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Exploring The Link: Obesity Markers and Heart Rate Variability in Young Adults

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ABSTRACT

Background: Obesity is considered a major independent risk factor for various diseases including Cardiac Autonomic Neuropathy (CAN). Diagnosing CAN sub clinically is difficult and uncommon, however it may be detected through Heart Rate Variability (HRV) analysis. Nevertheless, HRV is not done routinely in obese individuals. **Aims & Objectives:** To determine the correlation between obesity markers and HRV parameters to know which obesity marker(s) can be used as a screening tool for CAN in obese population. **Method:** Study participants were 60 morbidly obese volunteering patients from the bariatric surgery outpatient department between 20-40 years of age. Anthropometric measurements (Height, Weight, Waist Circumference, Hip Circumference) were taken using non-elastic measuring tape. Body fat percentage was measured using QUADCAN-4000 and ECG was recorded for 5 minutes using Medicaid-Physiopac PP-8 device. Recorded ECG was retrieved and further analysed using software Kubios HRV version 2.0 to get time domain and frequency domain parameters of HRV. Data collected was manually entered into a Microsoft Excel sheet and analysed using EPI Info (version 7.2). The correlation between obesity markers and HRV parameters, was analysed using Pearson's correlation coefficient. **Result:** BMI and Body Fat % showed a significant correlation with Mean RR, LF and HF while no significant correlation was seen between WHR and HRV parameters. **Conclusion:** BMI and Body Fat Percentage can be used as a preliminary screening tool for early detection of the autonomic imbalance related to obesity in morbidly obese individuals.

INTRODUCTION

Obesity is the abnormal or excessive fat accumulation that presents a risk to health[1]. It is regarded as one of the most serious public health problems of the 21st century. According to latest updates by WHO in 2022, the prevalence of obesity worldwide is 16%[1]. In developed country like US, prevalence of obesity was 39% in 2015[2], and the prevalence is projected to reach around 51% by 2030[3]. While in India, the 5th national family health survey (NFHS V) conducted in 2021 has stated that prevalence of obesity has increased from around 20.7% in 2016 to 24% in 2021 in women and around 18.9% in 2016 to 22% in 2021 in men[4]. This indicates that the prevalence of obesity in India is rising by almost one percent every year. If this current trend continues around 35% of women and 33% of men in India will be obese by 2030.

Obesity is considered a major independent risk factor for various diseases including cardiovascular diseases[5]. Researchers have also found that obesity has a major direct impact on the cardiac autonomic regulation[6,7].

Cardiac Autonomic Neuropathy (CAN) is a condition in which damage to the parasympathetic and/or sympathetic part of ANS leads to the dysfunction of neural regulation of heart and vascular dynamics which can increase the risk of mortality according to ACCORD Trial[8]. Diagnosing CAN sub clinically is difficult and uncommon, and this phase can be detected through Heart Rate Variability (HRV) analysis before development of any clinically visible signs and symptoms[9]. However, HRV is not done routinely in obese individuals.

Thus, this study aimed at finding the correlation of obesity markers with the HRV parameters in view of finding out the obesity marker which is strongly associated with heart rate variability, for its possibility to be used as a screening tool for obese population at risk of developing cardiac autonomic neuropathy in early adulthood.

MATERIAL AND METHODS

This was a cross-sectional study conducted on the obese (BMI > 25 as per WHO Asian Guidelines[10]. adult males and females in the age group of 20-40 years. Morbidly obese patients from the bariatric surgery outpatient department at our tertiary care institute who agreed to participate were included in the study.

The sample size was calculated to be 60 according to the prevalence of obesity in India as per the WHO studies of 2016[1]. The study included only volunteers with a Fasting Blood Sugar level below 110 mg/dl or a Random Blood Sugar level below 200 mg/dl[11][12]. While, volunteers with significant cardiopulmonary diseases, or the presence of any disease condition that can alter cardiac autonomic activity like systemic hypertension, diabetes mellitus, hyperthyroidism, bronchial asthma, diagnosed coronary artery disease, inflammatory bowel disease and tuberculosis were excluded. Also, those who were on medications which can alter autonomic activity, tobacco smokers, alcoholics and pregnant women were not included in the study.

Study Procedure

1. A study was conducted after the Ethical Approval has been obtained from the Institutional Ethics Committee.
2. A detailed history was taken and physical examination was done of all those who volunteered. Individuals who met the study's inclusion and exclusion criteria were scheduled for an appointment and asked to report to the Department of Physiology 10-11am for recording anthropometric measurements, body composition, and heart rate variability. They were asked to restrain from caffeinated drinks and alcohol 24 hour prior to the test. They were also advised to have a sound sleep the previous night and to undergo fasting for 4 hours before starting the study procedure.
3. Each volunteer provided written informed consent after the purpose and detailed procedures of the study were discussed with them on the appointment date.
4. Anthropometric measurements were then taken, which included,

a. Height: measured in centimetre
b. Weight: measured in kilogram
c. Waist Circumference (WC) measured in centimetre.
d. Hip circumference (HC) measured in centimetre.

5. After that body fat percentage, one of the body composition parameters, was measured using QUADCAN-4000 (Isle of Mann, U.K.)

DATA ANALYSIS

Then ECG was recorded for 5 minutes using Medicaid-Physiopac PP-8 (Chandigarh, India) device. Recorded ECG was retrieved and further analysed using software Kubios HRV version 2.0 to get time domain (Mean RR, SDNN, RMSSD) and frequency domain (LF, HF, LFnu, HFnu, LF:HF ratio) parameters of HRV[13,14].

Data collected using the methods was manually entered into a Microsoft Excel sheet and analysed using EPI Info (version 7.2). After collecting the data, with the methods explained above, the data was manually entered into Microsoft excel sheet, which was then analysed using EPI info (version 7.2). For categorical data, such as gender distribution, results are presented as percentages. The correlation between quantitative variables, such as obesity markers and HRV parameters, was analysed using Pearson's correlation coefficient. We analysed the data assuming relationships could go in either direction (2-tailed) and considered a result statistically significant if the chance of it happening by random chance was less than 5% (p-value < 0.05).

RESULTS

Table 1: Mean and SD of the anthropometric parameters

Anthropometric parameters	Obese (n=60)	
	Mean	SD
Height (cm)	160.62	10.82
Weight (Kg)	88.62	16.43
BMI (kg/m²)	34.52	6.67
Waist circumference (cm)	106.67	14.61
Hip circumference (cm)	116.43	12.95
Waist: hip Ratio	0.92	0.08

HF High Frequency power, HF nu- High Frequency power in normalised unit, LF- Low Frequency power, LF nu- Low Frequency power in normalised unit, LF/HF- Low Frequency high Frequency Ratio. Mean RR- Mean of R-R intervals, RMSSD- Root mean square of the successive differences, SDNN -Standard deviation of NN interval
'r' is Pearson's correlation coefficient.
*Statistically significant p<0.05 **Statistically highly significant p<0.001

This study was conducted with a sample of 60 obese individuals with mean age 32.15 ± 7.30 years. Of total subjects 65% (n=39) were females, while 35% (n=21) were males. Table 1 shows the anthropometric measurements of the all the subjects.

Table 2: Correlation of body mass index with heart rate variability parameters (n=60)

HRV Indices	BMI	
	r	p value
Mean RR	0.24183	0.06500
SDNN	-0.10276	0.43867
RMSSD	-0.13205	0.31879
LF nu	0.16628	0.20816
HF nu	-0.16628	0.20816
LF/HF	0.12230	0.35613
LF	-0.387	0.00245*
HF	-0.389	0.00235*

Table 2 shows a significant negative correlation between the body mass index and two HRV parameters i.e. LF and HF. It shows non-significant inverse correlation with SDNN, RMSSD and HF nu and non-significant positive correlation with LF nu and LF/HF ratio.

Table 3: Correlation of waist: hip ratio with heart rate variability parameters (n=60)

HRV Indices	WHR	
	R	p value
Mean RR	0.06928	0.59888
SDNN	0.06650	0.61369
RMSSD	0.05963	0.65085
LF nu	0.10298	0.43364
HF nu	-0.10298	0.43364
LF/HF	0.08927	0.49759
LF	-0.13952	-0.15573
HF	0.28771	0.23478

In Table 3, correlation was observed between the Waist Hip Ratio and heart rate variability parameters. A negative correlation was found between WHR and two HRV parameters i.e. HF nu and LF. While a positive correlation was found between WHR and all other HRV parameters. However, in all the parameters the correlation observed was statistically not significant.

Table 4: Correlation of fat% with heart rate variability parameters (n=60)

HRV Indices	Body Fat %	
	R	p value
Mean RR	0.263	0.04263*
SDNN	-0.19683	0.13172
RMSSD	-0.24685	0.05725
LFnu	0.03155	0.81087
Hfnu	-0.03155	0.81087
LF/HF	0.00886	0.94644
LF	-0.455	0.00026**
HF	-0.446	0.00035**

Table 4 shows a significant correlation between the Body Fat Percentage and various heart rate variability parameters. A significant negative correlation between Body Fat Percentage and two HRV parameters i.e. LF and HF while, a significant positive correlation was seen with Mean RR-the time domain parameters of heart rate variability.

DISCUSSION

The present study was conducted on 60 obese adult males and females in the age group of 20-40 years. We studied the association of the three obesity markers (BMI, WHR and Body Fat %) with various HRV parameters. BMI and Body Fat % showed a significant correlation with some of the HRV parameters while no significant correlation was seen between WHR and HRV parameters. This suggests that both BMI and Body Fat % can act as indicators for autonomic disturbances in morbidly obese individuals.

The significant negative correlation of BMI and Body Fat % with LF indicate that the sympathovagal imbalance occurs as the BMI and Body Fat % increase. Similarly, the significant negative correlation of BMI and Body Fat % with HF indicates that parasympathetic activity, which is suggestive of a restful state of the body, also decreases as BMI and Body Fat % increases. It was also found that among all HRV parameters, LF, HF and Mean RR were more significantly associated with obesity markers on testing with Pearson's correlation coefficient. LF is a measure of both sympathetic and parasympathetic activity. HF reflects the parasympathetic activity alone. LF: HF ratio gives the sympathovagal balance. The normalized unit of the LF and HF i.e. LF nu and HF nu reflect sympathetic and parasympathetic activity respectively[15]. And, SDNN represents a measure of overall autonomic function (sympathetic and parasympathetic function), while RMSSD represents a measure of parasympathetic function[16].

In a study done by Plaza-Florido A et al to find association between body composition and HRV, it was found that Fat Mass Index and Body Fat were better associated with HRV [17]. Our study results are consistent with these findings.

Sztajzel J et al[18] and Dan S Sharp et al [19] in their study found fat parameters better predictors of cardiac health than BMI[19]. While, Yi SH et al [20] concluded that WHR and body fat percentage may be more reliable indicators of low heart rate variability compared to body mass index. In our study we found body fat percentage and BMI significantly associated with HRV parameters.

Yi SH et al[20] found that WHR was inversely related to RMSSD, LF, and pNN50; PBF with RMSSD, HF, and pNN50; BMI with RMSSD ($p<0.05$). These findings are similar to our study. However, they identified a stronger negative association between HRV measures and waist-to-hip ratio only in participants with a BMI of 25 kg/m² or higher; suggesting that the association between abdominal adiposity and HRV was stronger in overweight subjects. This is in contrast with our findings where we did not find any such association between WHR and HRV in morbidly obese individuals.

Koenig et al came to conclusion that obesity parameters (BMI, Waist circumference, Waist to Height ratio) were negatively correlated with RMSSD[21]. This is similar to our study findings. Ram Lochan Yadav et al in their study fo--und that WHR was strongly associated with HRV parameters showing reduced cardiac parasympathetic and increased sympathetic activity in obese individuals[22]. BMI showed weak relationship with HRV cardiac autonomic markers. And in their study LF nu, HF nu and LF: HF ratio were the parameters which showed significant correlation with obesity markers. These findings are different from our findings.

The differences in result with Ram Lochan Yadav et al; Koenig et al; Yi SH et al may be due to different study population[22]. In our study the population were mostly the morbidly obese patients who consulted bariatric surgery OPD while, in these studies they chose obese individuals who were apparently healthy. And since they did not study fat %, the individuals with high BMI in their study may have more lean mass in the body than fat and thus are healthier than our study subjects. Also, many of the studies had predominantly male subjects [22][21][20], while, our study had 65% female subjects. Men generally have more muscle mass in their arms, stronger bones, and less fat in their limbs. They also tend to store more fat around their abdomen. In contrast, women typically store more fat in their hips and thighs, especially when younger. Thus, the WHR for men show greater response to increase in weight than WHR for women.

The Baltimore Longitudinal Study of Aging also looked at how weight changes affect fat distribution differently in men and women. They found that both waist and hip circumferences increased with weight gain, but the pattern differed by sex. In men, the waist grew significantly more than the hips, leading to a larger increase in their waist-to-hip ratio. For example, with a weight gain of roughly 10 pounds, men's waist circumference increased by 1.6 inches compared to only 1 inch for their hips. Women, on the other hand, experienced a more balanced increase in both waist (1.3 inches) and hips (1.4 inches) with similar weight gain[23][24]. This explains the differences in the results of this study with those of Ram Lochan Yadav et al; Koenig et al; Yi SH et al.

Farah et al studied HRV and its relationship between central and general obesity[25]. In their study significant correlation was noted between WC with RMSSD and PNN50 (%). However, they did not find the significant correlation between BMI and HRV parameters. This is in contrast with our study. Similarly, in another study done by Banerjee A et al, also found correlation between WC and HRV[26].

In a study conducted by Gutin B et al [27], investigates whether the length of time someone has been obese influences their sympathetic nervous system activity. This may explain why BMI has differing effects on HRV in some individuals. Interventions applied for a short period are less likely to produce dramatic changes compared to the clear distinctions observed between healthy and diseased groups, where the disease has had more time to exert its influence.

This could be another reason for the differences in our study findings with that of Farah et al and Banerjee A et al[25][26]. These studies were conducted on obese subjects who had obesity since childhood. While, we do not know the duration of obesity in our study subjects.

Thus, age, gender, duration of obesity plays a role in the development of impairment of cardiac autonomic functions and thus should all be taken into consideration while making an inference about the effect of obesity on HRV.

CONCLUSION

From the present study, it could be observed that the sympathovagal imbalance occurs in the obese young adults indicating development of cardiovascular autonomic neuropathy. Thus, there is an urgent need for developing measures for early detection of obesity related cardiovascular autonomic neuropathy. In the present study we studied the association of the three obesity markers (BMI, WHR and Body Fat %) with various HRV parameters. BMI and Body Fat % were observed to be more strongly correlated with HRV parameters than WHR. Therefore, these can be used as obesity indicators for detecting autonomic imbalances in obese individuals. Also, only three of the HRV parameters (Mean RR, LF and HF) seem to be most sensitive to be affected by BMI and Body Fat %. Thus, BMI and Body Fat Percentage can be used as a preliminary screening tool for early detection of the autonomic imbalance related to obesity.

LIMITATIONS

We included only morbidly obese individuals in our study and thus there were no groups of subjects with varying BMI to compare the results of association. Therefore, we suggest further study with wider subject population with respect to grade of obesity to understand the cut-off at which early detection of CAN, can be done using obesity markers itself.

We also suggest to include age, gender and duration of obesity in further study on obese individuals to make appropriate inferences.

The comparison of strength of association of the three obesity markers with HRV was not done. Thus, we cannot comment on which amongst the two (BMI or Body Fat %) is a better indicator for detecting CAN.

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