(HDT)*

INTRODUCTION

For maintaining homeostasis , autonomic nervous system depends on a continuous flow of sensory input from visceral organs and blood vessels. Montano *et al.*,(1995) analysed the HRV during graded orthostatic tilt in 22 healthy volunteers at angles of 15, 30, 45 and 90 degrees . He found a progressive increase in the LF of HRV on HUT. Cerebral autoregulation was studied by Cooke WH *et al.*,(2003) during acute HDT and it was found that the systolic arterial pressure spectral power of the LF decreased from 5.7 to 4.4 from supine to HDT and mean arterial pressure spectral power of the LF decreased from 3.3(supine) to 2.0(HDT) . HDT did not affect cerebral blood flow velocity. Akatsu *et. al.* (1999) studied the differences in HRV between young and elderly normal men during graded HUT. The HF decreased with tilt angle in both age groups. He suggested that parasympathetic withdrawal have an important role in adaptation to an upright posture in both age groups. However, mean HF amplitude at the 0^0 position in elderly men was not significantly different from that of young men at 60^0 tilt. The increase in LF and the increase in LF/HF ratio in elderly subjects from 0^0 to 15^0 seemed to be larger than that in young subjects. Sympathetic activities may be sensitive to lower levels of orthostatic stress in the elderly, and the elderly workers were easily affected by a change in workload. Koska *et.al.* had studied the head down bed rest on the neuroendocrine response to orthostatic stress in physically fit men and observed that after head down bed rest , BP was elevated , while resting HR did not change. The plasma renin activity was also increased. Wieling *et.al.* studied the dynamics of circulatory adjustment to HUT and tilt back in healthy and sympathetically denervated subjects and observed that in healthy humans upon HUT neural compensatory mechanisms became very effective in maintaining arterial pressure at heart level. The gradual circulatory adjusments to HUT in healthy subjects contrasted with the pronounced and abrupt circulatory changes on tilt back. In patients with a lack of neural circulatory reflex adjustments , graded BP decreased on HUT and gradually increased to tilt back position. The age dependent response of HRV parameters to HUT tests in young syncope patients and controls was done by Maier *et.al.* and it was observed that the difference between patients and controls were significant only in the older group. There was no evidence for gender-specific differences in HRV data. Maximum average R-R interval decrease was much stronger in older patients than in younger, whereas controls exhibited an average decrease of about 15% regardless of age. The LF/HF increase was slightly greater in older patients than in others, which was due to a reduced absolute LF/HF level at baseline. Effect of graded HUT tilt and head reverse tilt on the sympathetic nervous system versus parasympathetic nervous system was demonstrated by Yograj *et.al.* and it was observed that on graded HUT, pulse rate and DBP showed significant increase. On reversal of tilt all the parameters showing significant increase returned to near pre-tilt values. These responses indicated that graded HUT lead to decrease in parasympathetic activity relatively by increasing the sympathetic tone, which was more significant during higher tilt levels. On reversal of tilt, both the parasympathetic activity and the sympathetic activity returned to normal pre-tilt level.

MATERIALS AND METHODS

In the present study 100 healthy male subjects between 15-45 years of age were taken after taking into consideration the exclusion criteria of obesity, alcoholism, smoking, hypertension, diabetes ,subjects suffering from any illness or subjects using any medication , which was done by a pretested proforma to collect the required information. After taking the consent, the procedure was explained and the test was conducted pre-lunch to limit the symptoms of nausea and vomiting.

The tilt table test was done for both HUT and HDT by a manually operated tilt table which can be tilted by various degrees to a completely vertical position. Also ECG leads were placed at right arm, left arm , left foot and right foot and the recordings were observed in the monitor. When normal lead II ECG was obtained , the recordings were taken for 5 minutes for each tilt position and frequency domain analysis was done. The subjects were brought to the supine position for 5 minutes rest before changing the angle of the tilt. The tilt angles were 30^0, 60^0 , 80^0 HUT and 30^0 , 60^0 , 80^0 HDT. Frequency domain analysis was done by using Nivique software and statistical analysis was done.

RESULTS

The results obtained in the present study, which was conducted on 100 healthy male subjects were analyzed and expressed as mean ± standard deviation.

Low frequency (LF):

The resting mean value of low frequency in males was 0.1 ± 0.0. On head up tilt the mean values in males were 0.2 ± 0.1 and 0.3 ± 0.1 and 0.4 ± 0.1 at 30^0, 60^0 and 80^0 respectively (Table1). On head down tilt the values were 0.01 ± 0.0, 0.001 ± 0.1 and 0.001 ± 0.1 at 30^0, 60^0 and 80^0 respectively (Table 2). There was a increase in low frequency with head up tilt. Low frequency values showed statistically a highly significant value in all position ($p < 0.001$). On comparison with supine and 30^0, 60^0 and 80^0 up tilt and down tilt the low frequency showed a significant value (Tables 3,4)

High frequency (HF):

The mean high frequency value in males at supine position was 0.3 ± 0.1. The mean high frequency (Hz) value on head up tilt in males were 0.3 ± 0.1, 0.2 ± 0.1 and 0.1 ± 0.1 at 30^0, 60^0 and 80^0 respectively. (Table 1). On head down tilt the high frequency values were 0.2 ± 0.1, 0.1 ± 0.1 and 0.1 ± 0.0 at 30^0,$60^0$and 80^0 respectively (Table 2). The high frequency values also showed a significant decrease on head up and head down tilt. In comparison with supine and head up tilt position, high frequency values showed a statistically significant decrease only at 60^0 and 80^0 head up tilt and also showed statistically significant decrease at 30^0, 60^0 and 80^0 down tilt position.

Low frequency to high frequency ratio (LF/HF):

The mean value of low frequency to high frequency ratio at supine position was 0.3 ± 0.1

On head up tilt the mean ratio values were 0.6 ± 0.2, 1.5 ± 1.4 and 4.0± 2.0 at 30^0, 60^0 and 80^0 respectively (Table 1). On head down tilt the mean ratio values in males were 0.05±0.01, 0.01 ± 0.0, 0.01 ± 0.0 at 30^0, 60^0 and 80^0 respectively (Table 2). With head up tilt there was increase in the LF/HF ratio and on head down tilt there was decrease in the LF/HF ratio.

Head up tilt showed statistically a highly significant value ($p < 0.001$). In comparison with supine and 30^0, 60^0, 80^0 head up tilt, the ratio showed a statistically high significant increase ($p < 0.001$) only at 60^0 and 80^0 head up tilt. In comparison with supine and 30^0, 60^0, 80^0 head down tilt, there was no significant increase.

TABLE – 1: HRV RESPONSES TO HUT IN MALES

Parameters	Supine		30 Deg		60 Deg		80 Deg	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
LF(Hz)	0.1	0.0	0.2	0.1	0.3	0.1	0.4	0.1
HF (Hz)	0.3	0.1	0.3	0.1	0.2	0.1	0.1	0.1
LF/HF	0.3	0.1	0.6	0.01	1.5	1.4	4.0	2.0

TABLE – 2: HRV RESPONSES TO HDT IN MALES

Parameters	Supine		30 Deg		60 Deg		80 Deg	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
LF(Hz)	0.1	0.0	0.01	0.0	0.001	0.1	0.001	0.1
HF (Hz)	0.3	0.1	0.2	0.1	0.1	0.1	0.1	0.0
LF/HF	0.3	0.1	0.05	0.01	0.01	0.0	0.01	0.0

TABLE – 3: COMPARISON OF HRV PARAMETERS BETWEEN SUPINE AND VARIOUS DEGREES OF HUT IN MALES

Parameters	Supine I	30 Deg II	60 Deg III	80 Deg IV	P* Value	Significant Pairs**
LF(Hz)	0.1	0.2	03	0.4	p <0.001 HS	I&II, I&III,I&IV,II&III,II&IV
HF(Hz)	0.3	0.3	0.2	0.1	p <0.001 HS	I&II, I&III,I&IV,II&III,II&IV,III&IV
LF/HF	0.3	0.6	1.5	4.0	p <0.001 HS	I&III,I&IV,II&III,II&IV,III&IV

*Repeated measures ANOVA test **Tukey's test HS – Highly significant S – Significant

TABLE –4: COMPARISON OF HRV BETWEEN SUPINE AND VARIOUS DEGREES OF HDT IN MALES

Parameters	**Supine I**	**30 Deg II**	**60 Deg III**	**80 Deg IV**	**P* Value**	**Significant Pairs****
LF(Hz)	0.1	0.01	0.001	0.001	p <0.001 HS	I&II, II&III,II&IV,III&IV
HF(Hz)	0.3	0.2	0.1	0.1	p <0.001 HS	I&II, I&III,I&IV, II&III,II&IV,III&IV
LF/HF	0.3	0.05	0.01	0.01	p >0.05 NS	-

*Repeated measures ANOVA test **Tukey's test HS – Highly significant NS – Not significant

DISCUSSION

Autonomic responses to postural stress can be distinguished by changes in frequency components of heart rate variability in terms of low frequency and high frequency. The low frequency to high frequency is a quantitative and specific index of sympatho vagal activity. Slight changes in the ratio confirms the immediate responses to head tilt and reflects the autonomic nerve activity.

In the present study , the low frequency component of the HRV which is a marker of sympathetic activity has increased significantly with head up tilt (p<0.001). Whereas, there was a significant decrease in the high component (p<0.001) with head up tilt. On standing , maximum amount of blood is pooled in the lower parts of the body leading to a sudden decrease in venous return. This causes the pressure receptors to get activated in the heart , lungs , carotid sinus and aortic arch within seconds and results in sympathetic outflow. The decrease in high frequency component with head uptilt is mainly due to decrease in vagal tone. So there is a significant increase in the ratio of LF to HF (p<0.001) with gradual increase in head up tilt.

With head down tilt, the low frequency component decreased which was significant enough (p<0.001) and was mainly due to decrease in sympathetic activity. There was also decrease in the value of high frequency component with head down tilt which was due to decrease in vagal tone. This caused a decrease in the ratio of LF/HF with gradual head down tilt. The ratio is a convenient index of sympatho-vagal interaction. This test suggests that mixed autonomic responses to orthostatic stress is mediated by both cardiopu-lmonary and arterial baroreflex mechanisms which can be distinguished by changes in the frequency components of heart rate.

CONCLUSION

Cardiovascular reflex effects can be assessed by determining heart rate variability using various postural stress tests effectively for both physiological and clinical investigations in man in health and disease.

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