ABSTRACT

INTRODUCTION:
Stress is a huge problem which affects many physiological parameters in human body. In contrast with other lifestyle risk factors, no consensus about stress exists with respect to either definition or measurement. In particular, with reference to the ways in which people cope with stress, it was found convenient to postulate the existence of two separate personality types characterized by differing sets of behavior patterns known as Type A or Type B behavior (Friedman and Rosenman, 1959).

OBJECTIVE:
The goal of our study was to evaluate the changes in heart rate variability due to physical and mental stress in different type of personalities (Type A and Type B) and to investigate a possible link between psychological traits and autonomic imbalance.

METHOD:
In laboratory set up, 25 subjects (9 males, 11 females; 5 rejected) of mean age 20.30 ±1.53 years were taken. After taking written consent, subjects were instructed to fill in personality
questionnaire. In each of the subject, baseline ECG was recorded for 5 minutes and they were subjected to mental (reverse calculations) and physical stress (45 degree shoulder abduction) with 15 minutes interval period in between. Spectral analysis of HRV for our study, characterized by High frequency (HF) component, Low frequency (LF) component and LF/HF ratio. All the subjects were divided into Type A (Scores > 207), Type B (Scores <187) and AB (Scores in 188 to 207).Correlation was found between type of personalities and the frequency domain of HRV.

RESULTS:
All the components of HRV (LF, HF, LF/HF) were sensitive to physical and mental demands. Type A personality were more prone to stress, despite similar baseline values and stress tests to Type B personality. Statistically significant change in heart rate and thus RR interval was observed during the physical and mental stress as compared to resting condition in Type A individuals. Although personality scores gave positive correlation with HR, LF and LF/HF while negative correlation was seen with HF domain, but the correlation was not significant.

Due to mental stress, significant increase in heart rate, LF domain and LF/HF ratio was seen as compared to physical stress. HF domain, although increased with physical stress, but it was not statistically significant.

CONCLUSIONS:
Both physical and mental stress influence risk factors that may increase risk for cardiovascular diseases especially in type A personality.

KEY WORDS: Stress, Personality, cardiovascular risk, Heart Rate Variability, Autonomic Function
INTRODUCTION

Stress, is defined as a mismatch between perceived demands and perceived capacities to meet those demands. It is a huge problem in the present scenario, which may lead to work related illness directly or indirectly\(^1\). It affects many physiological parameters in human body and causes imbalance in homeostasis mechanism\(^2\).

Cardiovascular diseases are the highest cause of death in the industrialized world, and many of these deaths may be work related. Epidemiological studies have implicated stress as one of the risk factors for cardiovascular disease (CVD) but little is known about the mechanisms that underlie this connection\(^3\).

Individuals belonging to the Type-A group are those more exposed to stress (mental> physical) and present a higher chance of suffering from a physical or mental disorder on account of the pressure of stressful events. For example, Type-A people are very vulnerable with respect to cardiovascular disease (heart attack, stroke, hypertension etc.). Those in the Type-B category on the other hand reveal a greater capacity to cope with potentially stressful situations, consequently reducing their risk of becoming ill. The difference between the two types does not depend on the fact they present two different and well-defined personality structures but rather on the way in which they organize their responses to stressful situations\(^4\).

However, the physiological mechanisms accounting for these associations between personality traits on one hand, and cardiovascular morbidity and mortality on the other are not completely understood. Candidate mechanisms have included: limbic and hypothalamic–pituitary–adrenal deregulations, dysfunctions of the autonomic control of the heart (e.g., defective neuronal reuptake of noradrenalin), altered blood platelet function, and non-compliance to medical treatments\(^5,6\). Experimental evidence for an association between a propensity for lethal arrhythmias and signs of either increased sympathetic or reduced vagal activity has encouraged the development of quantitative markers of autonomic activity\(^7\).

To date about 26 different types of arithmetic manipulations of RR intervals have been used for assessing autonomic activity\(^8\). Heart rate variability (HRV) represents one of the most promising such markers\(^9\). The apparently easy derivation of this measure has popularized its use\(^10\). It is the variation of period between consecutive heartbeats and provides powerful means of observing interplay between sympathetic and parasympathetic nervous systems\(^11\).

Heart rate variability is generally measured using automated computer software wherein, ECG is generated, which is digitized using analog to digital converter (ADC) and several methods can be used to analyze the data (time domain, spectral or frequency domain, geometric, and nonlinear)\(^12\). This study utilized frequency domain analysis of heart rate variability. Spectral analysis of R-R intervals was done using Fourier transformations, which decomposes a complex function into various frequencies of oscillatory functions, like the sine and cosine functions. Spectral analysis takes the Fourier transform and splits the graph into different levels of frequency power:
Our study was inspired by the fact that very few studies were done in Indian subcontinent to demonstrate how different types of personalities react to physical as well as mental stress and document its effect on HRV. Since, recent studies have documented that 6-10% of myocardial infarction takes place in younger age group, thus, we targeted this age group for our study\textsuperscript{14}.

MATERIALS AND METHODS:
The present study comprises of 25 subjects of mean age 20.30 ±1.53, selected randomly from the apparently healthy MBBS students of Maulana Azad Medical College and Lok Nayak Hospital, New Delhi. After taking Institutional ethical clearance, experiment protocol was explained and consent was taken. These subjects would be of either sex, and will be given Personality questionnaire according to which they will be divided into Type A and Type B personality. Those students who will have borderline scores will be rejected from our study.

STUDY DESIGN
This was a self control type of study. The subjects in the study were selected on randomized basis and that they extended their cooperation for the same.

- Study duration: 8 Weeks
- Selection Criteria

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{spectral_frequency_analysis_modified.png}
\caption{SPECTRAL FREQUENCY ANALYSIS (Modified)\textsuperscript{13}}
\end{figure}
[1] Inclusion Criteria

a) Individuals of either sex and of adult age group (18-35 years)
b) Apparently healthy individuals without any known disease which may directly or indirectly affect Autonomic nervous system.
c) No history of any medication or drug affecting the ANS.

[2] Exclusion Criteria

a) Individuals with any known disease or drug which may directly or indirectly affect ANS.
b) Borderline personality scores (Type AB)
c) Any orthopedic abnormality
d) Unable to cooperate to undergo the study design.

- **Experiment Protocol: In laboratory set up, the following protocol will be followed:**

  1. All the subjects filled a consent form that they are willing to participate in study.
  2. Relevant history was taken and the subjects were instructed to fill in the given Personality questionnaire\(^\text{15}\).
  3. Anthropometric measurements: height, weight and body mass index was calculated using formula individual body mass in kg divided by square of his/her height.
  4. Subject’s Blood pressure was measured using automated apparatus
  5. In each of the subject, baseline ECG was recorded for 5 minutes after 15 minutes of rest at comfortable room temperature\(^\text{10}\). The acquired ECG signal is digitized and stored. The analysis was done by frequency domain methods as described below.
  6. After which each of them were subjected to mental (reverse calculations of subtracting 13 starting with 3000)\(^\text{16}\) and physical stress (45 degree shoulder abduction, one arm unsupported with maximum extension)\(^\text{17}\) with 15 minutes rest period in between.

- **Spectral analysis of HRV\(^\text{10}\)** will be characterized by the following three frequency domain components:

  1. High frequency (HF) component (0.15Hz - 0.40 Hz): Predominantly parasympathetic,
  2. Low frequency (LF) component (0.04Hz – 0.15 Hz): Predominantly sympathetic.
  3. LF/HF ratio: Sympathovagal balance
STATISTICAL ANALYSIS

Student’s t-test was used for the analysis and a p value of < 0.05 was considered as significant. The correlation between the different parameters was studied by using Pearson’s correlation coefficient.

RESULTS

For analyzing the data, acquisition was done by computed software in RMS polyrite. Each data file was filtered in order to remove low-frequency composite oscillating waves. Since the QRS waves were high frequency waves, this filter made the QRS peaks in the electrocardiograph stand out more and facilitated selection in later parts of the program. The program then found the peaks of each graph, and other outliers caused by irregularities were eliminated through the use of a threshold.

The mean age of the subjects was 20.30 ±1.53 years and various anthropometric parameters are given in the Table-1 below.

<table>
<thead>
<tr>
<th>#</th>
<th>PARAMETER</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Age (years)</td>
<td>20.30 ± 1.53</td>
</tr>
<tr>
<td>2</td>
<td>Male : Female</td>
<td>9 : 11*</td>
</tr>
<tr>
<td>3</td>
<td>Height(cm)</td>
<td>166.29 ± 11.36</td>
</tr>
<tr>
<td>4</td>
<td>Weight(kg)</td>
<td>63.60 ± 16.21</td>
</tr>
<tr>
<td>5</td>
<td>Body Mass Index(kg/m²)</td>
<td>23.00 ± 4.08</td>
</tr>
</tbody>
</table>

*5 subjects excluded from the study due to borderline personality scores (Type AB)

Most of the components of HRV were sensitive to physical and mental demands. Due to physical stress statistically significant increase in heart rate, low frequency and low/high frequency was seen, whereas high frequency and RR interval decreased significantly (see Table-2).

<table>
<thead>
<tr>
<th>#</th>
<th>DOMAIN</th>
<th>BASELINE</th>
<th>PHYSICAL STRESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Heart rate</td>
<td>80.80 ± 11.55</td>
<td>90.45 ± 9.48*</td>
</tr>
<tr>
<td>2</td>
<td>RR interval</td>
<td>0.76 ± 0.11</td>
<td>0.67 ± 0.07*</td>
</tr>
<tr>
<td>3</td>
<td>LF</td>
<td>180.10 ± 113.54</td>
<td>280.95 ± 118.36*</td>
</tr>
<tr>
<td>4</td>
<td>HF</td>
<td>159.50 ± 41.57</td>
<td>134.80 ± 41.85</td>
</tr>
<tr>
<td>5</td>
<td>LF/HF</td>
<td>1.19 ± 0.71</td>
<td>2.21 ± 0.89**</td>
</tr>
</tbody>
</table>

*Significant (p< 0.05); **Highly significant (p< 0.001)
When the group was subjected to mental stress, highly significant increase in LF domain and LF/HF ratio was seen whereas, HF domain decreased significantly (See Table-3)

**Table-3: Impact of Mental Stress on HRV Components**

<table>
<thead>
<tr>
<th></th>
<th>DOMAIN</th>
<th>BASELINE</th>
<th>MENTAL STRESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Heart rate</td>
<td>80.80 ± 11.55</td>
<td>97.90 ± 9.88**</td>
</tr>
<tr>
<td>2</td>
<td>RR interval</td>
<td>0.76 ± 0.11</td>
<td>0.62 ± 0.07**</td>
</tr>
<tr>
<td>3</td>
<td>LF</td>
<td>180.10 ± 113.54</td>
<td>396.70 ± 231.37**</td>
</tr>
<tr>
<td>4</td>
<td>HF</td>
<td>159.50 ± 41.57</td>
<td>119.75 ± 50.87</td>
</tr>
<tr>
<td>5</td>
<td>LF/HF</td>
<td>1.19 ± 0.71</td>
<td>3.32 ± 1.31**</td>
</tr>
</tbody>
</table>

*Significant (p< 0.05); **Highly significant (p< 0.001)

Mental Stress resulted in significantly higher variation in HRV parameters vis-à-vis Physical Stress, except HF domain where difference was not significant.

Amongst 20 subjects, 6 subjects were of Type A personality (Score >207), 14 Type B personality (Score <187) and 5 Type AB (Score in 187-207); which were excluded from the study. When the baseline characteristics were compared between Type A and Type B personalities, no significant difference was seen between them (details in Table-4)

**Table-4: Comparison of baseline HRV characteristics for Type-A and Type-B subjects**

<table>
<thead>
<tr>
<th></th>
<th>PARAMETER</th>
<th>TYPE-A SUBJECTS</th>
<th>TYPE-B SUBJECTS</th>
<th>SIGNIFICANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Heart rate</td>
<td>74.50 ± 10.15</td>
<td>83.5 ± 11.37</td>
<td>NS</td>
</tr>
<tr>
<td>2</td>
<td>RR interval</td>
<td>0.82 ± 0.12</td>
<td>0.73 ± 0.10</td>
<td>NS</td>
</tr>
<tr>
<td>3</td>
<td>LF</td>
<td>191.67 ± 119.1</td>
<td>175.14 ± 115.32</td>
<td>NS</td>
</tr>
<tr>
<td>4</td>
<td>HF</td>
<td>185.33 ± 43.93</td>
<td>148.43 ± 36.65</td>
<td>NS</td>
</tr>
<tr>
<td>5</td>
<td>LF/HF</td>
<td>1.09 ± 0.69</td>
<td>1.23 ± 0.74</td>
<td>NS</td>
</tr>
</tbody>
</table>

*NS: Not-Significant (p>0.05); S: Significant (p< 0.05); HS: Highly significant (p< 0.001)

Both Type A and Type B personalities when exposed to mental stress demonstrated significant changes as shown Table-5 and Table-6 below:
Table – 5: Impact of Mental Stress on Type A Personality

<table>
<thead>
<tr>
<th>#</th>
<th>PARAMETER</th>
<th>BASELINE</th>
<th>MENTAL STRESS</th>
<th>SIGNIFICANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Heart rate</td>
<td>74.50 ± 10.15</td>
<td>103.67 ± 7.28</td>
<td>HS</td>
</tr>
<tr>
<td>2</td>
<td>RR interval</td>
<td>0.82 ± 0.12</td>
<td>0.58 ± 0.04</td>
<td>HS</td>
</tr>
<tr>
<td>3</td>
<td>LF</td>
<td>191.67 ± 119.1</td>
<td>471 ± 275.18</td>
<td>S</td>
</tr>
<tr>
<td>4</td>
<td>HF</td>
<td>185.33 ± 43.93</td>
<td>121.17 ± 14.50</td>
<td>HS</td>
</tr>
<tr>
<td>5</td>
<td>LF/HF</td>
<td>1.09 ± 0.69</td>
<td>3.76 ± 1.86</td>
<td>HS</td>
</tr>
</tbody>
</table>

*NS: Not-Significant (p>0.05); S: Significant (p< 0.05); HS: Highly significant (p< 0.001)

Table-6: Impact of Mental Stress on Type-B Personality

<table>
<thead>
<tr>
<th>#</th>
<th>PARAMETER</th>
<th>BASELINE</th>
<th>MENTAL STRESS</th>
<th>SIGNIFICANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Heart rate</td>
<td>83.5 ± 11.37</td>
<td>95.43 ± 10.02</td>
<td>HS</td>
</tr>
<tr>
<td>2</td>
<td>RR interval</td>
<td>0.73 ± 0.10</td>
<td>0.64 ± 0.07</td>
<td>HS</td>
</tr>
<tr>
<td>3</td>
<td>LF</td>
<td>175.14 ± 115.32</td>
<td>364.86 ± 213.24</td>
<td>S</td>
</tr>
<tr>
<td>4</td>
<td>HF</td>
<td>148.43 ± 36.65</td>
<td>119.14 ± 60.83</td>
<td>NS</td>
</tr>
<tr>
<td>5</td>
<td>LF/HF</td>
<td>1.23 ± 0.74</td>
<td>3.14 ± 1.03</td>
<td>HS</td>
</tr>
</tbody>
</table>

*NS: Not-Significant (p>0.05); S: Significant (p< 0.05); HS: Highly significant (p< 0.001)

When Type A personality was subjected to physical stress, highly significant changes was seen with Heart rate, RR interval, HF and LF/HF ratio, whereas, in Type B personality LF/HF ratio was increased significantly whereas, non-significant difference was seen in other parameters (Table-7, Table-8)

Table-7: Impact of Physical Stress on Type A Personality

<table>
<thead>
<tr>
<th>#</th>
<th>PARAMETER</th>
<th>BASELINE</th>
<th>PHYSICAL STRESS</th>
<th>SIGNIFICANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Heart rate</td>
<td>74.50 ± 10.15</td>
<td>89.83 ± 7.17</td>
<td>HS</td>
</tr>
<tr>
<td>2</td>
<td>RR interval</td>
<td>0.82 ± 0.12</td>
<td>0.67 ± 0.05</td>
<td>HS</td>
</tr>
<tr>
<td>3</td>
<td>LF</td>
<td>191.67 ± 119.1</td>
<td>311.67 ± 123.76</td>
<td>NS</td>
</tr>
<tr>
<td>4</td>
<td>HF</td>
<td>185.33 ± 43.93</td>
<td>125.33 ± 21.36</td>
<td>HS</td>
</tr>
<tr>
<td>5</td>
<td>LF/HF</td>
<td>1.09 ± 0.69</td>
<td>2.59 ± 1.17</td>
<td>HS</td>
</tr>
</tbody>
</table>

*NS: Not-Significant (p>0.05); S: Significant (p< 0.05); HS: Highly significant (p< 0.001)
**Table 8: Impact of Physical Stress on Type B Personality**

<table>
<thead>
<tr>
<th>#</th>
<th>PARAMETER</th>
<th>BASELINE</th>
<th>PHYSICAL STRESS</th>
<th>SIGNIFICANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Heart rate</td>
<td>83.5 ± 11.37</td>
<td>90.71 ± 10.55</td>
<td>NS</td>
</tr>
<tr>
<td>2</td>
<td>RR interval</td>
<td>0.73 ± 0.10</td>
<td>0.67 ± 0.08</td>
<td>NS</td>
</tr>
<tr>
<td>3</td>
<td>LF</td>
<td>175.14 ± 115.32</td>
<td>267.79 ± 118.17</td>
<td>NS</td>
</tr>
<tr>
<td>4</td>
<td>HF</td>
<td>148.43 ± 36.65</td>
<td>138.86 ± 48.21</td>
<td>NS</td>
</tr>
<tr>
<td>5</td>
<td>LF/HF</td>
<td>1.23 ± 0.74</td>
<td>2.05 ± 0.73</td>
<td>HS</td>
</tr>
</tbody>
</table>

*NS: Not-Significant (p>0.05); S: Significant (p< 0.05); HS: Highly significant (p< 0.001)

Correlation amongst the personality scores and HRV parameters were done using Pearson’s Coefficient. Although positive correlation was seen with LF domain and LF/HF ratio, it was non-significant. A significant positive correlation was seen with BMI in type B personality group.

**DISCUSSION**

HRV analysis has gained much importance in recent years as a technique employed to explore the activity of ANS, and as an important early marker for identifying both physiological and pathological conditions. An attempt was made to examine the influence of stress on Heart Rate Variability in Type A and Type B personalities. We explored this relation recording data for three conditions: at rest, with physical stress followed by mental task. The experimental tasks were intended to induce mental and physical stress. For almost all described measures (Mean RR, LF, HF, LF/HF), the active conditions can be distinguished from the rest condition, meaning that heart rate variability is sensitive to any change in mental or physical state.

Mean values ± SD for heart rate at rest was 80.80 ± 11.55 bpm, which increased highly significantly to 90.45 ± 9.48 bpm during physical stress and 97.90 ± 9.88 bpm with mental stress. Thus, as expected there was significant decrease in RR interval both during physical and mental stress.

Due to stress, there was statistically significant increase in LF and LF/HF ratio and decrease in HF domain. Moriguchi et al\(^1\) and Lucini D et al\(^1\) also documented the same. Contrary to these findings, Tharion et al in 2009 stated that there was no significant change in frequency domains due to stress\(^2\).

Although more sympathetic activation was observed in mental stress vis-à-vis physical stress; the difference was not significant in our study. Whereas, Garde et al reported that physical demands have major influence on autonomic modulation and role of mental stress is insignificant\(^3\).
Personality may favor emotional stress, which in turn may alter autonomic drive, reduce coronary blood flow, and induce ischemia\textsuperscript{22}. Effect of stress (physical and mental) on heart rate variability in Type A and Type B personality was also ascertained. While some earlier studies suggested that type A personality doubled your risk of heart disease and made you five times more likely to have a recurrent heart attack,\textsuperscript{23} other studies have found no association between type A personality and heart disease risk\textsuperscript{24, 25}. Increased sympathetic activity at baseline and during stress is an attractive potential mechanism that may link personality characteristics to cardiovascular disease\textsuperscript{26}. We found although the baseline stress levels were same in both the personality types, but when type A individuals were exposed to mental stress, highly significant increase in LF and LF/HF ratio was seen. Psychological characteristics have been proposed as possible mechanisms that contribute to sympathetic activation. Behavioral responses are frequently accompanied by sympathetic activation. These behavioral responses are regulated by central control mechanisms, which are linked closely to brain stem centers that modulate autonomic outflow\textsuperscript{27}. Several prior studies have examined the association between type A personality (with its related hostility and anger) and cardiovascular disease. Some have shown a direct relationship between the two\textsuperscript{28,29} and others have shown no interaction\textsuperscript{30,31}.

On comparing both the sexes, females had higher HR, LF domain, LF/HF with respect to males, although the difference was not significant. K. Umetani in 1998 documented that in young females (< 50 years), Heart rate was significantly more than males, whereas after 50 years, this effect disappeared\textsuperscript{32}. However, D. Ramekers stated that there is no influence of gender on heart rate variability\textsuperscript{33}.

**Important and unique strengths of the present study include:**

- Data analysis was completed with the investigator blinded to personality type
- Effect of both physical and mental stress on heart rate variability was seen
- Stressors used in this study replicated real life stressors
- Non-invasive technique was used to assess sympathovagal balance.
- We studied normal subjects over a narrow range of age and body mass index, which minimized the influence of these variables on the responses we report. Young individuals were chosen due to increase in rate of myocardial infarction in this age group.

**CONCLUSION**

Thus, we conclude both physical and mental stress influence risk factors that may increase risk for cardiovascular diseases especially in type A personality.

**SCOPE FOR FURTHER STUDY**

Scope and reliability of the study can be enhanced by:

- Increasing number of subjects
- Including subjects from different professions
- Testing efficacy of other physical and mental stress inducers, to identify the optimal inducer to be used for the study.
- Assessing biochemical parameters like cortisol and catecholamines during the study.

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