Stress Detection Using Heart Rate Variability

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Abstract: In today’s world stress is one of the major factor leading to health problem. The diagnosis and the solution is mainly dependent on how experienced the clinician is in determining the factors of stress.

The stress can be identified on the basis of parameters such as Galvanic Skin Response (GSR), Heart Rate (HR), Body Temperature, Blood Pressure (BP) which provides detailed information of the state of mind of a person. These parameter’s defer from person on the basis of their body condition, age, gender and experience.

In this paper, we have focused on heart rate variability (HRV) as a major technique for determining stress. HRV serves as a substitute for “vertical integration” of the brain mechanism that guide flexible control over behavior with peripheral physiology and thus it provides an important way of understanding stress and health.

Keywords: Stress; Heart Rate Variability (HRV); Physiological; Galvanic skin response (GSR); Health; Autonomic nervous system

I. INTRODUCTION

At present time the role of researchers and clinicians in searching biomarkers of stress and health is still a challenging task as there are many obstacles in this search. Firstly, lack of consensus and second being lack of comprehensive framework in which to investigate.

Stress is a term that describe our body reaction to physical and psychological threats. If the level of stress increases it can lead to serious health consequences, which cause various risk factor for heart diseases, diabetes, asthma and depression.

Despite knowing its effect on health, it is not possible for both the physician and the patient to continuously monitor our stress levels. Thus there is a need of device that can monitor stress over regular time intervals (weeks or months), which provides an individual and their caretakers with data with which to monitor their progress on their health.

II. LITERATURE SURVEY

A. Definition and mechanisms of heart rate variability

The automatic nervous system (ANS) is a part of peripheral nervous system that controls that mechanism of our body and maintain it under stable condition. ANS consist of two main parts: a) sympathetic nerve system (SNS) b) parasympathetic nerve system (PNS).

The SNS prepares our body against threats so called “fight or flight” response, while the PNS becomes active under unchallenging situation, working in opposite direction and bringing the body back to its normal state. SNS activation increases the heart rate; on the other hand PNS activation decreases it. By analyzing fluctuation in beat to beat periods we can separate the role played by both branches. And this is known as HRV analysis. HRV is a non-invasive electrocardiographic maker which reflects on the activity of the sympathetic and vagal components of ANS. It depicts the total amount of variation of both HR and RR interval. In this way, HRV analysis the tonic baseline automatic function.

There is a continuous physiological variations of the sinus cycles in a normal Heart with an integer ANS, which reflect a balanced sympathovagal state and normal HRV. A damaged heart which has suffered from myocardial necrosis, the activity change in the afferent and efferent fibres of the ANS and in the local nerve regulation contributes to the resulting sympathovagal Imbalance which is reflected by a diminished HRV.

B. Measurement of HRV

While analyzing HRV there are a serious of measurement which consist of successive RR interval various of sinus variation which provides information about automatic tone.
Various factors influencing HRV include age, gender, respiration and body position. HRV is generally performed on the basis of 24 hour Holter recording or on a short range in between of 0.5 to 5 min mainly focusing on electrocardiography field.

The HRV triangular index is measured by dividing the integral of the density distribution by the maximum density distribution. The estimated value can be found by using a measurement of NN intervals on a separate scale, the measure is estimated by the value, which depends on the length of the bin, that is, on the correctness of the separate scale of measurement.

C. Role of neural network

The technology especially artificial neural network (ANN) techniques could result in reducing cost, time, medical error and need of human expertise.

Neural network model is used to detect stress with the help of physical symptoms and risk factors. Once the neural network model is trained, it will predict the possibility of stress.

Artificial Neural Networks are non-linear mapping structures based on the function of the human brain.

Artificial Neural Networks can identify and learn correlated patterns between input data sets and corresponding target values.

The statistical time domain indices are divided in to two categories i.e. beat-to-beat intervals and intervals derived from the differences between adjacent NN intervals.

Table I summarizes two different categories, the first category consists of parameters like SDNN, SDANM and SD and these of second category are RMSSD and PNN50.

SDNN is a global index of HRV, which reflect the long term components responsible for variability in the recording period. SDANN is an index of variability having an average of 5 min interval over 24 hours. SD is consider to reflect the day night changes of HRV .RMSSD and PNN50 are common parameters which are based on the differences in the interval. These are not dependent on day and night variations and respond to short term HRV changes. As RMSSD is more stable hence it should be preferred for clinical use.

E. Geometric methods

The conversion of sequences of NN intervals when derived and constructed gives geometric methods. There are different geometrical forms available which allow access to HRV: the 24-hour histogram, the HRV triangular index its modification, the triangular interpolation of NN interval histogram and the method based on Lorenz or Poincare plots. The relationship between the total number of RR interval detected and the 24-hour RR interval variation is accessed by 24-hour histogram. The triangular HRV index has the measure peak of histogram as a triangular with its height corresponding to the most frequently observed duration of RR intervals, its baseline width corresponding the amount of RR interval variability and its area corresponding to the total number of all RR interval used to constructed. By the quality of the recorded data, geometrical methods are less affected and they may provide on alternate to less easily obtainable statistical parameters.

F. Frequency domain analysis

The periodic oscillations of heart rate signal decompose at different frequencies and amplitudes are described by frequency domain analysis, and it provide information on the amount of their relative intensity in the heart’s sinus rhythm. Power spectral analysis is obtained when white light passes through a prism which results in different light of different colour and wavelength. The analysis of power spectral can be done in two ways: 1) Using non parametric method, the fast fourier transformation (FFT), which is distinguished by discrete Peaks for the several frequency components. 2) Using parametric method, the auto regressive model estimation, which results in a continuous smooth spectrum of activity.
The parametric method is more complex and needs verification of the suitability of the model chosen whereas FFT is simple and rapid methods.

Due to this almost 20-30\% of high risk post-MI patients are neglected from any HRV analysis due to episodes of atrial arrhythmias, particularly atrial fibrillation.

III. LIMITATION OF STANDARD HRV MEASUREMENTS

As HRV measurement deals with RR interval variations, its measurement is limited to only those patient with low number of ectopic beats and patients in sinus rhythm.
The table below shows the different stress level depending on different HRV Triangular Indexes:

<table>
<thead>
<tr>
<th>SDNN(ms)</th>
<th>HRV Triangular Index</th>
<th>Stress Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-55</td>
<td>2-15</td>
<td>Highly Tense</td>
</tr>
<tr>
<td>55-110</td>
<td>14-25</td>
<td>Slightly Tense</td>
</tr>
<tr>
<td>110-180</td>
<td>22-52</td>
<td>Mildly Calm</td>
</tr>
<tr>
<td>180-215</td>
<td>50-60</td>
<td>Quietly Relaxed</td>
</tr>
<tr>
<td>215-230</td>
<td>60-73</td>
<td>Deeply Relaxed</td>
</tr>
</tbody>
</table>

IV. HRV AND EMOTIONAL REGULATION

The ability to control emotion is related to the ability to shape affective brain pressure flexibly in response to changing context. Emotions represent on individuals vision of personally relevant environment interactions, which includes not only the challenges and threats but also the ability to respond to them. Emotion reflect the status of an individual’s ongoing adjustment to repeatedly changing environment demands. The role of HRV in emotional regulation is seen at two different levels. The first level is at tonic level where individual differences in resting HRV are associated with the differences in their emotional regulation. People with high level of resting HRV produce context appropriate emotional responses as indexed by fear – potentiated startle responses, phasic heart rate responses, self reported emotional responses, emotions modulated startle responses, as compared to people with low level of resting HRV. The second level is the phasic level where the HRV values increases where there is a successful regulation of emotion during emotional task.

V. CURRENT LIMITATION AND FUTURE DIRECTIONS FOR THE USE OF HRV

A large number of experimental and clinical studies which are earlier published for the measurement of HRV is still a research technique and still has not proved to be a routine clinical tool. There are many reasons behind this, Firstly, the physiopathological mechanism of HRV which establishes a direct link between mortality and reduce HRV which is still not fully clear. Secondly, the application of HRV assessment in clinics is limited due to lack of standard methodology which is due to the variability of the parameters varying with respect to age, gender, drug interferences and associated diseases. Third, even with relative evidences of the vigorous character of parameters, there is still no consensus about the most accurate parameter.

Fourth, the specificity, sensitivity and positive analytical accuracy of HRV are limited. Mostly, it’s positive analytical accuracy is modest, which ranges from 14 to 40%. While it is also having negative analytical value which ranges from 77 to 98%. At last contradictory results have been found pertaining to HRV measured after MI, suggesting that this technique may be not enough by itself to adequately risk stratify these high risk patients.

The combination of HRV with other risk stratifies, which includes LVEF, NSVT, LP and BRS may increase the overall analytical accuracy. In recent times an approach using a variety of noninvasive and invasive tests in a stepwise fashion was proposed. In stage one LP and LVEF were obtained whereas in stage two with the help of an ambulatory 24- hour ECG recording for the documentation of complex ventricular arrhythmias and for the measurement of HRV, and in stage three use of an electrophysiology study with potential induction of ventricular tachycardia.

VI. SUMMARY AND CONCLUSION

In this paper, we have presented different analysis for Heart Rate Variability (HRV). We have shown the correlation between two analysis. We have also focused on the relation between HRV and emotional regulation. It is our hope that this review highlights the different analysis for HRV calculations. As we are using digital pulse sensor, it could be less time consuming and more accurate than the older techniques. Our expectation is to maintain accurate stress using Artificial Neural Network (ANN), we are going to analyze the records provided by the hardware machine and depending on that reading we are going to determine stress level.

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