Frequency Domain Analysis of Heart Rate Variability (HRV) Among the Resident Population of North Eastern Hilly Regions of West Bengal

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Abstract

Background Heart Rate Variability (HRV) is already an established and one of the most promising quantitative markers of autonomic activity. This study establishes the Frequency Domain Analysis of short time recordings of HRV among the resident population of the North Eastern Hilly regions of West Bengal.

Key words: Heart Rate Variability, VLF, HF, LF, PSD.

1. Introduction

Frequency domain method of analysis is one of the key factors of analyzing for the HRV analysis. Literature survey shows numerous studies relating to versatile spectral methods [13] for the analysis of the tachogram since the last four decades. Analyzing by Power spectral density (PSD) provides the basic information of how power (i.e. variance) distributes as a function of frequency. Independent of the method employed, only an estimate of the true PSD of the signals can be obtained by proper mathematical algorithms. PSD calculation is classified as non-parametric and parametric. It is advantageous considering the factors as, the simplicity of the algorithm employed (FFT in most of the cases), the high processing speed, smoother spectral components which can be identified separately for preselected frequency bands, easy post-processing of the spectrum with an automatic calculation of low and high frequency power components with an easy identification of the central frequency of each component, and accurate estimation of PSD even on a small number of samples on which the signal is supposed to maintain stability.

1.1 Spectral components

Three main spectral components are distinguished in a spectrum calculated from short term recordings of 2 to 5 min [1, 2, 3, 20], viz.

I. Very low frequency (VLF),
II. Low frequency (LF), and
III. High frequency (HF) components

The physiological explanation of the VLF component is defined to a lesser extent and the existence of a specific physiological process attributable to these heart period changes might even be questioned. VLF assessed from short-term recordings (e.g. 5 min) is although a tedious measure is considered here for analysis.

2. Materials and Methods

HRV was measured from 5 minutes continuous recording (Short Term HRV) of Heart Rate using SuuntoT6 Heart Rate Monitor and using HRV Analysis Software, version 1.1, on 30 subjects (20 – Male and 10 - Female), selected randomly (age 17 to 81). The Standard Deviation of age of the set calculated as 13.208. Three sets of recordings were taken from each subject with time interval of zero, three and five minutes. All data’s were recorded in wake state in activity and as well as rest schedule. A data collection form was prepared for
recording and validation (Signature or LTI taken in almost all cases) of the collected data in three sections as
i. General Survey, ii. Life Style survey, Work and Activity Schedule and iii. Medical Survey
The domains of analysis selected in the study are:
a. **Parametric** - AR Spectrum: Frequency band (VLF, LF, HF), Ratio of LF/HF, Peaks of the frequencies, Power (ms$^2$), Power (%), Power(nu)
b. **Non parametric** - FFT Spectrum: Frequency band (VLF, LF, HF), Ratio of LF/HF, Peaks of the frequencies, Power (ms$^2$), Power (%), Power(nu) and Welch’s Periodogram are selected

3. Evaluation and Experiments

3.1 Measuring Part
Recordings of heart rate were taken by using Suunto T6 Heart Rate Monitor in three time intervals as described above and transferred using USB data cable to a computer for analysis. Software, Suunto Training Manager is used for the data collection from the HR monitor. Of the various options of available data such as HR, EPOCH, Respiration Rate, VE, VO2, Energy, Speed, R-R Interval; the data of R-R interval is taken. Fig.1. shows the graph as available from the Suunto Training Manager Software of HR (bpm) and corresponding R-R interval variation plot in m-s.

3.2 Feature Extraction
The data of the various recordings are stored as ASCII values in one of the components of the software. The R-R interval datas of the 5 minutes recording were extracted and stored as .txt format in a file for future reference. Fig.2 shows the Plot of RRI and corresponding selected RRI time series for analysis as fed to HRV software 1.1. The stored .txt format values are now fed to HRV Analysis Software, version 1.1 for evaluation and analysis. The software gives us Time domain, Frequency Domain and Poincare Plot analysis of the fed data. We have used frequency domain results for this study.

4. Result and Discussion
Frequency domain plots are obtained in parametric and non parametric forms and corresponding datas are noted for evaluation in a larger scale of 30 subjects for three sets of recordings. Fig3. shows the AR spectrum as described. The limiting conditions for the data were as shown in Table1.1
Of the three datas noted at three time interval the third data taken at an interval of 18 minutes from the start of the recording shown stabilization and thereby the third data of every subject is chosen for the study.
The AR Spectrum characterization of the datas shows the following characteristics with average value of the HF/LF ratio as 14.246433 and Max at 169.923 and Min at 0.
FFT characterization is also carried out of the data ranges. The characterization is a random one and the sex and characteristics of the subjects is not reflected in this study and is kept for future analysis. The above characterization can be used for by the researchers in the field of medicine and biomedical engineering and also by the defense for their reference. The research extends to various analysis procedures but remains restricted in this particular study.
5. Conclusion

The finding reflects that all values available from the subjects irrespective of their age group, sex etc. shows either low values in LF & HF characteristics or a very high value in the LF/HF ratio. This can be significant finding in this region which shows a misbalance of the sympathetic and parasympathetic nervous system. A rigorous research in this region is being carried out in the region taking higher number of samples and particular age domains and sex domains.

References


Table 1.1. Boundary Conditions

<table>
<thead>
<tr>
<th>Frequency Band</th>
<th>Interpolation RR series</th>
<th>Detrending RR series</th>
<th>No. of Samples</th>
<th>Interpol Rate (Hz) – 2</th>
<th>Points in Frequency Domain</th>
<th>Window width – 1024</th>
<th>Window overlap – 512</th>
<th>AR Model Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>VLF – 0.0 - 0.04 Hz</td>
<td>Interp Rate (Hz) – 2</td>
<td>Trend - Smooth Priors</td>
<td>One</td>
<td></td>
<td>1024</td>
<td></td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>LF – 0.04 – 0.15 Hz</td>
<td></td>
<td>Model - Eye</td>
<td></td>
<td></td>
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<tr>
<td>HF – 0.15 – 0.4 Hz</td>
<td></td>
<td>Welch's Periodogram</td>
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VLF – 0.0- 0.04 Hz
LF – 0.04 – 0.15 Hz
HF – 0.15 – 0.4 Hz

Fig. 1. HR and RRI plot from Suunto Training Manager Software
Fig. 2. Plot of RRI and corresponding selected RRI time series for analysis as fed to HRV software 1.1.
Fig. 5. VLF Characteristics of the subjects in AR spectrum with an average of 11.957 of %Power
Fig. 6. LF Characteristics of the subjects in AR spectrum with an average of 59.1167 of power in n.u
AR

Fig. 3. AR Spectrum (Parametric) of a subject of the third recording taken at rest in supine spectrum with an average of 19.8033 of power in n.u.

Fig. 4. FFT Spectrum of the same data (Welch’s Periodogram- non parametric)

Fig. 7. HF Characteristics of the subjects in