Cardiac Autonomic Response to Saturated Fatty Meal in Overweight and Obese Late Adolescent Females

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Abstract

Aim: Little research has been conducted on the effect of fatty meal ingestion on heart rate variability (HRV) parameters. The present study aimed to assess the effect of saturated fatty meal on HRV time and frequency domain parameters in overweight and obese late adolescent females. Also to assess the possible correlation between HRV parameters and obesity indices in that particular age group.

Methods: HRV was analyzed by 15-minute period of standardized ECG recording in 42 normotensive euglycemic females aged (18 to 21 years) three hours following saturated fatty meal ingestion. According to body mass index (BMI) they were classified into 3 groups; lean (n=13), overweight (n=13) and obese (n=16).

Results: rMSDD and HF waves were significantly decreased in overweight and obese groups. Also there was significant increase in LF waves and LF/HF ratio in overweight group. On the contrary, LF waves were significantly reduced in the obese group, with insignificant change in the LF/HF ratio. No significant correlations were observed between HRV indices and parameters of total or visceral obesity.

Conclusion: HRV indices showed sympathetic hyperactivity in overweight late adolescent females in response to saturated fatty meal, highlighting the possible risk of cardiac problems. Interestingly this response was blunted in obese females. Both overweight and obese females showed decreased protective vagal influence on the heart. The present findings add to the literature concerning HRV in late adolescent females.

Key Words: Fatty meal — Heart rate variability — Obesity — Overweight.

Introduction

OBESITY is a serious health problem in both developed and developing countries and it has reached an epidemic proportion in many countries [1].

Obesity is associated with many cardiac complications with increased mortality risks such as coronary heart disease, heart failure and arrhythmias. It may affect the heart through its influence on the known risk factors such as dyslipidemia and hypertension [2].

It is believed that female obesity has greatly increased and most of the time it is also followed by related diseases like gout, hypertension, diabetes, cardiac problems, sleep apnea, cancer, osteoarthritis and many other disorders. It was demonstrated that the prevalence of overweight and obesity continuously increases in both men and women with higher incidence in women [3].

Heart rate variability (HRV), defined as degree of fluctuation of beat-to-beat difference in cardiac rhythm, has been widely used as a functional indicator of autonomic nervous activity to the heart [4]. HRV has been investigated in girls, adult females and post menopausal females [5-7], and results of previous investigations regarding the association between HRV and obesity are still conflicting [8].

Late adolescent overweight and obese females have not been investigated for the effect of saturated fatty meal on HRV. A fatty meal may represent an in vivo challenge, and women are more markedly susceptible to fatty meal challenge, as compared to men [9].

Aim of work:

The present study aimed to assess the effect of ingestion of a meal rich in saturated fat on cardiac autonomic regulation in overweight, obese and lean late adolescent females through assessment of heart rate variability time and frequency parameters. Also to assess any possible correlations between HRV parameters and obesity indices in that particular age group.
Subjects and Methods

The study was conducted during January — June 2012, Faculty of Medicine.

Female volunteer medical students were recruited for the study. Detailed history was obtained to detect exclusion criteria which involved; less than one year duration of overweight or obesity, history of metabolic, cardiovascular disease or any acute or chronic illness, medications, participation in any regular physical activity or change in dietary habits during the 6 months preceding the study.

Forty two (18-21 years old) normotensive euglycemic participants who fulfilled the criteria were enrolled in the study.

Weight and height measurements were done with the participants wearing light clothes and no shoes. Body mass index (BMI) was calculated by dividing weight (kg) by the square of height in (m).

Waist hip ratio (WHR) was obtained by dividing the circumference of the abdomen at the level of the umbilicus by that of the hip at the largest perimeter in (cm).

Based on the international classification of adult weight according to BMI [10], the participants were included into one of the following groups:

I- Control lean group: BMI ranged from 18.5-24.99kg/m$^2$ (n=13).
II- Overweight group: BMI ranged from 25.00-29.99kg/m$^2$ (n=13).
III- Obese group: BMI exceeded 30kg/m$^2$ (n=16)

Experimental design:

Participants were instructed to visit our lab at day 7 of their menstrual cycle to standardize the status of ovarian hormones to avoid introducing a confounding factor III.

At the day of the experiment, participants were instructed to have the high fat milkshakes [12] at 8 a.m, 3 hours preceding HRV assessment. It contained saturated fatty acids (refined palm oil) blended with 1% milk, strawberry flavored syrup, low fat frozen yogurt, and non-fat dry milk powder. Milkshakes contained approximately 12.8 kilocalories per kilogram body weight with 59% fat, 30% carbohydrate, and 11% protein.

Blood pressure measurements were taken in the supine relaxing period prior to HRV assessment. The average of 2 readings was used to determine the systolic and diastolic values.

Heart rate variability indices were obtained from short term (15 minutes) electro cardio graphic, ECG, recording while participants were in the supine position.

Electro cardio graphic data analysis:

The ECG recordings were obtained from each participant for 15 minutes. It was sampled at 1000 Hz with the PowerLab® acquisition system (AD Instruments Pty Ltd, Castle Hill, Australia) installed on IBM computer. The first 5 minutes of each ECG recording were disregarded to allow for stabilization of the data prior to analysis. The time domain HRV parameters implemented in the present study were; the standard deviation of all R-R intervals (SDRR), which reflects all the cyclic components responsible for variability in the period of recording, and the root mean squares of successive differences between adjacent R-R intervals (rMSSD), which is considered as an index of parasympathetic modulation of HRV [13]. The power spectral analysis included; the low frequency waves (LF) (0.05-0.15Hz) which is dually regulated by vagal and sympathetic systems [14], the high frequency waves (HF) (0.15-0.5Hz) which reflects cardiac vagal activity [15], and the total power (0-0.5Hz). The ratio of LF/HF was calculated to assess the cardiac autonomic balance [16].

Statistical analysis:

Statistical analysis of data was done using SPSS for windows package version 20 (SPSS Inc., Chicago, IL., USA). K-S test was applied to test the normal distribution of variable data. One way analysis of variance ANOVA test was used to compare between means of the variables in the study groups and association between variables was carried out using Pearson’s correlation coefficient. Ap-value D3.05 was considered significant.

Results

The physical characters of the participants in the present study in addition to the mean values of their pulse rate, systolic and diastolic blood pressures are shown in Table (1).

The time and frequency domain parameters of the heart rate variability assessment in the study groups are shown in Table (2).

The rMSSD was significantly decreased in over weight and obese late adolescent females when compared to control group indicating decline in the cardiac vagal influence in response to saturated fatty meal.
The low frequency waves (LF) were significantly increased in overweight group and significantly decreased in obese group when compared to control group.

On comparing the mean values of high frequency (HF) waves between the study groups, there was significant decrease in both overweight and obese groups when compared to control group.

The LF/HF ratio showed a significant increase in the overweight group, and a non significant increase in the obese group when compared to the control group.

Regarding the correlation studies, the present work found no significant correlations between BMI or WHR and HRV indices in the study groups.

Table (1): Physical parameters of all groups (Mean ± S.D.).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control</th>
<th>Overweight</th>
<th>Obese</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>19.9±1.3</td>
<td>19.1±1.8</td>
<td>19±1.1</td>
</tr>
<tr>
<td>BMI</td>
<td>21.92±2.36</td>
<td>27.19±1.71*</td>
<td>36.72±4.73*#</td>
</tr>
<tr>
<td>WHR</td>
<td>0.68±0.04</td>
<td>0.76±0.07*</td>
<td>0.78±0.05*</td>
</tr>
<tr>
<td>Pulse</td>
<td>69.62 ± 5.94</td>
<td>70.15±7.01</td>
<td>69.00±10.65</td>
</tr>
<tr>
<td>SBP</td>
<td>102.31±10.13</td>
<td>102.31±9.27</td>
<td>107.05±10.65</td>
</tr>
<tr>
<td>DBP</td>
<td>59.23±4.94</td>
<td>63.85±9.61</td>
<td>67.5±12.38*</td>
</tr>
</tbody>
</table>

*Significant when compared to control group.  
#Significant when compared with overweight group.  
BMI: Body mass index.  
WHR: Waist hip ratio.  
P1: Significance when compared to control group.  
P2: Significance when compared to overweight group.

Table (2): HRV parameters of all groups (Mean ± S.D.).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control</th>
<th>Overweight</th>
<th>Obese</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDRR</td>
<td>105.75±22.82</td>
<td>99.33±12.63</td>
<td>77.62±25.14*#</td>
</tr>
<tr>
<td>rMSSD</td>
<td>131.76±30.41</td>
<td>96.02±19.47*</td>
<td>71.24±21.13*#</td>
</tr>
<tr>
<td>LF</td>
<td>1511.69±645.95</td>
<td>3690.86±795.06*</td>
<td>1020.73±257.76*#</td>
</tr>
<tr>
<td>HF</td>
<td>2722.71±649.09</td>
<td>1659.44±403.39*</td>
<td>1537.47±497.7*</td>
</tr>
<tr>
<td>LF/HF</td>
<td>0.59±0.3</td>
<td>2.37±0.82*</td>
<td>0.74±0.31#</td>
</tr>
</tbody>
</table>

*Significant when compared to control group.  
#Significant when compared with overweight group.  
SDNN : Stander deviation of all R-R intervals.  
rMSSD: Root mean squares of successive differences between adjacent R-intervals.  
VLF: Very low frequency power.  
HF: High-frequency power.  
LF: Low frequency power.  
LF/HF: The ratio of LF/HF.  
P1: Significance when compared to control group.  
P2: Significance when compared to overweight group.

Discussion

The present study adds important findings concerning cardiac autonomic regulation in young, late adolescent, females.

The main findings of the present study revealed loss of protective vagal influence on heart rate in both overweight and obese females following a saturated fatty meal. In addition, there was blunted sympathetic response in obese group which was still preserved in overweight group.

There is consistent evidence that HRV is capable of identifying patient at high risk of all-cause mortality and predicting sudden death [17].

In the current work, the time domain analysis of HRV revealed a significant decrease in rMSSD, after adrenergic stimulation induced by saturated fatty meal in overweight and obese late adolescent females compared to their matching lean group. The foregoing data showed evidence of decreased parasympathetic activity in overweight and obese groups.

In support of this concept, the present study also showed a significant decrease in the HF waves in overweight and obese females.

In accord with our finding, lower parasympathetic modulation of HRV was observed in obese girls with high central fat [5], and in obese adults [18].

On the other hand, higher parasympathetic modulation of HRV in obese women was reported specially when there was combination of upper body and visceral obesity [6]. A favorable vagal HRV profile was also recently observed in obese postmenopausal women [7].

An explanation for the controversy regarding vagal cardiac influence in overweight and obese females could be attributed to the difference in the age of females in the present and previous researches which ranged between childhood and postmenopause. It seems that cardiac parasympathetic control needs further investigations in females in relation to age and ovarian hormonal status.

Interestingly, analysis of the frequency domain components of the HRV in the present study showed a significant increase in LF waves and LF/HF ratio in response to saturated fatty meal in overweight females when compared to the control subjects suggesting sympathetic over activity, as higher values of LF/HF ratio indicated greater sympathetic modulation of HRV [19].
This observation could be a point of strength in the present study as it highlighted the risk to which overweight young females are exposed following saturated fatty meal due to cardiac sympathetic over activity.

On the contrary, the LF waves were significantly decreased in obese late adolescent females compared to the control group. In addition, the LF/ HF ratio was insignificantly different in the same group indicating blunted sympathetic response in obese subjects.

Previous researchers raised controversy regarding sympathetic modulation of HRV in obese subjects.

Previously it was stated that in spite of increased plasma nor-adrenaline level in the obese subjects, yet there was decreased end organ sympathetic responsiveness [20]. Another study observed that there was no difference in sympathetic function between normal and obese individuals [18]. On the other hand, higher sympathetic modulation of HRV was observed in obese girls with higher central fat compared to those with lower central fat [5].

Postprandial hyperinsulinemia was reported in obese adolescents [21], and fat ingestion resulted in insulin resistance in rats [22]. Hyperinsulinemia has been shown to stimulate sympathetic nervous system via the hypothalamus or indirectly via the baroreflex in response to insulin-mediated vasodilation [23]. Explaining the present findings in view of the previous researches, we can hypothesize that in the overweight group there is hyperinsulinemia-mediated sympathetic over activity, while in obese group, the repeated episodes of transient insulin resistance may underlie the diminished cardiac sympathetic activity. This hypothesis may solve the conflict between the researchers who postulated sympathetic over-activity and those postulated hypo-activity in obese subjects.

No significant correlation was observed in the present study between BMI or WHR and HRV indices, although previously positive association between central fat and decreased parasympathetic and increased sympathetic activity was stated in overweight and obese girls [5].

Further researches are still needed to solve the conflicts regarding cardiac autonomic control in different age groups in overweight and obese females and the possible influence of different dietary habits.

**Conclusion:**

The present study postulates an important hypothesis. During the course of gaining weight, sympathetic hyperactivity was observed especially in response to saturated fatty meal. This could be a negative feedback to increase energy expenditure and prevent the increase in body fat mass. This sympathetic over activity may contribute to the high risk of cardiac problems in the overweight late adolescent females following fatty meals. On the other hand when obesity is already developed, prolonged sympathetic over activity would result in a blunted sympathetic response.

Although females normally display enhanced protective parasympathetic input into cardiac regulation, yet the present study revealed a diminished protective vagal cardiac modulation in overweight and obese late adolescent females in response to fatty meal.

**References**


