

Spectral Entropy Estimation of HRV Data of Thyroid and Healthy subjects

CH.RenuMadhavi
R.V.C.E
Bangalore
Karnataka, India

A.G.Ananth
R.V.C.E
Bangalore
Karnataka, India

ABSTRACT

Heart Rate Variability (HRV) indicates the variation of heart rate about its mean value. HRV has been found to be influenced by various physiological phenomena and also by various pathologies. In this paper the influence of Thyroid on HRV data has been investigated. For the purpose of investigation the Spectral Entropy (SpEn) values of six Thyroid and ten healthy subjects of 23 years -30years age group, having eight male and 8 female were estimated. From the results it is observed that average SpEn values of Healthy subjects is 2.1 and thyroid subjects average SpEn is 0.45. From the results it is concluded that SpEn of Thyroid subjects is 33% of healthy subjects, which is significantly lower than that of Healthy subjects and SpEn values of males is little higher than that of females. Further it may be interpreted as HRV has been influenced by thyroid. This influence of thyroid on HRV may be attributed due to the Autonomous Nervous System (ANS) dysfunction. The SpEn may be useful for the noninvasive detection of Thyroid.

General Terms

HRV Analysis, Spectral Entropy, Thyroid

Keywords

Heart Rate Variability, Autonomous Nervous System, Spectral Entropy, Thyroid, Health

1. INTRODUCTION

Electrical activity of heart is represented graphically by a waveform containing PQRST as shown in figure1 is known as an Electrocardiogram.(ECG)The electrical activity is initiated by Sino Atrial(SA) node which is a natural pacemaker present in the heart..SA node modulates the heart Rate (HR). HR is also modulated by the two branches of the Autonomous Nervous system namely Sympathetic Nervous system and the Parasympathetic Nervous system. HR is modulated not only by the functioning of the heart alone it is also modulated by ANS thus the heart is treated as a nonlinear system[10]

HR is expressed as reciprocal of RR interval measured in seconds multiplied by 60.HR thus derived is expressed as beats per minute(bpm)..Heart Rate Variability (HRV) is defined as the variation of HR about its mean value..RR interval is the interval between successive QRS complexes or successive R peaks. The balance between Sympathetic and Parasympathetic nervous system which is acting on SA node is measured by HRV.HR

variations about the mean value is caused due to the continuous variation in the sympatho vagal balance [8]

2. CURRENT SCENARIO

HRV analysis has been shown to provide clinically useful and otherwise hidden information about the health of the system producing the dynamics. Previous studies demonstrated that HRV is consistently and reproducibly altered in illness, and the degree of HRV alteration is prognostic of illness severity. [saif.ahmed.et.al2009].There are various methods used to evaluate the HRV .The most simple one is the time domain method, which measures the Standard deviation (SD) of the time series data. Time domain measures are complemented by frequency domain methods. In order to quantify the degree of information, disorder, or complexity of time series, Entropy Measures such as Approximate Entropy(ApEn),Sample Entropy(SampEn), MultiScale Entropy (MSE)] which reflect the degree of irregularity across a range of time scale, are used , yet another distinct evaluation method is scale invariant analysis Detrended Fluctuation Analysis(DFA)and Power law [6,11]. Lot of study has been done on HRV in association with Nervous system, blood pressure, Myocardialinfarction, Cardiac arrhythmias, Diabetes, Renal failure, gender and age, drugs, smoking, Alcohol, Sleep, and in Infants.[10] . Gautam.et.al[14] have compared autonomic status of female thyroid patients with normal healthy female subjects of both hypothyroid and hyper thyroid and found significant difference in the autonomic indices. They also found no difference in the mean values of hypothyroid and hyper thyroid patients.[12]Evaluated the impact of Hypothyroidism on Autonomic regulation of cardiovascular system using spectral analysis using Thyroxin therapy and observed that with Thyroxin replacement the BP and Heart Rate restored to normal. It is noteworthy that studies reported in the literature for early diagnosis of Thyroid using HRV analysis so far only been performed by using frequency domain analysis. in specific spectral analysis[9,12] Xing et.al[15] found autonomic dysfunction in Hypothyroid patients with higher level of vagal tone [12].[9]studied the relationship of Thyroid hormones with HRV. using power spectral analysis and found the sympatho vagal balance with ECG recordings of 5minute,for hyperthyroid subjects and found that changes in the serum levels effect the ANS regulations for hyperthyroid subjects. [4,5,6]have found that ApEn values of Thyroid subjects are lower than that of healthy subjects and found that Symbolic Entropy values of Thyroid subjects higher than healthy subjects, they also used bicoherence plots for visual identification of thyroid subjects. The ApEn values obtained [4,5,6] for thyroid subjects is not

significantly low. This paper tried to find Spectral Entropy with a hypothesis that SpEn values of Thyroid subjects will be significantly lower than that of healthy subjects.

2.1 Problem definition

Conventional methods of HRV Analysis based on time domain methods are unable to detect the small but significant changes in inter beat heart rate behavior. Nonlinear methods are required to find the hidden information. found autonomic dysfunction as a major factor of cardiac diseases[7]. This paper is aimed to evaluate the subjects suffering with noncardiac disease such as thyroid..HRV is analyzed using spectral entropy measures (SpEn)Thyroid dysfunction are associated with changes not only in cardiac or vascular function but also found to modify autonomic regulation of cardiovascular system [2] Early diagnosis and treatment does have significant effect on cardiovascular autonomic activity and can help in reducing the risk of cardiovascular diseases [12]

2.2 This Study

In this paper the noninvasive detection of ANS dysfunction is done for thyroid subjects by quantifying the HRV using the nonlinear measures such as Spectral Entropy (SpEn) parameters estimated and compared with the healthy subject

2.3 Materials and methods

For the proposed work HRV data has been acquired from 10 healthy subjects and 06 Thyroid subjects who are otherwise healthy. The subjects are in the age group of 20-30Years and 10 of them are males and 6 of them are females. The number of thyroid subjects is limited to six based on the availability.

2.4 Data Acquisition

First ECG has been acquired using three leads namely left arm(LA), right arm(RA)) and left leg(LL).Electrode from (RL) is grounded. Figure1 shows the block diagram of the work. The ECG is acquired for five minutes using three electrodes and the acquired signal is connected to the Bio-amplifier. The output of the Bio-amplifier is transmitted to the PC for the analysis purpose using the Virtual Instrumentation (National Instruments) Data acquisition (DAQ) card 6009. The ECG signal through NI DAQ is sent to the PC where in the signal is filtered, QRS peaks are detected and RR intervals are extracted in the Lab view environment. The acquired RR interval data which is the HRV data is used as an input file for the estimation of Spectral Entropy. The Spectral Entropy algorithm is implemented in MATLAB

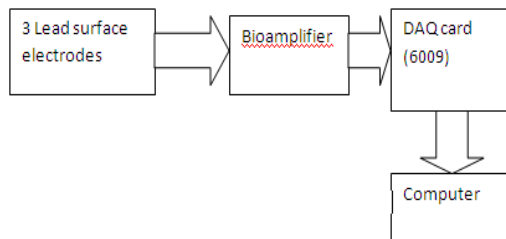


Fig1.Block diagram

2.5 Spectral Entropy

The algorithm for Spectral Entropy (SpEn) is explained below referring to [1,2]

1. First Transform the Time series HRV data into power spectrum by applying FFT
2. Next Compute the Power spectral density
3. Normalize the Power spectral density
4. Using Shannon’s Entropy find Power Spectral Entropy

$$H = - \sum_f P_f \ln P_f$$

Where P_f is the PDF at frequency f

3. RESULTS

The Power Spectral Entropy has been computed for HRV data of thyroid subjects and healthy subjects which was acquired using Lab view software along with NI DAQ (National Instrument’s Data acquisition) card .The results obtained are plotted in figure1 S_1 to S_{10} denote the subjects ,different color marking is used for Thyroid subjects and healthy subjects.thy subjects

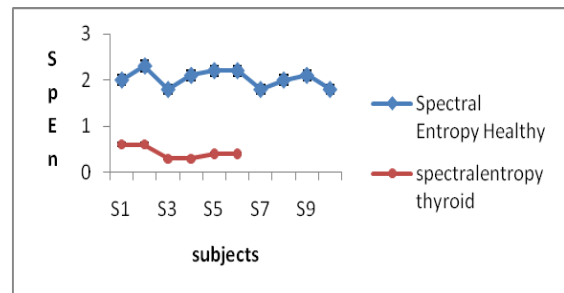


Fig2 shows the variation of SpEn values of Healthy and Thyroid subjects with error

Figure2 shows the variation of SpEn values of healthy subjects and Thyroid subjects’. The variation in the values for healthy subjects is around the mean value of 2.0.The variations are with in the errors. For thyroid subjects also the variation in the SpEn values is less having a mean value of 0.45From figure2 it can be observed that the SpEn values of Thyroid subjects are significantly lower than that of healthy subjects.

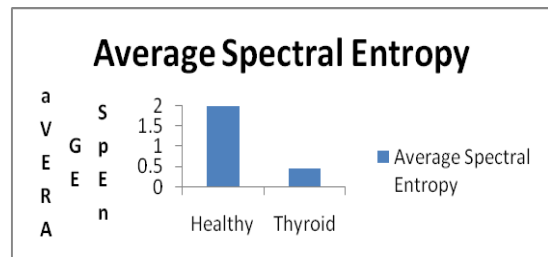


Fig3 Shows the average SpEn of Healthy and Thyroid subjects

Figure3 shows the average SpEn values of ten healthy and six thyroid subjects clearly indicating that average SpEn value of thyroid subjects is significantly lower than the average SpEn value of healthy subjects.

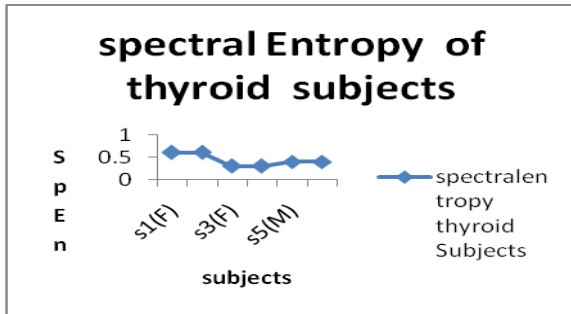


Fig4 shows the variation in SpEn of thyroid male and Female subjects

Figure4 shows the SpEn variation of thyroid subjects both male and female subjects, it is evident from the figure that there is no significant difference between the SpEn values of male and female subjects.

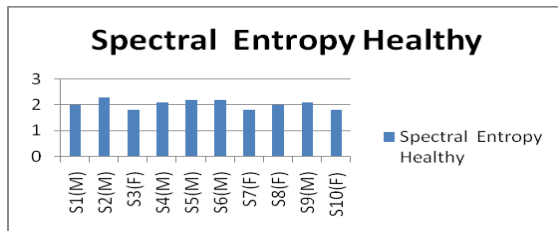


Fig5 SpEn values of Healthy subjects

Figure5 displays the SpEn values of both male female healthy subjects. From the figure it has been investigated that the SpEn values of Female subjects is lower than that of healthy male subjects.

4. DISCUSSION

From the results obtained it is observed that the average SpEn of healthy subjects is significantly high about 77% than the thyroid subjects. This indicated uncertainty of the event at frequency f is high indicating the complexity of the corresponding time series. The lower value of SpEn of Thyroid subjects contributes to the reduced uncertainty about the event at frequency f indicating the regularity of the corresponding time series. This reduced uncertainty in thyroid subjects may attribute to the Autonomic Nervous System (ANS) dysfunction with respect to the Thyroid gland functioning, which is contributing indirectly by reducing SpEn of thyroid subjects. It may be interpreted that thyroid can be noninvasively detected using SpEn effectively. Further it is observed that there is no significant difference in the SpEn values of thyroid effected female and male subjects. It may be inferred that for both males and females in the age group of 20-30 years Thyroid acts similarly.

5. CONCLUSIONS

The SpEn values of male and female thyroid subjects do not differ significantly. The future direction of this work could be investigation of effect of degrees of thyroidism on SpEn.

6. REFERENCES

- [1] Aihua zhang, Bin Yang, and ling huang “feature extraction of eeg signals Using Power Spectral Entropy, proceedings of international conference on biomedical Engineering and Informatics, vol2, pp435-439, 2008]
- [2] B.Anuradha and V.C.Veera Reddy”Cardiac Arrhythmia classification using fuzzy classifiers”Journal of theoretical and applied information technology, pp352-359,2005
- [3] Bhat.A.N.,Kalsotra .L,Yograj.S”Autonomic reactivity with altered thyroid status” J.K.Sci, 8, pp70-74, 2007
- [4] CH.Renumadhavi and A.G.Ananth”Noninvasive detection of Thyroid dysfunction using bicoherence plot and bicoherence metric of HRV data”International J. of Multidiscipl.. Research &Advcs in Engg, vol3, no1, pp81-90, 2011
- [5] CH.Renumadhavi and A.G.Ananth”Quantification of Heart Rate Variability (HRV)Data using symbolic Entropy to Distinguish between healthy and disease subjects” International Journal of computer Applications, vol8, no.12, pp, 2010
- [6] CH.Renumadhavi and A.G.Ananth”Analysis and Characterisation of Heart rate Variability (HRV) data of different sets of subjects Using Nonlinear Measure (Approximate entropy)” International Journal of Computer Theory and Engineering” Vol2, No.4, pp619-623, 2010
- [7] Keesam Jeong et.al” Astudy on relationship between heartrate variability and autonomic balance” Proceedings - 19th International Conference –IEEE/EMBS, California,USA1997,
- [8] Nasim Karim,Jaban Ara Hasan and Syed saarowar Ali “HRV Review “Journal of Basic and applied sciences,vol 7,no’1,pp71-75,2011
- [9] Rassel Kabir,Noorzahan Begum,Sultana Ferdousi,Shelina Begum,and Taskina Ali”Relation ship of Thyroid Hormones with Heart Rte Variability”Journal of Bangladesh Society of Physiologist,vol.5,no.1,2010
- [10] U.Rajendra Acharyaet.al”heart rate variability :A review”Med.Bio.Eng.Comput,44:1031-1051,2006
- [11] Saif Ahmed et.al”A Review and Analysis of HRV and diagnosis and prognosis of infection”critical care,13:232,2009
- [12] Vijaya Lakshmi ,N.Vaneyet.and S.Madhu”Effect of Thyroxine on Autonomic status in hypothyroid patients”Indian J.Physiol.Pharmacol,53(3),pp219-226,2009
- [13] Xiaopeng Bai,Jingxiu Li,Lingoj Zhou and XueqiLi”Influence of the menstrual cycle on nonlinear properties of heart rate variability in young women” Am.J.Physiol Heart Circ Physiol 297,H765-H774,2009
- [14] S.Gautam.et.al”Correlation of Autonomic Indices with Thyroid status”Indian journal of Physiol.pharmacol,47(2),pp164-170,2003
- [15] Xing.H.et.al”Heart rate variability and its response to thyroxine replacement therapy in patients with hypothyroidism”ChinMedJ.,114(9):906-8,2001