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Effect of body mass index on cardiac autonomic function in young adult females

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Abstract: *Background:* Obesity is an independent modifiable risk factor for cardiovascular disease and a high incidence of autonomic nervous dysfunction has been reported in obese. Heart rate variability (HRV) has been used as a noninvasive tool to estimate cardiac autonomic activity. *Objectives:* The present study was conducted to understand the contribution of body mass index (BMI), an indicator of obesity, to sympathovagal imbalance (SVI), by short term analysis of HRV. *Method:* BMI and HRV indices i.e. frequency domain indices and time domain indices were assessed in two groups of 30 female subjects each within the age group of 18-23 years. Group 1 comprised of subjects having BMI between 18.5 and 24.99kg/m^2 and group 2 comprised of subjects having BMI > 25kg/m^2. Unpaired students *t* test and Pearson's correlation coefficient were used for statistical analysis. *Result:* Indices of parasympathetic drive to the heart are decreased and the index of sympathetic activity is increased in group 2 subjects when compared to group 1 subjects although the difference is not statistically significant. The cardiac autonomic dysfunction in overweight individuals is due to sympathetic over activity and vagal inhibition. *Conclusion:* Cardiac autonomic dysfunction due to obesity can be assessed by analyzing heart rate variability.

Keywords: Body mass index (BMI), Heart rate variability (HRV).

Introduction

According to the WHO, overweight and obesity are defined as abnormal or excessive fat accumulation that presents a risk to health. A crude population measure of obesity is Body Mass Index (BMI).BMI is calculated as a person's weight in kilograms/square of his or her height (in meters).Obesity results from a chronic imbalance between energy intake and energy expenditure [1].

Autonomic nervous system (ANS) dysfunction has been associated with obesity in humans [2]. The Heart rate variability (HRV) is the assessment of beat to beat functions in rhythm of the heart as defined by the degree of balance in sympathetic and vagal activity. The HRV provides us an indirect measure of nervous control on functioning of heart [3].

This study was conducted to compare the ANS activity by analyzing the HRV in normal and obese young adult females.

Material and Methods

The study was conducted in the Department of Physiology, Mahadevappa Rampure Medical College, Kalaburagi, India. 60 apparently healthy females of the age group of 18-23 years (18.21± 0.83) of first year MBBS students were recruited for the study. The subjects were divided into two groups based on their BMI using classification used by Garrow [4].Group 1 comprised of 30 females with BMI between 18.5-24.99 kg/m^2 and group 2 comprised of 30 females with BMI >25kg/m^2.

The purpose and procedure of the study was explained to each subject and written informed consent was taken. The procedure was conducted under thermo neutral conditions and at the same time of the day for all subjects. All readings were recorded by single observer so that interpretational differences were eliminated. Detailed medical and family history was recorded in a preformed questionnaire. Exclusion criteria included those with any cardiovascular disease, endocrinal disorders, lung disease, and smoking or on any medications. The height of the subjects was measured using a stadiometer whose least count was 1cm. The recording was then converted into meters. Weight was measured using weighing machine whose least count was 0.5kgs. BMI of each subject was calculated using Quetlets index.

$$BMI=WEIGHT\ (in\ kg)/HEIGHT^2\ (in\ m)$$

ANS activity was evaluated by HRV analysis during 5 minute ECG recordings using AD instruments-Power lab^R/30 series, New Zealand. Parameters of frequency domain were low frequency [LF] (0.04-0.15H_3), high frequency [HF] (0.15-0.40H_3) and LF/HF ratio. Parameters of time domain were standard deviation of normal to normal RR interval (SDNN in ms) and square root of mean squared differences of successive normal to normal intervals (RMSSD in ms). Artificial and arrhythmic data were excluded.

All parameters were represented as mean ± SD. Data was analyzed using students't' test and HRV parameters were correlated with BMI by Pearson's correlation coefficient. p value less than 0.05 was taken as statistically significant and p value less than 0.01 was highly statistically significant.

Results

Table-1: Basic Parameters of the Two Groups

Parameter	Group 1 (n=30)	Group 2 (n=30)	P value
AGE (in years)	18± 0.64	18.43± 0.97	0.047
HEIGHT (in meters)	1.722± 0.06	1.69± 0.06	0.043
WEIGHT (in kg)	67± 4.79	81.43± 9.85	0.001
BMI (in kg/m^2)	22.60± 1.47	28.26± 2.33	0.001

Table1 shows the general characteristics of the subjects. There was significant difference in age and height between the two groups ($p<0.05$).The difference between the weight and BMI between group 1 and group 2 was found to be highly statistically significant ($p<0.01$).

Table-2: Comparison of Frequency Domain Indices of HRV with BMI

Frequency Domain	Group 1	Group 2	P value
LF	781.75 ± 565.47	1203.75 ± 1202.9	0.05
HF	1371.12 ± 1042.86	1167.4 ± 836.23	0.4
LF/HF	0.81 ± 0.40	1.15 ± 1.21	0.14

HRV- Heart Rate Variability; BMI-Body Mass Index; LF- Low Frequency; HF- High Frequency

Table 2 shows the comparative study of frequency domain indices between the two groups. On comparing the LF domain, it is seen that the LF is greater in group 2 subjects (BMI>25kg/m^2) than compared to group 1subjects (BMI=18.5-24.99kgs/m$^{2)}$ which is almost statistically significant ($p=0.05$).

Table-3: Comparison of time domain indices of HRV with BMI

Time Domain	Group 1	Group 2	P value
SDNN	55.25±21.72	51.14±19.18	0.44
RMSSD	47.76±20.10	46.45±15.39	0.77

HRV- Heart Rate Variability; BMI-Body Mass Index; SDNN- Standard Deviation of Normal to Normal RR Interval; RMSSD- Square Root of Mean Squared Differences of Successive Normal to Normal Intervals

Table 3 shows the time domain indices of HRV recorded in the two groups. It is seen that there is a non-significant decrease in the SDNN and RMSSD readings of group 2 when compared to group 1.

Table-4: Correlation of HRV Parameters with BMI

		r value	p value
Frequency Indices	LF	+0.19	0.14
	HF	-0.009	0.94
	LF/HF	+0.12	0.36
Time domain indices	SDNN	-0.09	0.49
	RMSSD	-0.177	0.17

HRV- Heart Rate Variability; BMI-Body Mass Index; LF- Low Frequency; HF- High Frequency; SDNN- Standard Deviation of Normal to Normal RR Interval; RMSSD- Square Root of Mean Squared Differences of Successive Normal to Normal Intervals

Table 4 depicts the Pearson's correlation of HRV parameters with BMI. It is observed that BMI is positively correlated to LF and LF/HF ratio and negatively correlated to HF, SDNN and RMSSD, though not statistically significant.

Discussion

Although cardiac automaticity is intrinsic to various pace makers, heart rate and rhythm are largely under the control of autonomic nervous system [5]. The heart is abundantly supplied by sympathetic and parasympathetic vagal nerves. The vagal fibers are distributed mainly to the atria and not much to the ventricles and hence mainly affects the heart rate. This is in contrast to the sympathetic innervation which mainly effects strength of heart contraction [6]. Under resting conditions vagal tone prevails and variations in heart period are largely dependent on vagal modulation. The vagal and sympathetic activity constantly interact. An understanding of the modulatory effects of neural mechanism on the sinus nodes has been enhanced by spectral analysis of HRV [5].

Heart rate variability is done to assess the oscillations in the interval between consecutive heartbeats as well as the oscillations between consecutive instantaneous heart rates. It can be assessed under two domains:-

1. Time domain methods.
2. Frequency domain methods.

Time Domain Methods: In a continuous ECG record, each QRS complex is detected and the intervals between adjacent QRS complexes called NN intervals is determined. From this, the standard deviation of NN intervals is calculated and is called SDNN. SDNN thus reflects all the cyclic components responsible for variability in period of recording. Another short term variation to estimate high frequency variation in heart rate is the square root of the mean squared differences of successive NN intervals (RMSSD). Thus SDNN and RMSSD primarily reflect actions of parasympathetic system.

Frequency Domain Methods: This analysis provides information of how power distributes as a function of frequency. The most important spectral components are low frequency and high frequency which vary in relation to the changes in autonomic modulation of the heart. The vagal activity is a major contributor to the HF component and LF component is considered a marker of sympathetic modulation. The LF/HF ratio is thus a sensitive measure of sympathovagal balance [7]. HRV has thus emerged as a cardiovascular risk marker [5]. The major findings of HRV analysis in the present study depicts decrease in HRV, increased sympathetic and decreased parasympathetic drive in group 2 subjects when compared to group 1 subjects. The intensity of SVI is evidenced by degree of increase in LF/HF ratio and LF which was more in subjects with higher BMI compared with subjects to normal BMI.

There was decrease in the time domain indices in group 2 subjects than compared to group 1subjects indicating that the decrease in vagal tone plays a critical role in the shift of sympathovagal balance [8]. BMI could be a potential factor for the causation of SVI and this has been shown in our study as BMI is positively correlated with LF/HF ratio. Disturbed sympathetic nerve function is of importance in obesity [9]. Excess adiposity is recognized is an independent risk factor for all the cause and cardiovascular mortality with the relative risk associated with excess weight being particularly pronounced in younger subjects [10]. Leptin is the peptidehormone product of the obese gene expressed in adipose tissue [11]. Leptin has been shown to stimulate the sympathetic nervous system (SNS) activity [12], to stimulate heart rate and also increases arterial blood pressure [13]. There are leptin receptor messenger RNA expressed at the heart which are responsible for the decline in cardiac vagal activity and direct activation of SNS [12].

Schmidt et al reported that increase in BMI is significantly associated with increase in sympathetic tone which promotes inflammatory mediated arterial rigidity [14] and thus increases blood pressure in young over weight subjects [15]. Chronic hyperinsulinaemia observed in obesity has been postulated to lead to enhanced sympathetic tone and cardiovascular risk in obese [16]. There are several studies that have reported alterations in HRV in relation to fluctuating hormonal levels throughout the reproductive life. The persistence of obesity and associated sympathetic over activity through the reproductive age in females would thus aggravate SVI leading to end organ damage.

Conclusion

Obesity related health problems including various cardio vascular diseases are common in our country. In addition to the recognized complications of obesity, the association of autonomic nervous system dysfunction also exists in obese persons. Our study shows marked SVI with sympathetic over activity and vagal inhibition. In females, where the hormonal changes during the reproductive ages are closely related to the ANS control of cardiac activity, management of obesity becomes the need of the hour. Over weight females must thus be encouraged to practice regular aerobic exercises such as morning walk, swimming, cycling, yoga etc. which would improve vagal tone and decrease body weight and thereof help in combating the common complains of the reproductive years.

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