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Original Article

Effect of Acute Mental Stress on Heart Rate Variability in Obese Adults – A comparative Study

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Abstract

Stress and obesity are the lifestyle risk factors that affect many physiological parameters in human body. The extent to which an individual cope up with stress depends on autonomic neuronal activity. In the present study, we compared the frequency domain indices of HRV before and during mental arithmetic stress test between obese and non obese adults. Age matched 60 male subjects (30 obese and 30 non obese) underwent mental arithmetic stress task for 5 mins. Before stress test LFnu and LF/HF ratio showed statistically significant ($p<0.001$) increase in obese group. During mental arithmetic test LFnu, HFnu and LF/HF ratio was reduced in obese subjects with LFnu reduction being statistically significant ($p<0.01$). Whereas in non obese subjects, there was statistically increase in LFnu ($p<0.001$) and LF/HF ratio ($p<0.01$) with reduction in HFnu ($p>0.05$) which was statistically not significant.

Introduction

Modern day is the age of stress. Evidence is accumulating that specific 'triggers' such as psychological and physical stress may precipitate myocardial infarction and sudden cardiac death (1, 2). Many studies have demonstrated an association of high body mass index (BMI) with greater risk for cardiovascular disease (3, 4). Physiologically, coping with stress imposes modulation in neuroendocrine and autonomic nervous system such that there is minimal organ damage. The major system that is going to be affected in the long run, in response to stress is cardiovascular system. The increase in sympathetic nerve activity in humans during mental stress is thought to reflect the balance between two opposing forces i) central nervous system arousal, which is sympathoexcitatory, and ii) arterial baroreflex activation, which is sympathoinhibitory. Last two decades have witnessed significant relationship between the autonomic nervous system and cardiovascular mortality, including sudden cardiac death (5,6).

Signs of lethal arrhythmias in the form of either increased sympathetic activity or reduced vagal tone or both have led for the advent of measures to evaluate autonomic nervous system. And one such promising quantitative marker of autonomic nervous system is Heart rate variability (HRV). The frequency domain analysis in HRV yields valuable information regarding both sympathetic and parasympathetic

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components of autonomic nervous system (ANS). Stress testing unveils autonomic dysfunction through HRV, even if the autonomic neuronal activity is normal during basal condition. There are numerous tests to induce mental stress such as Stroop test, general knowledge quiz, reaction time task, memory tests, simulated speech task, mental arithmetic test etc. Mental arithmetic test is the commonest, easier to administer and precisely regulated by the investigator. Many studies have shown a higher sympathetic activity to mental stress in healthy non obese subjects (7, 8). However, limited studies are done to assess ANS in obese using frequency analysis of HRV during mental stress. Hence the present study was undertaken.

Methods

The present study was conducted in the department of Physiology, JSS medical college Mysuru. Permission from the institute's ethics committee was obtained prior to the commencement of the study. The study was done on 30 healthy male volunteers aged between 17-20 years, BMI<25 Kg/m^2 forming control group from JSS medical college. Mysuru. Likewise age and sex matched 30 obese individuals (BMI>30 Kg/m^2) were chosen from the same college forming the study group. None of the subjects were previously diagnosed with cardiovascular illness or psychiatric disorder nor found taking any medications that affected their heart rate. All the subjects gave an informed consent after the detail procedure of the non invasive technique was explained to them in their own language. The subjects were asked to refrain from physical activity, food and beverages 2 hrs before the study commences. The study was done in morning hours. A baseline BP was recorded using mercury sphygmomanometer after 10 min of rest. Then baseline ECG in lead II was recorded for 5 mins in both non obese and obese group using AD Instruments power lab (Model- ML870, S.NO.830-0732). Signal acquisition, storage and processing were performed on computer. The digitalized ECG signals were stored on removable hard disk for analysis. The frequency domain of HRV analysis such as LFnu, HFnu and LF/HF ratio recordings was carried out using HRV module software for Lab Chart. HRV module analyses beat to beat interval variation in ECG recordings by detecting the R waves from each ECG waveform. Stable, noise free and ectopic free fiducial points of R waves were located and power spectrums of these R waves were obtained by means of Fast Fourier Transformation. A sampling rate of 500Hz was used.

The mental stress test used and described in the study Holly R (8) was applied as a mental stressor. The test was based on subtracting 3 or 4 numbers from 3 digit number continuously in mind by the subjects and was asked to tell the answers aloud. Throughout the test the subjects were asked to work quickly and gently chastised for wrong answers. This was, in order to increase the sympathetic response to perceived mental stress. The ECG was recorded for 5 mins during mental stress in both control and obese group and HRV analysis was done as described above. Arithmetic mean and standard deviation was worked out to assess the values in the 2 groups (obese and non obese). Unpaired t test was applied to assess the significance of changes in autonomic function between the groups. And in the group itself using paired t test. SPSS version 16 was used for statistical analysis.

Results

The present study consisted of 30 obese and 30 non obese subjects in the age group of 17-20 years. The physical characters of the two groups are shown in Table I.

Table II shows systolic blood pressure, diastolic blood pressure and frequency domain analysis of HRV

TABLE I: Comparison of physical parameters between Non Obese and Obese subjects.

	Non obese (Mean±SD)	*Obese (Mean±SD)*	*p-value*
Age (years)	19±0.7	19±0.4	0.07
Height(cm)	171±6	171±4	0.7
Weight(kg)	62±9	93±7	<0.001***
BMI(kg/m^2)	21±2	32±2	<0.001***

***p value<0.001 suggests very highly significant.

There was no significant difference between Obese and non Obese in terms of age and height. But there was significant difference in weight and body mass index (p-value <0.001) between the two groups.

TABLE II : Systolic blood pressure, Diastolic blood pressure and Frequency domain parameters of HRV at rest in Non Obese and Obese subjects.

	Non obese (Mean±SD)	*Obese (Mean±SD)*	*p-value*
SBP (mm Hg)	113±6	126±8	<0.001***
DBP (mm Hg)	66±4	77±6	<0.001***
LFnu	30±14	49±13	<0.001***
HFnu	48±12	37±7	<0.001***
LF/HF	0.7±0.4	1.4±0.5	<0.001***

***p value <0.001 suggests very highly significant.

There was significant increase in LF nu-Low frequency power in normalized unit (p<0.001) and LF/HF ratio (p<0.001) in obese individuals when compared to Non obese. However there was significant reduction in HFnu-High frequency power in normalized unit (p<0.001) in obese individuals when compared to Non obese.

TABLE III : Comparison of Frequency domain parameters of HRV at rest and during mental stress in Non obese subjects.

	At Rest (Mean±SD)	*During mental stress (Mean±SD)*	*p-value*
LFnu	30±14	35±13	<0.001***
HFnu	48±12	46±8	0.4
LF/HF	0.7±0.4	0.8±0.4	0.003**

***p value <0.001 suggests very highly significant. **p value <0.01 suggests highly significant.

LFnu and LF/HF ratio showed statistically significant increase during mental stress in Non Obese adults.

TABLE IV : Comparison of Frequency domain parameters of HRV at rest and during mental stress in obese subjects.

	At Rest (Mean±SD)	*During mental stress (Mean±SD)*	*p-value*
LFnu	49±13	38±18	0.002**
HFnu	37±7	34±10	0.2
LF/HF	1.4±0.5	1.2±0.7	0.12

**p value <0.01 suggests highly significant.

In Obese individuals, there was statistically significant decrease in LFnu during mental stress. There was decrease in HF nu and LF/HF ratio, but it was not statistically significant.

before mental stress. There was statistically significant increase in SBP (p<0.001) and DBP (p<0.001) in obese individuals compared to Non Obese subjects.

Discussion

In our study, LFnu and LF/HF ratio showed a significant increase in obese individuals at rest when compared to Non obese. As LF/HF ratio indicates sympathovagal balance, an increase in this ratio suggests sympathetic dominance (9). Moreover blood pressure was significantly increased in obese group when compared to control group. Our study is consistent with the study done by Louis J. Aronne et al, Khwaja Sarwari et al, Chethan HA et al (10, 11, 12), which also suggested increased sympathetic activity during basal condition in Obese.

The frequency domain parameters during mental stress in non obese individuals showed an increase in LFnu and LF/HF ratio suggesting higher sympathetic activity during mental stress as sympathovagal balance was towards sympathetic predominance. But our main aim was to detect changes in autonomic regulation to mental stress in obese. We expected a similar sympathetic overdrive to stress in obese as well. But to the contrary, in obese individuals mental stress induced decrease in LFnu, HFnu and LF/HF ratio. As HFnu is a component suggesting parasympathetic activity (9), decrease in this component, although not statistically significant in our study suggests decrease in parasympathetic activity. Moreover LFnu showed statistically significant (p=0.002) decrease during mental stress in obese individuals. As LF nu indicates both sympathetic activity and parasympathetic activity (9), the combined decrease in HFnu, LFnu and LF/HF ratio may probably indicate that there is vagal withdrawal in obese individuals to mental stress which is a risk factor in developing cardiac disorder. The decreased stress reactivity is also thought to play a role as a factor for higher morbidity and mortality. Although LFnu and LF/HF ratio in obese individuals remained elevated during mental stress compared to non obese individuals, yet obese individuals responded to mental stress by parasympathetic withdrawl. Our study is consistent with the study done by K Laederach-Hofmann (13). So most of the data including our study, agree that obesity is characterized by Sympathetic nervous system (SNS) predominance in the basal state and reduced ANS responsiveness after various sympathetic stimuli (14, 15, 16).

We conclude that HRV shows subtle yet significant

changes in autonomic regulation to mental stress in both non obese and obese group. But there is reduced autonomic neuronal activity in obese group during mental stress suggesting that being obese could be a risk factor for the early onset of many stress induced ailments. Hence analysis of HRV during mental stress can be used as a tool to detect early subclinical autonomic dysfunction in obese.

Limitation of the study

We did not measure subjective state of stress in either of the group which may probably give some insight towards the cause for the changes in autonomic regulation during stress. Also measurement of plasma norepinephrine levels could have put some insight on this topic. Gender variation in stress reactivity could also be taken up for further study.

Conclusion

The results suggest reduced Autonomic neuronal activity to mental stress in obese group.

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