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RESEARCH ARTICLE

Heart rate variability is reduced in sedentary young females with higher body mass index

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ABSTRACT

Background: Heart rate variability (HRV) is affected by respiration, circadian factors, environmental factors, yoga, and exercises. There are emerging reports of myocardial infarction in young adults. Reduced HRV is a sign of poor autonomic function. Sedentary life habits in the younger generation have become an important issue in consideration along with the unmodifiable risk factors such as aging and hormonal influences. Several studies have shown that young obese males have reduced HRV. However, there are not many studies, which have explored the changes in HRV indices in young females with higher body mass index (BMI). **Aims and Objectives:** The aim of this study was to assess and compare the HRV status of young women with higher BMI and women with normal BMI. **Materials and Methods:** A total of 40 apparently healthy females of age between 18 and 25 years were recruited in the study. Sedentary behavior was assessed using the International Physical Activity Questionnaire. According to BMI (WHO guidelines for Asian population), subjects were divided into test group (BMI >23 kg/m^2 and waist/hip [W/H] ratio >0.8, n = 20) and control group (BMI = 18-23 kg/m^2, W/H ratio <0.8 n = 20). The subjects were made to lie in supine position for 10 minutes and then 5 min electrocardiogram was acquired in lead II configuration following Task Force Guidelines. After screening for ectopic beats and noise, time domain and frequency domain analysis of the data were done using the Kubios HRV analysis software. Mann Whitney U test was used to test for any significant differences between the groups using the SPSS software version 20. **Results:** There was no significant differences in the time domain analysis data between the test group and the control group does not show any significant differences. Under frequency domain analysis, low-frequency normalized units (LF nu) is significantly higher (P = 0.043), high-frequency (HF) nu is significantly lesser (0.043), and LF/HF ratio is significantly higher (P = 0.05) in the test group as compared to the control group. This implies that there is predominance of sympathetic activity in the young overweight and obese females. **Conclusion:** Apparently healthy young females, who are overweight and obese, have reduced HRV, which is an alarming signal in today's scenario, wherein we have reports of cardiovascular morbidities and mortalities at an earlier age. This urges us to think if we have to establish HRV analysis as a prophylactic investigation and also to emphasize on earlier adoption of lifestyle modifications to prevent the progress of impending alterations in the cardiovascular status of these young women.

KEY WORDS: Heart Rate Variability; Sedentary Females; Sympathetic Overactivity

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INTRODUCTION

Heart rate variability (HRV) is the beat to beat variation in the cardiac cycle which occurs due to the periodic alterations in the parasympathetic and sympathetic inputs to the heart. HRV analysis and interpretation are emerging as one of the early indicators of cardiac autonomic function derangement.

Low HRV has an increased risk of sudden cardiac death and myocardial infarction.[1] HRV is affected by various factors such as respiration, circadian rhythm, environmental factors, yoga, and exercises.[2-6]

Body mass index (BMI) is also known to influence the cardiac autonomic activity.[7] It is known that obesity is associated with increased sympathetic and decreased parasympathetic activity.[8] Moreover, sympathetic overactivity and decreased responsiveness by the β adrenergic metabolic receptors have been stated as the underlying mechanism for the linkage between weight gain and hypertension.[9]

Sedentary activities such as sitting and watching television for long hours, and using the computer for most hours of the day lead to increased weight gain. Studies have shown that over the past few years the incidence of obesity has been increasing among young adolescents due to sedentary behaviors such as watching TV and playing video games for prolonged duration.[10] Nowadays, this has become another important issue in consideration along with the unmodifiable risk factors such as aging and hormonal influences. There are studies, which report a decrease in HRV in young males and children who are overweight and obese.[11,12] HRV is also known to be reduced in older females,[13] and regular exercise training has been shown to improve the HRV in these individuals.[14] However, the physical endurance of the aged women may not permit them to start any new hard tasks to reduce the alterations in HRV. Considering this factor, any intervention in the younger age group may have profound effects on their health status. However, studies related to the cardiac autonomic status of young sedentary females are very limited. Hence, in this study, the cardiac autonomic activity of young sedentary females with higher BMI was assessed using HRV technique and was compared with that of young females with normal BMI.

MATERIALS AND METHODS

The study was conducted in the Department of Physiology, Shri Sathya Sai Medical College and Research Institute, Kancheepuram. A total of 40 healthy females aged 18-25 years were recruited in the study. The study was prior reviewed and approved by the Institutional Ethical Committee. The study was explained in detail to all the participants and written informed consent was obtained. The level of physical activity of the participants was assessed using the International Physical Activity Questionnaire (IPAQ),[15] and those with the sedentary level of physical activity were included in the study. However, females with history of irregular menstrual cycles, known case of polycystic ovarian syndrome, acute or chronic medical illnesses and those who were performing some form of physical exercises or yoga on a regular basis were excluded from the study.

Measurement of Anthropometric Variables

Following standardized procedures, height and weight of the subjects were measured using a stadiometer and a weighing scale, respectively. BMI of the subjects was calculated using the Quetelet's index, weight in kg divided by the height in m^2. Waist and hip circumferences were measured using a non-flexible tape to an accuracy of 0.1 cm. Waist circumference was measured by placing the tape around the bare abdomen above the hip bone at the lower level of the belly button. Hip circumference was measured by placing the tape around the widest part of the hip. Waist/hip ratio (W/H) was then calculated.

Following the WHO guidelines for categorization of BMI for Asian population,[16] the subjects were divided into two groups:

1. Test group - Women with BMI >23 kg/m^2 (along with W/H ratio >0.8)
2. Control group - Women with BMI between 18 and 23 kg/m^2.

Recording of Blood Pressure

As the HRV varies with the phases of menstrual cycles,[17] recordings were done for all the women in the proliferative phase, approximately between 5^{th} and 8^{th} day of their menstrual cycle. The subjects enrolled in the study were asked to come to the Department of Physiology between 9 and 11 am, 2-3 h after a light breakfast on the day of recording. They were asked to rest on a couch in supine posture for 10 min following which their blood pressure was measured using a manual sphygmomanometer.

Mean arterial pressure (MAP) was calculated using the formula,

$$MAP = DBP + 1/3PP$$

(DBP - Diastolic blood pressure, PP - Pulse pressure, the difference of systolic and DBP)

Recording of Short-term HRV

Following standardized procedures, as per the recommendations of the Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology,[18] 5 min electrocardiogram (ECG) was recorded in Lead II configuration. After screening for ectopics, RR intervals were derived from the ECG data and were fed into the Kubios HRV analysis software version 2.2 to obtain the short-term HRV indices.

Data Analysis

The analysis was done in terms of time domain and frequency domain measures from the R-R tachogram obtained with the above software. Statistical tests of significance by Mann Whitney U test was performed using statistical Package for the Social Sciences software version 20 (SPSS Software Inc., Chicago, IL, USA). $P < 0.05$ was considered significant. The time domain indices, which were included for the analysis, were the standard deviation of normal to the normal interval (SDNN), measure of total HRV and square root of the mean of the sum of the squares of the differences between adjacent NN intervals (RMSSD) and proportion derived by dividing NN50 by the total number of NN intervals (pNN50), measures of cardiac parasympathetic activity. Similarly, with respect to frequency domain indices, low-frequency (LF) power, and LF normalized units (nu), measures of cardiac sympathetic activity and high-frequency (HF) power and HF nu, measures of cardiac parasympathetic activity and LF/HF ratio, measure of cardiac sympatho-vagal balance were considered for analysis.

RESULTS

BMI and waist-hip ratio were significantly high among the test group individuals. There was no significant difference in MAP between the test and control groups (Table 1). Table 2 shows the comparison of time domain and frequency domain parameters between the control and test groups. There was no significant difference between the groups with respect to the time domain parameters. The mean RR value was lower in the test group although it did not differ significantly from the control group.

Under frequency domain analysis, there were no significant difference in the LF power, HF power, and total power between the test group and the control group. However, LF nu was significantly higher (p=0.043) and HF nu was significantly lower (p=0.043) in the test group (Figure 1). LF/HF ratio was also high among the test group individuals, though the difference was not statistically significant. This implies that there is predominance of sympathetic activity in the young overweight and obese females.

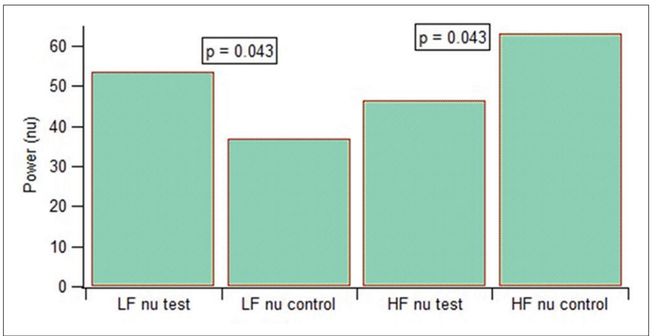

Figure 1: The mean low-frequency normalized unit (nu) and high-frequency nu values of test and control groups. Both had significant differences implying a sympathetic over activity in females with higher body mass index

DISCUSSION

In this study, the cardiac sympatho-vagal activity of 40 young sedentary females was assessed using HRV technique. IPAQ, a simple self-administered questionnaire which assesses one's own physical activities in the last 7 days was used to assess the physical activity of the study participants.[19] Based on this questionnaire, participants with a sedentary level of physical activity were included in the study. The association between age, BMI, body fat percentage, and cardiovascular diseases seem to be varying among the Asian population.[20] Consequently, the WHO expert consultation

Table 1: Comparison of anthropometric variables and blood pressure values between the control and test groups

Parameters	Mean (SD)		*P* value
	Control (normal BMI) *n*=20	Test group (higher BMI) *n*=20	
Age (years)	22.31 (4.80)	21.78 (3.19)	0.514
BMI (kg/m^2)	20.94 (1.56)	27.33 (2.14)	<0.001*
W/H ratio	0.732 (0.046)	0.814 (0.06)	0.041*
MAP mmHg	78.82 (8.20)	80.18 (7.66)	0.618

*P<0.05 is considered significant. BMI: Body mass index, W/H ratio: Waist-hip ratio, MAP: Mean arterial pressure, SD: Standard deviation

Table 2: Comparison of HRV parameters between the control and test groups

Parameter	Mean (SD)		*P* value
	Control	Test	
Mean RR (ms)	759 (37.02)	723.6 (22.74)	0.050
Mean HR	81.11 (5.97)	83.27 (2.32)	0.216
SDNN (ms)	52.66 (18.97)	40.4 (8.59)	0.108
RMSSD (ms)	48.76 (24.80)	46.38 (18.03)	0.428
pNN50 (%)	27.1 (19.86)	15.38 (5.39)	0.118
LF power (ms^2)	219.2 (98.69)	331.33 (230.27)	0.170
HF power (ms^2)	526.6 (504.2)	397.33 (412.7)	0.325
Total power (ms^2)	857.6 (656.31)	872.5 (726.29)	0.486
Lf nu	36.72 (12.37)	53.6 (15.97)	0.043*
HF nu	63.28 (12.37)	46.4 (15.97)	0.043*
LF/HF	0.62 (0.28)	1.41 (0.92)	0.050

*P<0.05 is considered significant. Mean RR: Mean RR interval, Mean HR: Mean heart rate, SDNN: Standard deviation of normal to normal interval, RMSSD: The square root of the mean of the sum of the squares of the differences between adjacent NN intervals, pNN50: The proportion derived by dividing NN50 by the total number of NN intervals, LF power: Low-frequency power, HF power: High-frequency power, LF nu: Normalized low-frequency power, HF nu: Normalized high-frequency power, LF-HF ratio: Ratio of low-frequency to high-frequency power, HRV: Heart rate variability, SD: Standard deviation

committee concluded that the existing WHO cut-off points for BMI classification may not be correct for the Asian population and hence, recommended a lower cut-off range for BMI for the same population.[16] In this study, the BMI cut-off ranges for the Asian population were considered, and accordingly, the study participants were categorized as normal, overweight, and obese.

Cardiac vagal tone is reported to be reduced in sedentary individuals.[21] Arbind et al. have reported that sedentary females have increased body fat percentage and altered cardiac sympatho-vagal activity.[22] In our study, the waist-hip ratio of sedentary overweight and obese females was significantly higher than those with BMI in the normal range. Mosca et al., in 2006 reported that 90% of women with waist circumference ≥35 inches (88.9 cm) had at least one modifiable cardiovascular risk factor.[23] In our study, the mean value of waist circumference of overweight and obese females was 90.37 ± 5.21 cm, which implies that these individuals are at increased risk of developing cardiovascular disorders.

Time domain parameters indicative of cardiac parasympathetic activity such as RMSSD and PNN50 and SDNN, measure of total HRV were not significantly different between the test group and the control group. Among the frequency domain parameters, LF nu, measure of cardiac sympathetic activity was significantly high among the test group individuals. It has been proposed that adipokines such as leptin, tumor necrosis factor alpha, and interleukin-6 produced by the adipose cells may contribute to the sympathetic overactivity in individuals with higher BMI.[24,25] Similarly, HF nu, measure of cardiac parasympathetic activity was significantly low in the test group. The reduced parasympathetic activity observed among the overweight females in our study is in accordance with a previous study by da Silva et al., which also reported decreased parasympathetic activity and insulin resistance in adolescent overweight and obese females.[26] LH/HF ratio, indicator of cardiac sympatho-vagal balance was also high among the females with higher BMI, although the value was not statistically significant ($P = 0.05$). This implies a state of sympathetic dominance or parasympathetic withdrawal in females with higher BMI. Similarly, a study by Paula et al., in 2013 has stated that the Insulin resistance can also be the cause of sympathetic overactivity in individuals with higher BMI, which in-turn can make them more liable for developing various cardiovascular diseases and diabetes mellitus.[27] Overall, the results of our study indicate that the cardiac autonomic activity is altered in young overweight and obese sedentary females.

LIMITATIONS OF THE STUDY

The limitation of our study would be the relatively small sample size.

CONCLUSION

The cardiac sympatho-vagal status of apparently healthy young overweight and obese females is altered and is characterized by an increase in cardiac sympathetic activity and a decrease in parasympathetic activity. Hence, necessary measures such as lifestyle modifications and regular health assessment need to be done in these individuals to prevent the progress of impending alterations in their cardiovascular status and its associated disorders.

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