Effect of head uptilt on HRV in female human subjects

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ABSTRACT

AIM: Cardiovascular autonomic response to orthostatic challenges are affected by cardiorespiratory fitness in adults. The mixed response to postural stress can be distinguished by changes in frequency components of Heart Rate Variability (HRV). Autonomic control via sympathetic and parasympathetic modulation of the heart can be assessed by power spectral analysis of heart rate variability. This is done by the Head up tilt test (HUT). Tilt Table Test is a standard clinical medical procedure used to diagnose dysautonomia or syncope. MATERIALS AND METHOD: With the use of a pretested structured proforma, 100 healthy female subjects were randomly selected. Head up tilt test was done at 30°, 60° and 80° with the help of a manually operated tilt table. Lead II ECG was monitored and frequency domain analysis was done in each position for 5 minutes by using Niviquire software. RESULTS: Low frequency values increased from supine position with head up tilt and the high frequency values decreased with head up tilt. The ratio of low frequency to high frequency increased with head up tilt. CONCLUSION: The determination of HRV gives an idea of autonomic nervous system activity in response to passive head up tilt. Cardiovascular reflex effects can be assessed by physiologists and clinicians to assess cardiovascular reflex response in man in health or disease.

1. Introduction

The cardiac automaticity is intrinsic to the pacemaker tissues. But the heart rate and rhythm are largely under the control of the autonomic nervous system (ANS). The parasympathetic influence on heart rate is by release of acetylcholine by the vagus nerve. The sympathetic influence is by release of epinephrine and norepinephrine. Under resting conditions, it is the vagal tone which prevails and any changes depend on vagal modulation. Both the vagal and sympathetic activity interact constantly. As the sinus node is rich in acetylcholinesterase, the effect of any vagal impulse is brief because the acetylcholine is rapidly hydrolysed. Parasympathetic influences exceed sympathetic effects probably via two independent mechanisms: a cholinergically induced reduction of norepinephrine released in response to sympathetic activity, and a cholinergic attenuation of the response to a adrenergic stimulus.[1]

The modulatory effects of neural mechanisms on the sinus node has been enhanced by spectral analysis of HRV. The efferent vagal activity is a major contributor to the High Frequency (HF) component. The Low frequency (LF) component which is considered by some as a marker of sympathetic modulation and by others as a parameter that includes both sympathetic and vagal influences. In some conditions, associated with sympathetic excitation, a decrease in the absolute power of the LF component is observed. During sympathetic activation the resulting tachycardia is usually accompanied by a marked reduction in total power, whereas the reverse occurs during vagal activation. When the spectral components are expressed in absolute units (ms²), the changes in total power influence LF and HF in the same direction and prevent the appreciation of the fractional distribution of the energy.[2]

Tulpoo et al had shown the effect of passive head up tilt on heart rate dynamics. It was observed that HF spectral component decreased and LF increased during both exercise and tilt test.
Exercise and passive tilt result in an increase of short-term frontal correlation properties of HR dynamics which is related to changes in the balance between LF and HF oscillations in controlled situation. [3]

Laitinen et al observed that the cardiovascular autonomic responses to HUT was dependent on age and it was observed that during HUT there was decrease in HRV and increase in SBP and these changes attenuated with aging. Age correlated significantly with amplitude of HUT stimulated response of HF component and the ratio of LF to HF power of HRV. BP in the upright position was maintained well irrespective of age. It has been concluded that cardiac autonomic regulation decreases, vascular responses related to vasoactive mechanisms and vascular sympathetic regulation become augmented with increasing age.[4] Nobuhero studied the effects of body position on autonomic regulation of cardiovascular function in young healthy adults. Comparing prone and sitting position, HRV parameters indicated sympathetic dominance during sitting.[5]

ECG recordings were observed in a monitor. Normal lead II ECG recordings were saved for 5 minutes and frequency domain analysis was done in each position for 5 minutes. The subjects blood pressure, pulse, heart rate and any symptoms were monitored throughout the test. The table is tilted to 30°, 60°, and 80° HUT position. The subject is brought to the supine position for 5 minutes rest before changing the angle of the tilt table. Niviqure software was used for frequency domain analysis. Statistical analysis was done.

### Acquiring R-R intervals

To analyze HRV, we must obtain the R-R Intervals

- **Acquiring raw ECG signals**
- **Preprocessing ECG signals**
- **Extracting R peaks RR intervals**

### Process of acquiring R-R intervals

HRV analysis methods:

**Linear measures of HRV**

- Linear measures of HRV include various time and frequency domain indices. Frequency domain indices provide information about the physiological function as well as its distribution as a function of frequency. Spectral analyses of R-R intervals derived from short term recordings of 2 to 5min yields 3 separate bands.

a) A very low frequency (VLF) band located in the less than 0.04Hz.

b) A LF band located in the 0.04-0.15Hz range.

c) A HF band with a very large range from 0.15-0.50 Hz.

### Frequency Domain Measures of HRV

<table>
<thead>
<tr>
<th>Variables</th>
<th>Units</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Frequency</td>
<td>Hz</td>
<td>Peak frequencies of the power spectral density (PSD)</td>
</tr>
<tr>
<td>VLF</td>
<td>ms(^2)</td>
<td>Power from 0-0.04 Hz</td>
</tr>
<tr>
<td>LF</td>
<td>ms(^2)</td>
<td>Power from 0.04-0.15 Hz</td>
</tr>
<tr>
<td>HF</td>
<td>ms(^2)</td>
<td>Power from 0.15-0.4 Hz</td>
</tr>
<tr>
<td>LF/HF Ratio</td>
<td>LF [ms(^2)]/HF [ms(^2)]</td>
<td></td>
</tr>
</tbody>
</table>

**3. RESULTS**

In our study, the mean values of low frequency in head up tilt test in females showed an increase from the mean value of low frequency in supine position of 0.1 ± 0.0 to values of 0.2 ± 0.1, 0.3 ± 0.1 and 0.4 ± 0.1 at 30°, 60° and 80° respectively. But the high frequency values showed a significant decrease on head up tilt which was statistically significant only at 60° and 80° head up tilt position. On head up tilt, the mean ratio values of low frequency to low frequency were 0.3 ± 0.1, 0.6 ± 0.5 and 0.7 ± 0.2 at 30°, 60° and 80° respectively. The mean values showed statistically a highly significant value (p < 0.001). And in comparison with supine
position and 30°, 60°, 80° head up tilt position, the ratio showed a statistically highly significant increase (p < 0.001) only at 60° and 80° head up tilt.

**TABLE – 1: Mean frequency values of HUT in females at different tilt angles**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Supine</th>
<th>30 Deg</th>
<th>60 Deg</th>
<th>80 Deg</th>
</tr>
</thead>
<tbody>
<tr>
<td>LF (Hz)</td>
<td>0.1</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
</tr>
<tr>
<td>HF (Hz)</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>LF/HF</td>
<td>0.02</td>
<td>0.03</td>
<td>0.1</td>
<td>0.1</td>
</tr>
</tbody>
</table>

**TABLE – 2: Frequency domain analysis in supine and various degrees of HUT in females**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Supine</th>
<th>30 Deg II</th>
<th>60 Deg III</th>
<th>80 Deg IV</th>
<th>P* Value</th>
<th>Significant Pairs**</th>
</tr>
</thead>
<tbody>
<tr>
<td>LF (Hz)</td>
<td>0.1</td>
<td>0.3</td>
<td>0.3</td>
<td>0.4</td>
<td>p &lt; 0.001 HS</td>
<td>I&amp;II, I&amp;III, I&amp;IV, II&amp;IV, III&amp;IV</td>
</tr>
<tr>
<td>HF (Hz)</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.2</td>
<td>p &lt; 0.001 HS</td>
<td>I&amp;II, I&amp;III, I&amp;IV, II&amp;III, II&amp;IV, III&amp;IV</td>
</tr>
<tr>
<td>LF/HF</td>
<td>0.2</td>
<td>0.3</td>
<td>0.6</td>
<td>0.7</td>
<td>p &lt; 0.001 HS</td>
<td>I&amp;III, I&amp;IV, II&amp;II, II&amp;IV, III&amp;IV</td>
</tr>
</tbody>
</table>

*Repeated measures ANOVA test
**Tukey’s test
HS – Highly significant

4. DISCUSSION

Most autonomic responses to postural stress, which are thought to be mediated by both cardiopulmonary and arterial mechanisms, can be distinguished by changes in frequency components of heart rate variability in terms of low frequency and high frequency. The low frequency is an index of sympathetic activity and high frequency is related to parasympathetic activity. The low frequency to high frequency ratio is a quantitative and specific index of sympatho-vagal activity.

In our study, the low frequency value showed a significant increase (p=0.001) with gradual increase in the tilt angle in head up tilt test.

On standing, about 300 to 800 mL of blood is forced downward to the abdominal area and lower extremities. Within seconds of this sudden decrease in venous return, pressure receptors in the heart, lungs, carotid sinus and aortic arch are activated and mediate an increase in sympathetic outflow and increase in low frequency on head up tilt. Similar findings were reported by Mukai S[6] and Mikko P[3].

In our study the high frequency decreased with head up tilt in females and this value showed significant decrease (p < 0.001). In the present study the ratio increased with gradual increase in the head up tilt. Low frequency component of HRV increased progressively as the angle increased (p < 0.005). During high level tilt the high frequency amplitude of heart rate variability decreased progressively with tilt angle. The low frequency amplitude of heart rate variability peaked at a tilt angle of 30°. The ratio increased with head up tilt. This result suggested that mixed autonomic responses to orthostatic stress, which are thought to be mediated by both cardiopulmonary and arterial baroreflex mechanisms, can be distinguished by changes in the frequency components of heart rate. Similar findings were observed by Jahan et al[8].

Low frequency to high frequency ratio indicates sympatho-vagal balance. In our study the low frequency to high frequency ratio increased with head up tilt. This value showed significant increase (p < 0.001). In the present study the ratio increased with gradual increase in the head up tilt. Low frequency component of HRV increased progressively as the angle increased (p < 0.005). During high level tilt the high frequency amplitude of heart rate variability decreased progressively with tilt angle. The low frequency amplitude of heart rate variability peaked at a tilt angle of 30°. The ratio increased with head up tilt. This result suggested that mixed autonomic responses to orthostatic stress, which are thought to be mediated by both cardiopulmonary and arterial baroreflex mechanisms, can be distinguished by changes in the frequency components of heart rate. Similar findings were observed by Jahan et al[8].

5. CONCLUSION

Low frequency component of heart rate variability increased with the head up tilt angles indicating that it is an index of sympathetic system. High frequency component decreased with head up tilt and it provides a quantitative, specific index of vagal cardiac function. Low frequency to high frequency ratio increased with head up tilt and is considered to be a convenient index of sympatho-vagal interaction. With head up tilt test there are changes in the cardiovascular parameters in females. Heart rate variability helps us to assess these changes.
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