Central markers of obesity affect heart rate variability independent of physical activity in young adults

Anushna Banerjee¹, Nikhilesh Singh², Aruna Raju², Richa Gupta²

¹MBBS Student, ²Department of Physiology, Mahatma Gandhi Medical College and Research Institute, Sri Balaji Vidyapeeth, Pondicherry – Cuddalore Rd, ECR, Pillayarkuppam, Puducherry, India

ABSTRACT

Introduction: Obesity is considered to be a risk factor for a variety of cardiovascular conditions. Various markers for obesity are used to evaluate effect of obesity on cardiovascular autonomic activity. In light of conflicting reports on effect of obesity on heart rate variability (HRV), use of obesity indices, and the effect of physical activity on HRV, we evaluated autonomic activity in young Indian obese adults using revised Indian and World Health Organization (WHO) body mass index (BMI) guidelines for obesity, waist circumference (WC), and waist–hip ratio (WHR) taking into consideration the level of physical activity. Methods: The study was conducted on 91 young healthy adults. Height, weight, waist, and hip circumference were recorded to determine BMI and WHR. Five-minute electrocardiogram (ECG) was recorded for assessment of HRV. Physical activity was assessed by the WHO Global Physical Activity Questionnaire (GPAQ). Results: Waist circumference showed a negative correlation with the time domain parameters of HRV and high frequency normalized units (HFnu) while a positive correlation with low frequency normalized units (LFnu). In multiple linear regression analysis, time domain indices, HFnu and total power decreased while LFnu increased with an increase in WC. The result was supported by the similar effect of waist–hip ratio categories on HRV in analysis of covariance (ANCOVA). Physical activity had no effect on HRV. Conclusion: Central obesity parameters are better predictors of effect of obesity on HRV independent of the effect of physical activity.

Keywords: Body mass index, heart rate variability, waist circumference, waist–hip ratio

Introduction

Obesity is considered to be a risk factor for a variety of cardiovascular conditions like hypertension, ischemic heart disease and stroke and is characterized by hemodynamic and metabolic alterations. The ultimate cause of obesity is an imbalance between energy intake and expenditure resulting from the complex interaction of genetic, physiological, behavioral, and environmental factors. Since energy metabolism as well as regulation of cardiovascular system are influenced by the autonomic nervous system (ANS), obesity and its clinical consequences may be accentuated by altered ANS.

Conflicting results have emerged over the nature of autonomic activity in obese individuals. In 2009, Bedi et al. found that there is decreased sympathetic activity in obese children compared to controls but no change in parasympathetic activity. These findings are supported by earlier reports. This reduced sympathetic reactivity may disturb homeostasis and lead to excess storage of energy. On the contrary, many studies found an increase in body weight is associated with increased sympathetic and
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decreased parasympathetic activity. At an young age, obesity is significantly associated with lower heart rate variability (HRV), indicative of impaired cardiac autonomic modulation in the direction of sympathetic overflow and reduced parasympathetic modulation. Rajalakshmi et al. demonstrated a decreased HRV, higher sympathetic and lower parasympathetic nerve activity in obese subjects. Body mass index (BMI) was the major determinant for the changes in time as well as frequency domain indices.

Based on various reports, it is being suggested that measurement of autonomic parameters in obesity may provide an early indicator of cardiovascular impairment. A systematic review suggests that HRV is an early accessible marker of a healthy lifestyle, and programs targeting cardiovascular risk associated with obesity should include HRV as a monitoring parameter. However, cardiovascular autonomic parameters are affected by multiple parameters which include obesity as well as physical activity. Increasing physical activity and regular training among adults are associated with increased parasympathetic activity and higher overall HRV, suggesting improved cardiac autonomic regulation. Because obesity and its associated problems are commonly encountered in family medicine practice, in order to tackle obesity and its associated cardiovascular problems, primary care physicians need to devise physical activity programs for their patients. It is imperative that to predict the impact of physical activity on cardiovascular risk, they need to be aware of the effect of central obesity markers on cardiovascular parameters like HRV.

However, there is paucity of literature studying the autonomic activity in people with obesity along with the level of physical activity. Moreover, for obesity, many studies have reported the relationship between BMI and autonomic functions. However, it has been found that the indicators of central obesity are more sensitive than the indicators of general obesity for determining the autonomic activity in obese individuals. If obesity is redefined using waist circumference (WC), WHR instead of using only BMI, the proportion of people categorized at risk of heart attack increases threefold worldwide.

In the light of conflicting reports on effect of obesity on HRV, use of obesity indices, and the effect of physical activity on HRV, we evaluated autonomic activity in young Indian obese adults using revised Indian and World Health Organization (WHO) BMI guidelines for obesity, WC, and waist–hip ratio (WHR) taking into consideration the amount of physical activity.

**Methods**

This analytical cross-sectional study was approved by Institutional Ethics Committee and conducted from Dec 2018 to 2019. The present study was conducted on 91 healthy volunteers aged 18–25 years. Subjects suffering from any chronic disease like hypertension, diabetes, CAD were excluded from the study. Other exclusion criteria included subjects with a history of smoking, alcoholism, drug abuse, and patients taking medication, for example, vasodilators, β blockers, barbiturates, opiates, tricyclic antidepressants, and phenothiazines that could affect autonomic functions.

After taking informed consent, the subjects were instructed not to perform any exercise 40 h before the day of the experiment and to avoid drugs and caffeine 12 h before the test. The volunteers reported in the laboratory of physiology, Mahatma Gandhi Medical College and Research Institute (MGMRCRI) at 10:00 am. Before data recording, history on average sleep duration was taken. If the sleep duration previous night was less or more than the average sleep duration of the subject or if the subject reported disturbed sleep previous night, the subject was asked to report another day for data collection.

Following this, the blood pressure of each subject was measured in supine position. Height of the participants was taken to the nearest 0.1 cm and weight was recorded on calibrated digital weighing machine. Height and weight were used to calculate BMI. WC was measured at the midpoint between lower margin of the last rib and top of the iliac crest, using a non-stretch measuring tape. Hip circumference was measured around the widest portion of the buttocks, with the tape parallel to the floor. Waist and hip circumference were used to calculate WHR. WHR ≥0.90 in males and ≥0.85 in females were considered as cut-off level. To evaluate autonomic activity, HRV was recorded ~2 h after a light breakfast. They were asked to rest in supine position for 10 min. Electrocardiogram (ECG) was then recorded for 5 min in supine position with eyes closed.

Physical activity profile of the participants was measured using Global Physical Activity Questionnaire (GPAQ) by WHO. GPAQ comprises of 16 questions regarding activity at work, travel to and from places and recreational activities. The guide provided by WHO for the interviewer for asking the questions and recording responses was followed for final calculation of metabolic equivalents (METS). A cut-off value of <600 METS/week was considered to classify physical activity into two categories – unmet and met recommended physical activity as recommended in the guide.

**Statistical analysis**

For HRV, ECG tracings were subjected to analysis using a Kubios HRV Finland software to measure frequency domain and time domain measures of HRV, after automatic exclusion of artifacts. Components for HRV analysis were expressed both in absolute (ms²) and normalized units (nu). All data acquisition and analyses were carried out in accordance with established standards.

The data was analyzed using statistical package for the social science (SPSS) version 16. Normality of the data was checked using Kolmogorov–Smirnov tests. Most of the HRV measures were not distributed normally. They were log transformed for
Further analysis. Tests of significance were two-tailed, and a P value of < 0.05 was considered statistically significant.

Results

The subjects (n = 91) were analyzed for descriptive statistics. Table 1 provides the baseline characteristics of the participants. Correlation analysis was done to assess association of BMI, WC and physical activity with HRV variables. Time domain and frequency domain parameters of HRV did not correlate with BMI and physical activity. WC was associated negatively with standard deviation of normal-to-normal intervals (SDNN; r = −0.35, P < 0.01), root mean square of the successive differences (RMSSD; r = −0.36, P < 0.01), Number of pairs of adjacent RR intervals (NN50) (r = −0.31, P < 0.05), Percentage of NN50 count of all RR intervals (PNN50) (r = −0.38, P < 0.01), and high frequency normalized units (HFnu; r = −0.25, P < 0.05). It was positively associated with low frequency normalized units (LFnu; r = 0.21, P < 0.05).

Multiple linear regression analysis was done to assess the relationship between continuous independent variables BMI, WC, WHR and physical activity on HRV. The analysis showed time domain indices, HFnu and total power decreased while LFnu increased with an increase in WC. The results are provided in Table 2.

A series of analysis of covariance (ANCOVA) analysis were done to compare the effect of WHO METS category, WHO BMI categories for obesity, revised Indian BMI categories for obesity and WHR categories on HRV indices while controlling for other independent variables. The time domain parameters (SDNN, RMSSD, and PNN50) values were significantly lesser in high WHR category compared to normal WHR category. Similar results were obtained for frequency domain parameters (low frequency – LF power, high frequency – HF power, and total power). The results are provided in Table 3. No effect was seen for WHO METS category and BMI category on HRV variables.

Discussion

In the present study, we did not find any effect of BMI on HRV variables. Some studies had previously reported that BMI and physical inactivity independently contribute to increased sympathetic activity and low HRV power. However, this association was only found when the BMI was above 30 kg/m². In the present study, only 13 subjects had BMI above 30 kg/m² so the population is not comparable to the conclusions drawn from other studies. Also, it has been suggested that duration of obesity may be a factor affecting sympathetic activity and may explain the variation in the effect of BMI on HRV.

In the present study, WC had a positive correlation with markers of sympathetic activity while negative correlation with markers of parasympathetic activity. This was supported by a study by Jain et al. where in a similar study design, they performed autonomic function tests instead of HRV and found an independent effect of WC on sympathetic and parasympathetic activity. Alternative measures of obesity especially those reflecting visceral obesity are being considered superior to BMI in predicting cardiovascular risk. In line with that many studies have reported a positive correlation of WC with LFnu, a marker of sympathetic activity and negative correlation with the time domain indices, a marker of parasympathetic activity. Even WHR has shown a similar relationship with HRV variables as is supported by the ANCOVA and multiple linear regression analysis results of the present study as well. Similar result was also found in children in a previous study. Theoretically, it is supported by studies which have shown that visceral fat secretes certain cytokines and chemicals that are involved in atherogenesis and alterations in the autonomic balance than the quantity of total body fat. Indeed, increased visceral adipose tissue is associated with a range of metabolic abnormalities, including decreased glucose tolerance, reduced insulin sensitivity, and adverse lipid profiles,
which are the risk factors for type 2 diabetes and cardiovascular disease (CVD). Nonetheless, in a study it has been found that longitudinal increase in WC was significantly associated with lower RMSSD even after controlling for longitudinal decrease in cardiorespiratory fitness. This is supported by our study because even in our study the effect of waist circumference on HRV was seen independent of the measure of physical activity. Thus, WC can be used as a surrogate measure of body fat.

In the present study, there was no effect of METS on any HRV variable. This result is surprising since many studies have shown an effect of physical activity on HRV. However, there are studies which have shown a positive effect of physical activity in individuals with normal weight but not in people with obesity. Nonetheless, the contradictory result can be due to a multitude of factors. First and foremost, the WHO questionnaire does not take into account the duration of physical activity. Since METS is a surrogate marker for cardiorespiratory fitness which in turn depends on the duration of physical activity too, in this case, METS derived from subjective questionnaire may not exactly represent cardiorespiratory fitness even though it may be useful for population-based survey. Indeed, intensity and duration of physical activities affect cardiovascular autonomic parameters in different ways. Farah et al. had demonstrated an improvement in parasympathetic modulation to the heart after a 4-month vigorous aerobic exercise in obese children, which is supported by other studies. Even though the population in the study is different from the present study, it may be that similar kind of effect will be seen in young adults as well. In fact, we also did a sub analysis analyzing the effect of METS categories in normal weight individuals and obese individuals. There was no effect of METS on HRV in any category. Secondly, since METS determination is a subjective measure of activity, reporting bias causing both under or over reporting might have affected the data even though we followed the WHO questionnaire guide for data collection. It has been recently suggested that studies showing a relationship between physical activity and HRV are limited by using self-reported physical activity as opposed to more objective measures of aerobic fitness such as the graded exercise test.

Obesity and its associated problems are commonly encountered in family medicine practice. Primary care physicians concur that to reduce the burden of CVD, it is required to prevent and treat obesity. Our study can serve as a guide for primary care physicians since even though physical activity can affect HRV or cardiovascular health, they should keep in mind the effect of central markers of obesity on cardiovascular health for long term follow up. Indeed in an RCT apart from insulin resistance, central obesity was found to have greatest influence on cardiac autonomic modulation in obese.

One strength of present study is that it considered various parameters of obesity along with physical activity while considering average sleep duration which itself affects HRV in short term. Also, the study used both revised Indian guidelines and WHO guidelines for obesity to report the effects of BMI on obesity. This is important because WHO states, wherever possible, countries should use all categories of BMI for reporting purposes to facilitate international comparisons. Nonetheless, to consider the implications of the present study, certain limitations need to be warranted. First, the study results could have been better interpreted if we had also done the metabolic profile for obesity. Second, the study did not consider the duration of physical activity. Hence, we recommend including duration of current amount of physical activity along with type of exercise, if any, in future studies.

Overall, the results of the study support previous studies showing central obesity parameters as being better predictors of effect of obesity on HRV. These findings support the importance of assessing central obesity as a marker for risk factor in CVD. Also, the modulatory effect of physical activity on HRV was not seen as observed in many previous studies probably because the effect of physical activity on HRV in obese individuals depends on the intensity and duration of exercise.

Declaration of patient consent
The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest
There are no conflicts of interest.

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