Electrocardiogram of Obese Young Adults in a University, Malaysia

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Abstract

Background and Aim: Obesity exhibits wide variety of electrocardiogram (ECG) abnormalities in adults. Previous researches have found different results since they tested mostly on children, adolescents, and middle aged persons. However, there’s no clear evidence of the association between obesity and ECG variables, especially in young adults. Hence, the aim of this research is to compare ECG parameters (PR interval, QRS interval, corrected QT, axis and height of P and R wave) of obese with normal BMI young adults.

Materials and method: A cross-sectional observational study was done on 38 students of a private university in Shah Alam. They were aged between 20 to 30 years, involving normal and obese persons. Anthropometric data, arterial blood pressure and standard 12-lead ECGs were collected for every participant. Independent-sample t-tests and non-parametric Mann-Whitney test were conducted to compare data of normal persons and obese persons. Pearson correlation was done to correlate ECG parameters with BMI, Weight and systolic arterial blood pressure.

Results: Heart rate, PR interval, QRS interval and QT interval of obese person were not significantly different from normal. Height of R wave in obese person is more than that of normal person (P<0.05). However, there was no correlation between BMI, Weight, systolic blood pressure and ECG parameters that could be found.

Conclusion: Thus, ECG wave and intervals except height of the R wave of obese young adults are not significantly different from those of the normal BMI. Finding of higher R wave in obese groups indicates ventricle wall of obese young adults are thicker than that of the young adults with normal BMI and it is not related to the effect of systolic arterial blood pressure, BMI and even weight of the person.

Key words: PR interval, QRS interval, QT interval, R wave, BMI
Introduction

Obesity is a state of excessive accumulation of fat in the body and now considered as a medical condition associated with a variety of non-communicable diseases including cardiovascular diseases. Worldwide obesity has nearly tripled since 1975. In 2016, 650 million that aged 18 years and older, were obese (WHO, 2018). Previous researchers found that a variety of electrocardiographic (ECG) abnormalities are associated with obesity. Most of their findings indicated changes in cardiac morphology leading to increasing risk of arrhythmias and sudden cardiac arrest (Fraley, Birchem, Senkottaiyan and Alpert, 2005; Lalani, Kanna, John, et al, 2000). These ECG changes include, leftward shifts of the P wave QRS and T wave axes, various changes in P wave morphology, low QRS voltage, various markers of left ventricular hypertrophy, T wave flattening in the inferior and lateral leads, lengthening of the corrected QT interval (QTc) and prolonged QT interval duration (Okin, Roman, Devereux, et al,1998).

In obese person there might be an increase in stroke volume, cardiac output, left ventricular end-systolic and pulmonary artery pressure (Okin, Roman, Devereux, et al,1998; Verdecchia, Schillaci, Borgioni, et al, 1998)). These hypervolemic and hyper dynamic status increases left ventricular work and lead to an increase in cardiac mass that is proportional to degree of obesity. Increased cardiac mass is due to increased muscle mass of left ventricle and not due to epicardial or myocardial fat infiltration (Karthikkeyan, Umadevi and Gajapriya, 2016).

ECG changes mostly in the older patients, with the mean age of 64 and above, who might have had the age-related ECG changes (Fraley, Birchem, Senkottaiyan and Alpert, 2005). However, there's no exact evidence of the association between obesity and ECG variables in obese young adults although obesity become worldwide problem for that age group (Ghee, 2016). This study was taken up to detect any significant electrocardiographic changes occurring in obese young adults. Hence, risk of getting the cardiovascular disease may be minimized among them.

Materials and Methods

This cross-sectional descriptive study was done on 38 students, aged between 20-30 years, of Management and Science University, Shah Alam, Malaysia from February to May of 2018. The 19 participants with normal BMI <20-25kg/m² were grouped as control and 19 obese participants with BMI >30Kg/m² were recruited for study group. The participant who had medical disease especially cardiovascular disease were excluded. Anthropometric and blood pressure data (age, height, weight and blood pressures) and standard 12-lead ECG were collected from each participant after taking written consent form. All research works were done in the Physiology lab of the International Medical School, Management and Science University, Shah Alam.

Body weight and height were measured by mechanical scale with height meter (accuracy: ± 0.1 Kg and ± 0.1cm, respectively) while the participants were barefoot and in light clothes. BMI was calculated using the following formula: Weight (Kg)/height (m²).

In the supine position arterial blood pressures were measured from the right arm by the researcher using a mercury sphygmomanometer. The subjects were advised to avoid coffee, tea and exercise for >30 min and had rested for >5 min before blood pressure measurement.

Standard simultaneous 12-lead resting ECGs were recorded in a supine position at the ECG workstation of that university by using ECG Kenz 302 (Suzukn Company, Japan). However, ECG results have been referred to the computerized printed results from the machine as the study time available was short.

The statistical analyses were conducted with SPSS version 22. Differences between the groups were compared using independent-sample t-tests and non-parametric Mann-Whitney test. Pearson correlation was done to correlate ECG parameters with BMI, Weight and systolic arterial blood pressure. P<0.05 was considered to indicate a statistically significant difference for all statistical test.

The protocol and procedure for this study were approved by the Ethics Committee of Management and Science University, Shah Alam, Malaysia. All individual data of participants remained confidential and experiments done are only for the purpose of this study.
Results

The baseline anthropometric characteristics and blood pressures of participants are presented in Table I. Two groups in this study were comparable as the mean ages were matched. The means of BMI, weight, SBP and DBP in obese were significantly higher than that of normal BMI group.

The differences in ECG data among normal and obese group are shown in Table II. When it was compared with normal weight group, mean height of R waves is higher and mean depth of S waves were deeper significantly in the obese group. It indicates that ventricles of obese persons are hypertrophied. Other parameters are not significantly different between normal and obese groups. However, although not significant, heart rate is higher in obese persons. The PR interval and QRS duration are shorter in obese persons. It shows that conduction of cardiac excitation may be faster in obese young adults.

Correlations of height of R wave and depth of S wave with BMI, weight and systolic blood pressure in obese persons were shown in Table III and IV, respectively. No significant correlations were found. It indicates that ventricular hypertrophy in obese young adults is not related with changes of weight, BMI and systolic blood pressure.

Discussion

The electrocardiogram (ECG) is a simple, noninvasive procedure to measure the electrical activities all over the heart. An ECG can be used to assess the heart rate and rhythm, blood supply to the heart muscle, abnormalities of heart structures such as heart chamber enlargement and abnormal electrical conductions. Two major determinants of ECG’s sensitivity are age and obesity (Frank, Colliver, and Frank, 1986). In the present study, the ECG findings are due to the effect of significantly high BMI in obese persons (32.34 ± 3.01 Kg/m²) when compare with normal BMI group (21.92 ± 1.60 Kg/m²) as the age of two study groups were matched. Out of 2 determinants of BMI, findings are due to the effect of weight as the height of two study groups were not significantly different. The weight is related to the increased muscle mass or the excessive accumulation of fat within the body and both of which affect the health.

In the study of Karthikkeyan, Umadevi, and Gajapriya (2016) 83% of the obese people included in the study had have the ECG changes. It is different finding from the present study. The reason may be the mean age of obese individuals included in their study that was older than the present study (38.81 vs 23.67 years). Therefore, it could be stated that the ECG changes are as much age-related as obesity-driven. In their study, the mean BMI was 33.80 with the range of 30-40 Kg/m². The less BMI of obese young adult in this study (32.69 ± 2.67 Kg/m²) may be another reason for different findings from their study. In their study, they found the ECG changes, except normal sinus rhythm in 17%, such as 42% people had left ventricular hypertrophy, 21% had interventricular conduction defects, 14% had T wave inversion, 13% had sinus arrhythmia and another 3% had sinusradycardia because they measured the parameters manually in detail (Sun, Li, Zhou, et al., 2013). In this study, all of the ECG variables were still in normal range because one of the exclusion criteria for this study was participants should not have any known disease especially related with cardiovascular diseases.

PR intervals is a measure of atrio-ventricular (AV) conduction time which include the time taken for atrial depolarization, the conduction delay in the A-V node and the time taken for an impulse to transverse the intraventricular conduction system before ventricular depolarization begins. The normal rate for PR interval is 0.12-0.21 seconds (Okin, Roman, Devereux, et al., 1998). For this study, heart rate is increased and conduction from SA node to interventricular septum is faster in obese person although their changes were not significant. It is agreed with the findings of Chethan, Niranjan and Basavaraju (2012). In 2012, Chethan, Niranjan and Basavaraju found that a significant reduction in parasympathetic activity and a significant increase in sympathetic activity in 50 obese young adult males (20 – 24 years). There was a shift in the sympathovagal balance towards sympathetic predominance among the obese young adult males of their study.

The QRS duration reflect the time of ventricular depolarization. Any broadening in QRS duration indicates delay in ventricular depolarization mostly due to bundle branch blockage leading to changes in ventricular rhythm and cardiac arrest (Medvegy and Antalóczi, 1993). According to the QRS duration of
this study ventricular depolarization rate is normal in obese young adults. It is different from the findings of Samata Krishnarao Padaki, Anita Herur, Amrut Aravindrao Dambal (2016), in which QRS duration in obese person were significantly longer than controls. This different may be due to higher mean age 38.81 years in their study. It may confirm that the ECG changes are as much age-related as obesity-driven.

For QT interval, the normal duration is supposed to be equal or lesser than 0.40 seconds for male while 0.44 seconds for female (Medvegy and Antalóczy, 1993). In this study, although 60% of the obese participants are women, mean QT interval was not significantly different from normal and in the range of male. It indicates that both ventricular depolarization and repolarization can be completed within normal duration in obese person and may be faster in women. It showed that the increasing body weight does not have direct effect on the conduction rate in the ventricles. This finding is in accordance with that of Okin, Roman, Devereux, et al. (1998). They stated that in obese person, there will be increase in cardiac mass in proportional to the degree of obesity but it is due to increased muscle mass of left ventricle and not due to fat infiltration into epicardium or myocardium. If there is a fat infiltration the conduction rate will be effected by the substances produced form fat depots in pericardium and myocardium (Anumonwo, and Herron, 2018).

In the previous studies, it was found that increase in LV wall thickness, LV mass and prevalence of echocardiographic LV hypertrophy are associated with obesity but not related to blood pressures (Karthikkeyan, Umadevi, and Gajapriya, 2016). It is agreed in this study according to the findings of systolic blood pressure, R wave and S waves. Hypertrophied ventricle can be reflected by height (voltage) of R and depth of S waves. R wave represent depolarization through the mass of ventricles. S wave represent the final depolarization in the Purkinje fibres. S wave travels in the opposite direction to the large R wave because the Purkinje fibers spread throughout the ventricles from top to bottom and then back up through the walls of the ventricles. In this study, systolic arterial blood pressure, height of R and depth of S waves were significantly higher in the obese groups but R and S shows no correlation with systolic blood pressure. Then, although it is higher in obese person, mean systolic blood pressure was still within normal range (126 ±5 mmHg). Thus, it can be postulated that in obese young adults, ventricles become significantly hypertrophied although systolic blood pressure is normal. Moreover, although ventricles are increased in mass, the electrical potential can pass through the hypertrophied ventricles with faster rate to get normal duration of QRS. It is different from the study of Ghanem, Al-Selevany and Habeeb (2016) who found association between effect of blood pressure on cardiac structure and function and increasing BMI because their study was on hypertensive participants with mean systolic blood pressure 143.78±14.793 mmHg and mean diastolic blood pressure 91.11±10.755 mmHg. Mean age of their participants were 53.04±9.04 years (Ghanem, Al-Selevany and Habeeb, 2016).

The findings of this study, however, is different from some other studies. Sun, Li, Zhou, et al. (2013) found that linear correlation between ECG variables such as prolong PR interval and QRS duration, left axis deviation except heart rate and QTc interval and BMI in obese children and adolescents. It may be due to high abdominal obesity percentage of the obese children in their study (80% vs 360%) as the increased intra-abdominal fat deposition can lead to change in position of the heart more to the left. In the study of Rashid, Qureshi, Ahmed and Sherwani (2014), they found that LV mass increases with increasing BMI and they suggested that it may also be due to age factor as the mean age of participants in their study was 42.42 ± 6.04 years. In the study of Frank, Collier and Frank (1986) the heart rate and height of R wave increase with increasing BMI. Conduction rate is slowed, and the QRS vector shifts toward the left as the percent of obesity increases (Frank, Collier and Frank, 1986). In this study, no correlation was found between BMI, weight, systolic arterial blood pressure and R and S wave voltages. This difference may be due to different in sample size and mean age of participants (n=1029 vs 38, mean age = 37 vs 23) between two researches.

On the other hand, sensitivity of precordial leads is presumably decreased in obese person because of attenuating effects of several factors such as upward displacement of the heart by the elevated diaphragm, increase in the distance between the heart and the electrodes due to fatty tissue in between or enlarged chest cavity or thickened and fat-laden chest wall and infiltration of fats into the myofibrils (Frank, Collier, and Frank, 1986; Okin, Roman, Devereux and Kligfield, 1995; Okin, Roman, Devereux, et al., 1998;
Verdecchia, Schillaci, Borgioni, et al., 1998). In this study, although these attenuating effects are taken into consideration, findings of significantly higher R and deeper S voltage in obese persons indicates the occurrence of ventricular hypertrophy including Perkinje’s fibers. It is supported by the review of Brady (2016) in which it was stated that risk factors for cardiovascular diseases, other than BP, including obesity may have an important role in the development of left ventricular hypertrophy even in children.

There were certain limitations to the present study. First one is sample size. If with more participants the clear cut results would be found. Second one is for long term effect of obesity cannot be explored as it was a cross-sectional study. On the other hand, since this study was made in a university, to find the real committed participants was really challenging along with limited period given to settle the whole research.

**Conclusion**

ECG wave and intervals except height of the R wave of obese young adults are not significantly different from those of the normal BMI. Finding of higher R wave in obese groups indicates ventricle wall of obese young adults are thicker than that of the young adults with normal BMI and it is not related to the effect of systolic arterial blood pressure, BMI and even weight of the person.

**Acknowledgements**

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References


Table and figures

Table I: Anthropometric characteristic and blood pressures of the study groups

<table>
<thead>
<tr>
<th>Variables</th>
<th>Normal (n=19)</th>
<th>Obese (n=19)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>23.74 ± 2.25</td>
<td>23.63 ± 2.96</td>
<td>0.66</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>60.74 ± 9.49</td>
<td>85.04 ± 15.83</td>
<td>0.00*</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.65 ± 0.1</td>
<td>1.61 ± 0.1</td>
<td>0.06</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>21.92 ± 1.60</td>
<td>32.34 ± 3.01</td>
<td>0.02*</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>121 ± 5</td>
<td>126 ± 5</td>
<td>0.01*</td>
</tr>
<tr>
<td>DBP (mmHg)</td>
<td>76 ± 9</td>
<td>81 ± 5</td>
<td>0.20</td>
</tr>
</tbody>
</table>

level of significant at p<0.05.

Table II: Comparison of ECG data between normal and obese young adults.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Normal, n=19</th>
<th>Obese, n=19</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR (beat/min)</td>
<td>74 ± 8</td>
<td>77± 12</td>
<td>0.64</td>
</tr>
<tr>
<td>PR interval, (sec)</td>
<td>0.25 ± 0.37</td>
<td>0.16 ±0.02</td>
<td>0.44</td>
</tr>
<tr>
<td>QRS duration (sec)</td>
<td>0.12 ± 0.15</td>
<td>0.08 ± 0.01</td>
<td>0.58</td>
</tr>
<tr>
<td>QTc interval, (sec)</td>
<td>0.41 ± 0.02</td>
<td>0.40 ± 0.02</td>
<td>0.17</td>
</tr>
<tr>
<td>R wave, (mV)</td>
<td>1.30 ± 0.10</td>
<td>1.35 ± 0.28</td>
<td>0.03*</td>
</tr>
<tr>
<td>S wave (mV)</td>
<td>0.75 ± 0.18</td>
<td>0.96 ± 0.35</td>
<td>0.04*</td>
</tr>
</tbody>
</table>

level of significant at p<0.05.

Table III: Correlation between height of R wave and BMI, Weight and systolic blood pressure in obese group

<table>
<thead>
<tr>
<th>Variables</th>
<th>R wave (mV)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI (Kg/m²)</td>
<td>0.09</td>
<td>0.59</td>
</tr>
<tr>
<td>Weight (Kg)</td>
<td>-0.03</td>
<td>0.8</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>-0.07</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Pearson correlation test was performed and level of significant at p<0.05.

Table IV: Correlation between depth of S wave and BMI, Weight and systolic blood pressure in obese group

<table>
<thead>
<tr>
<th>Variables</th>
<th>S wave (mV)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI (Kg/m²)</td>
<td>0.31</td>
<td>0.06</td>
</tr>
<tr>
<td>Weight (Kg)</td>
<td>0.11</td>
<td>0.5</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>-0.03</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Pearson correlation test was performed and level of significant at p<0.05.