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## Original article

# Body Mass Index (BMI) related changes of Electrocardiogram (ECG) in young adult females

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ABSTRACT

The association between body weight and health has received considerable attention and has major potential public health implications. Overweight and obesity are now a global epidemic, associated with increasing rates of non- communicable diseases. Due to lifestyle changes, Saudi Arabia now has one of the highest prevalence rates of overweight and obesity. In contrast, relatively little information is available about health risks including nutrient deficiencies, impaired immunity and female fertility issues of subjects with low body mass index (BMI). The present study aimed to explore the associations between BMI and early changes in ECG components in young adult females. The 100 female participants between 18 to 20 years of age were classified according to their BMI (kg/ $m^2$) into underweight (UW), normal weight (N), overweight (OW) and obese (OB). The electrocardiogram (ECG) recorded for 5 minutes at supine position and a statistical comparison of mean values of different ECG components were carried out between N group and other groups. The UW group showed a significant ($p<0.05$) increased mean heart rate (HR)(bpm) with smaller RR and larger QRS and QTc intervals (sec). OW group showed a significant ($p<0.05$) higher mean P wave amplitude (mV). OB group subjects represented a significantly ($p<0.05$) larger mean QRS, QTc and Tp – Te intervals (sec) with significant smaller mean T wave amplitude (mV). A significant weak positive correlation between BMI (kg/ $m^2$) and heart rate variability (HRV) (m sec) was observed. Whereas, OB and OW groups showed a respective significant and insignificant increase of mean HRV when compared with N group. In conclusion, although the ECG components recorded from various categories of BMI are under normal ranges, still demonstrated significant variations in comparison to normal BMI group can be used as a prognostic tool to predict the future complications related to abnormal body weights.

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## 1. Introduction

Over the past 3 decades, due to accelerated nutritional transition, globalization and sedentary life style, it is noted that in developing countries prevalence of obesity and overweight has increased markedly in both poor and rich populations.[1-2] Obesity and overweight, which are also the sources of various diseases including hypertension, diabetes, obstructive sleep apnea, cardiovascular diseases (CVD) etc.[3] According to studies obesity and overweight are increasing in KSA[4-5] affecting more than 75% of the total population of almost all age groups in general and adults particularly.[6-7] Overweight and obesity are more prevalent in Saudi females than in males.[4] However, conversely the prevalence of underweight in KSA cannot be ruled out among children[8], adolescence[9-10] especially in young adultfemales.[11]

In obesity accumulation of excessive adipose tissues are not only associated with altered metabolic profile but a variety of adaptive alterations in cardiovascular structure and functions occur.[12] The degree of cardiovascular function impairment parallels to the degree of obesity and obese subjects have

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abnormal changes on electrocardiogram (ECG).[13] Similarly, the risk of CVD associated with underweight are more profound in subjects especially below 40 years of age[14-15] resulting in the alterations of ECG components.[16]

The ECG is used in clinical practice and clinical trials, as a valid, reliable, accessible, inexpensive non-invasive technique. It is used to investigate the functionality of the cardiovascular system. ECG parameters are effectively used in to identify various heart rate (HR) and conductivity defects, different cardiac hypertrophies, ischemic processes and metabolic disturbances.[17-18]

Although body mass index (BMI) is known to affect ECG measurements, [19] early ECG changes among obese and underweight young adults have not been previously well characterized and there is currently no evidence of an association between anomalies of BMI and ECG variables in healthy adolescents. For this reason, present study will be carried out to analyse the differences in certain well-defined ECG components among healthy young adult females categorised based on their BMI.

## 2. Materials and Methods:

### Subjects

This work was carried out on 100 young adult females aged between 18-20 years. The participants were students at Umm Al-Qura University (UQU), Makkah, KSA. Prior to the day of research activity, subjects were requested to have their normal night's sleep, to avoid from any type of beverage (caffeinated /non caffeinated) or any medicine for 24 hours and to restrain from food three hours prior to the experiment. A self-reported information regarding the absence of any physical, neurological or pathological conditions related with Hypertension, Diabetes mellitus and cardiovascular diseases like arrhythmias, was also obtained to meet the eligibility criteria for the study.

### Procedure

The research was approved by the Research committee of Umm Al - Qura University, Makkah, KSA. (# HAPO-02-K-012-2018-01-243). The participants were requested to fill out a consent form before the start of experiment. The privacy rights of human subjects were always observed, and the experiment was conducted in accordance with the ethical principles of the Helsinki Declaration. [20] Task sessions were conducted between 10 a.m. and 2 p.m. on weekdays. The participants came to a designated room and received general instructions about the anthropometric form and prepared prior to ECG recording.

After preparation of subject electrodes were attached according to the lead II (left foreleg, right foreleg, and left rear leg) ECG scheme.

The recordings were taken supine for 5 minutes at baseline by using a digital data acquisition system (Powerlab model 26T; ADInstruments). The recorded ECGs were analysed by the LabChart8 software (AD Instruments, Bella Vista, Australia).

Statistical analyses were performed by IBM program SPSS 22. One-way ANOVA was used to compare the means of various categories of BMI followed by Tukey's HSD post hoc test to find the difference of means at $P<0.05$ level of significance.

## 3. Results:

Fig. 1 shows the distribution of mean ±SD of BMI (kg/m2) of 100 female students who participated in the study. There were 64 subjects fall in the category of normal (N) BMI with mean 21.37 ±1.80 (kg/m$^2$). The number of subjects included in the category of underweight (UW) with mean BMI of 16.83 ±0.7 (kg/m$^2$) was 18. 10 subjects with mean BMI of 26.41 ±1.13 (kg/m$^2$) were categorized as overweight (OW) whereas, remaining 8 subjects were considered obese (OB) with mean BMI of 32.74 ±2.43 (kg/m$^2$).

Table 1 represents the normal ranges along with the mean ± SD durations (sec) of various intervals and amplitude (mV) of different waves from ECG recordings of subjects, classified according to their BMI. A comparison of mean values of various ECG components among all categories of BMI showed an insignificant difference with the exceptions of the duration of mean QRS and amplitude (mV) of mean P waves.

The data was further analysed by comparing the mean values of duration (sec) of intervals and amplitudes (mV) of ECG recorded from subjects fall in the category of N with those categorized as UW, OW and OB with respect to their BMI.

The UW group showed a significant ($p <0.05$) smaller mean duration of RR interval with significant larger mean durations of QRS and QTc intervals in comparison to N group. Mean HR was also significantly higher than N subjects. Whereas, OW group in comparison to N group represented a significantly ($p <0.05$) higher mean amplitude of P waves.

Among OB subjects in contrast to N group the recorded durations of mean QRS, QTc and Tp - Te were significantly ($p <0.05$) larger. However, mean T wave showed a significant ($p <0.05$) low amplitude with respect to N subjects.

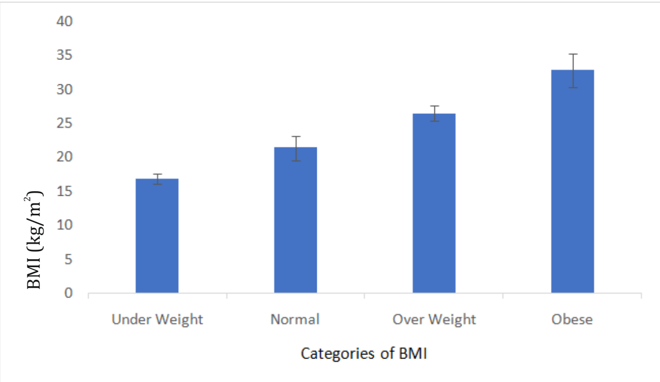
Mean Heart rate variability (HRV) expressed in m sec, calculated by Time Domain Method for all categories of BMI differ insignificantly from each other. Spearman's correlation between BMI (kg / m$^2$) and HRV (m sec) showed a weak positive statistically significant relationship. Whereas, OB and OW groups showed a respective significant ($p < 0.05$) and insignificant increase of HRV in comparison to N group (Table 1).

**Table 1. Normal ranges along with mean ± SD of various components of ECG recorded for 5 minutes at rest from adult females under different categories of BMI**

| Interval / Amplitude | Normal range | BMI (Kg / m$^2$) | | | |
|---|---|---|---|---|---|
| | | N | UW | OW | OB |
| RR (sec) | 0.6 - 1.2 | 0.68 – 0.08 | 0.64 – 0.06* | 0.66 – 0.07 | 0.65 – 0.09 |
| HR (bpm) | 60 - 100 | 90.02 – 11.39 | 95.20 – 8.87* | 93.63 – 11.79 | 95.60 – 11.24 |
| PR (sec) | 0.12 - 0.20 | 0.14 – 0.03 | 0.14 – 0.03 | 0.14 – 0.01 | 0.12 – 0.02 |
| P (sec) | 0.08 - 0.10 | 0.07 – 0.03 | 0.08 – 0.02 | 0.07 – 0.02 | 0.07 – 0.02 |
| QRS (sec) | 0.08 - 0.10 | 0.06 – 0.01 | 0.07 – 0.01* | 0.06 –0.01* | 0.08 – 0.04* |
| QT (sec) | 0.36 - 0.46 | 0.3 – 0.04 | 0.31 – 0.03 | 0.30 – 0.04 | 0.31– 0.02 |
| QTc (sec) | ≤ 0.40 | 0.37 – 0.04 | 0.38 – 0.02* | 0.37 – 0.04 | 0.39 – 0.03* |
| JT (sec) | ≤ 0.40 | 0.24 – 0.04 | 0.23 – 0.02 | 0.24 – 0.04 | 0.22 – 0.03 |
| Tp-Te (sec) | 0.10 - 0.25 | 0.06 – 0.01 | 0.06 – 0.01 | 0.06 – 0.01 | 0.06 – 0.01* |
| P (mV) | 0.05 - 0.25 | 0.07 – 0.02 | 0.07 – 0.02 | 0.10 – 0.01* | 0.07 – 0.04 |
| Q (mV) | < 0.4 | – 0.04 – 0.05 | – 0.04 – 0.06 | – 0.05 – 0.03 | – 0.06 – 0.06 |
| R (mV) | 2.5 - 3.0 | 0.66 – 0.29 | 0.61 – 0.25 | 0.82 – 0.34 | 0.56 – 0.25 |
| S (mV) | ≥ 0.3 | – 0.12 – 0.11 | – 0.15 – 0.11 | – 0.16 – 0.12 | – 0.07 – 0.09 |
| ST (mV) | 0.1 | 0.01 – 0.03 | 0.02 – 0.03 | 0.02 – 0.03 | 0.01 – 0.02 |
| T (mV) | < 0.5 | 0.18 – 0.07 | 0.17 – 0.10 | 0.21 – 0.08 | 0.12 – 0.09* |
| HRV (m sec) | | 88.58 – 51.43 | 86.66 – 50.82 | 116.45 – 94.14 | 145.08 – 148.67* |

N = Normal; UW = Underweight; OW = Overweight; OB = Obese

* significant at $p < 0.05$




## Discussion:

In the present investigation all components of the ECG recorded from adult females fall under normal limits (Table 2) owing to the participants were normal healthy subjects. However, the categorization of subjects based on their BMI (kg / $m^2$) followed by recorded ECG data analyses represents an insignificant difference in the mean durations of intervals and amplitudes of waves, with the exception of mean duration of QRS (sec) and mean amplitude of P wave (sec).

A statistical comparison of N group with UW group showed significant ($p<0.05$) smaller mean RR interval and greater mean HR among UW group, suggesting the presence of high blood pressure. [21-22] Other conditions associated with smaller mean RR interval and increased HR such as atherosclerosis [23-24], heart valve diseases [25] and heart muscles diseases [26] can be excluded as all participants were normal healthy subjects. Moreover, significant prolonged durations of mean QRS and QTc intervals of UW group are indicative of arrhythmia [27] and a predictor of coronary heart disease (CHD) [28-29] followed by sudden cardiac death (SCD). [30-31]

OW group when compared with N subjects presented a significant high mean amplitude of P wave might be attributed to hypokalemia [32] which is further supported by other reported case studies. [33-34]

More interestingly the OB group in comparison to N group presenting a significant longer mean QRS and QTc intervals, are not only the prognostic to arrhythmia [27] but based on the significant longer mean duration of Tp – Te, the risk of cardiac diseases and abnormalities cannot be ruled out. [35] Further the presence of significant smaller mean T wave amplitude could be the result of hypokalemia [36] and ventricular arrhythmia. [37]

HR is controlled by a complex interplay between the parasympathetic and sympathetic nervous systems. Hence, the HRV is considered a pertinent measure of the cardiac autonomic function. [38] Several studies investigated the relationship among HRV indices, BMI and other indices of adiposity. [39-41]

In the present study where the mean HRV (m sec) calculated by Time Domain Method among different categories of BMI (kg / $m^2$) showed an insignificant difference and the Spearman's correlation between BMI (kg / $m^2$) and HRV (m sec) exhibited a weak positive statistically significant relationship also supported by Yadav et al., [42]. However, conversely to their studies our data in comparison to N group presented a significant and insignificant high mean HRV of OB and OW groups respectively. This variation of studies can be explained by other findings [43-45], describing sex differences in autonomic cardiac control due to significant dominance of parasympathetic activity in females resulting in increased HRV regardless of greater HR.

## Conclusion:

In conclusion the early changes observed in some components of ECG recorded from normal healthy females classified under various categories of BMI can be used as a tool to screen out the future cardiac related health problems.

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