Electrocardiographic Changes in Relation to Body Mass Index

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Abstract

Introduction: There are various physiological factors that affect ECG waveforms which include sex, age, ethnicity, height, weight, body mass index, and pregnancy and produce inter individual variability in ECGs. **Hypothesis:** The present study was done to find out the electrocardiographic changes in relation to body mass index. **Approach:** The study was conducted in the Physiology department, VIMS, Bellary. 30 normal, 30 overweight and 30 obese individuals, each between ages 18-30 years were selected from student population, VIMS, Bellary and also from general population to find out electrocardiographic changes in relation to body mass index. The ECG was recorded and was evaluated for different parameters like heart rate, P wave, PR interval, QRS complex, QRS axis, QT interval, QT_c interval, and results were drawn. **Results:** There was statistically significant increase in heart rate, PR interval, QT interval, QT_c interval, in overweight and obese individuals when compared to normal individuals and decrease in QRS axis in overweight and obese individuals when compared to normal individuals. **Conclusions:** The study shows that there are a variety of adaptations/alterations in cardiovascular system with increase in body mass index which bring about changes in ECG in the absence of any cardiac disease.

Keywords: ECG; Body mass index; Physiological changes.

Introduction

An important factor to consider when reading electrocardiograms (ECGs) for clinical decision making is that the waveforms are influenced by normal physiological and technical factors as well as by pathophysiological factors. Physiological factors that affect ECG waveforms include sex, age, ethnicity, height, weight, torso morphology, body mass index (BMI) and pregnancy. Such characteristics account for the differences among individuals and produce inter individual variability in ECGs.[1]

Obesity is a complex multifactorial chronic disorder that develops from an interaction of genotype and the environment. The health hazards of obesity have been recognized for centuries. Populations in industrialized countries are becoming more overweight as a result of changes in lifestyle. Both overweight and obesity must be regarded as serious medical problems in our time since obesity is associated with reduced life expectancy. Indeed, obesity represents an independent predictor of cardiovascular disease (CVD) and this association is more pronounced in individuals under 50 years of age. The presence of obesity may limit the accuracy of the physical exam. Jugular venous pulse

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is often not seen, and heart sounds are usually distant.

Obesity has the potential to affect the ECG in several ways:

1) displacement of the heart by elevating the diaphragm in the supine position,
2) increasing the cardiac workload and
3) increasing the distance between the heart and the recording electrodes.[2]

Currently over weight and obesity are classified by Body Mass Index (BMI = weight in kilograms/square of the height in meters). In adults, overweight is defined as BMI of 25.0 to 29.9kg/m^2; obesity is defined as BMI>/=30kg/m^2.[3]

The objective of the present study is to determine electrocardiographic changes in overweight and obese individuals. This study is undertaken to highlight the effects of BMI on the ECG and thereby help to differentiate from that of pathological changes.

Subjects and Methods

This study was conducted in the department of Physiology, VIMS, Bellary. Study population divided into 3 groups such as normal, overweight and obese. Each group contains 30 subjects who are aged between 18-30 years were selected from student population, VIMS, Bellary and also from general population to find out ECG changes in relation to their BMI.

Following an explanation about the nature and purpose of the study, those subjects who were willing to participate in the study were included after obtaining informed consent.

A detailed history was taken from all the subjects which were followed by a detailed physical examination. A pretested structured proforma was used to record relevant information from each individual.

Physical examination included measuring height in centimeters, weight in kilograms, recording resting pulse rate by palpating radial artery and blood pressure recording with a mercury sphygmomanometer. Clinical examination of cardiovascular and respiratory systems was done in detail.

Following detailed assessment of the subjects, they were screened for the presence of inclusion and exclusion criteria and dropped if any exclusion criteria were present.

Individuals with heart diseases like valvular heart disease, myocardial infarction, congenital heart disease, arrhythmias, and hypertension, respiratory diseases like chronic obstructive pulmonary disease, corpulmonale, individuals with anaemia, thyroid disorders and individuals on medication were excluded.The instrument used to record electrocardiogram is the Magic R 12 channel electrocardiograph designed by Mediline's team of biomedical engineers. Following detailed assessment of the subject, a 12 lead ECG was recorded during the resting state.The ECG was recorded and was evaluated for different parameters like heart rate, P wave, PR interval, QRS complex, QRS axis, QT interval, QT interval and results were drawn.

Statistical Analysis

The data was compiled in Microsoft excel and analyzed using SPSS (Statistical Package for Social Sciences) version15 (SPSS Inc. Chicago, IL, USA). Data was presented as mean ± SD for continuous data. The changes in ECG in overweight and obese when compared to normal were examined using ANOVA test, Chi square test and Fischer exact test. Differences were considered as significant if p-value<0.05.

Results

The distribution of study population based

Figure 1: Age-wise Distribution of Study Subjects based on BMI (at Column Width)

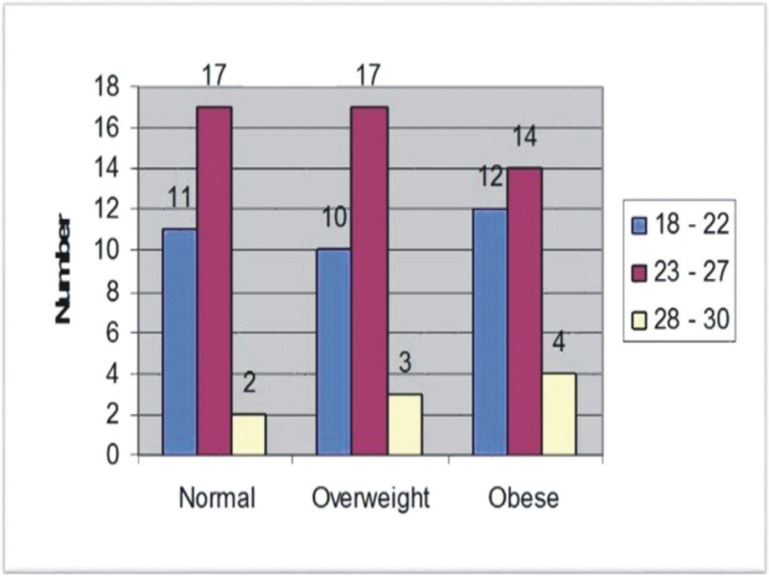

Table 1: Comparison of Pulse (bpm), Blood Pressure (mmHg), Heart Rate (bpm) and Respiratory Rate between Normal, Overweight and Obese Individuals

Variables	(Mean ± SD)			'F' value*	p-value	p-value (Multiple comparisons#)		
	(A) Normal	(B) Overweight	(C) Obese			A & B	A & C	B & C
SBP	118.80±2.7	121.87 ± 13.5	122.07 ± 2.5	13.47	0.00	0.00	0.00	0.27
DBP	79.67± 1.4	78.87 ± 3.3	80.93 ± 1.4	6.77	0.00	0.37	0.00	0.06
Heart rate	78.83 ± 3.0	75.13 ± 14.9	90.00 ± 3.4	56.43	0.00	0.00	0.00	0.00
Respiratory rate	15.93 ± 0.5	16.10 ± 0.5	15.87 ± 0.9	0.20	0.81	0.80	0.94	0.94

*ANOVA test applied, # post-hock Tuke test applied P>0.05 – not significant, P<0.05 – significant

Table 2: Comparison of 'P' Wave between Normal, Overweight and Obese Individuals

P wave	(Mean ± SD)			'F' value*	p-value	p-value (Multiple comparisons#)		
	(A) Normal	(B) Overweight	(C) Obese			A & B	A & C	B & C
Duration	0.080 ± 0.002	0.081 ± 0.004	0.082±0.006	3.19	0.08	0.72	0.07	0.31
Amplitude	1.00 ± 0	1.01±0.05	1.03±0.06	2.17	0.12	0.55	0.09	0.55

*ANOVA test applied, # post-hock Tuke test applied P>0.05 – not significant, P<0.05 – significant

Figure 2: Comparison of PR, QRS, QT and Qt_c Intervals between Normal, Overweight and Obese Groups (at Column Width)

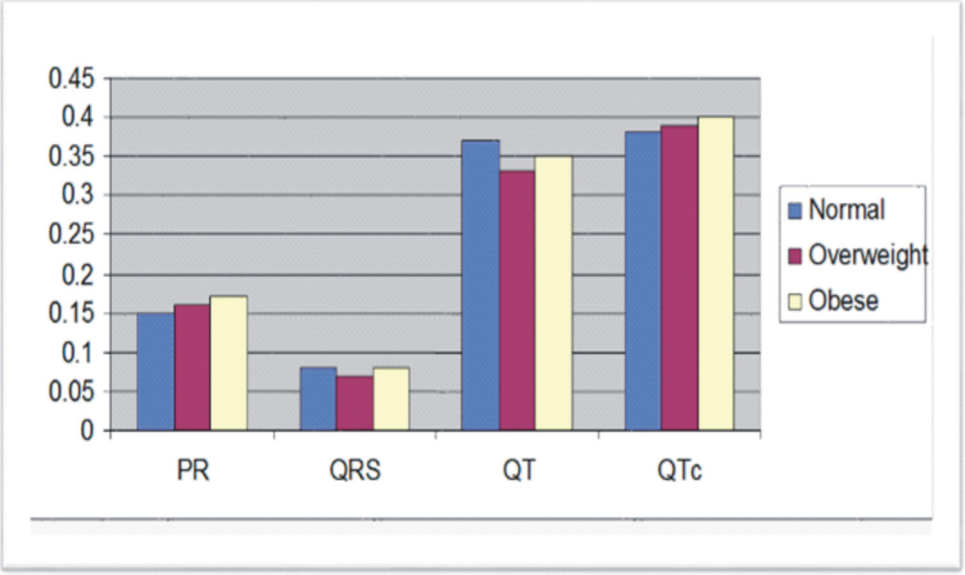

Table 3: Comparison of PR interval (Sec), QRS Complex(Sec), QT Interval (Sec), QTc Interval (Sec) and QRS Frontal Axis (Degree) between Normal, Overweight and Obese Individuals

Variables	(Mean ± SD)			'F' value*	p-value	p-value(Multiple comparisons#)		
	(A) Normal	(B) Overweight	(C) Obese			A & B	A & C	B & C
PR interval	0.15 ± 0.009	0.16 ± 0.00	0.17± 0.01	24.12	0.00	0.36	0.00	0.00
QRS complex	0.08 ± 0.003	0.07± 0.003	0.08± 0.009	1.42	0.24	0.55	0.80	0.22
QT interval	0.37 ± 0.02	0.33 ± 0.02	0.35± 0.03	12.59	0.00	0.00	0.02	0.04
QTc interval	0.38 ± 0.01	0.39 ± 0.006	0.40± 0.01	21.85	0.00	0.00	0.00	0.00
QRS axis	65.23 ± 7.29	50.20 ± 8.49	36.40± 11.86	70.51	0.81	0.80	0.00	0.00

*ANOVA test applied, # post-hock Tuke test applied, P>0.05 – not significant, P<0.05 – significant

on their age was summarized in Figure 1. Mean age was 23.4 ± 3.1, 23.6 ± 3.2 and 23.6 ± 3.4 years in normal, overweight and obese groups respectively (p = NS).Heart rate showed statistically significant increase in overweight and obese when compared to normal individuals (75.13±14.9, 78.83±3.00 and 90.0±3.4; p<0.01). There was also statistically significant increase in heart rate in obese individuals when compared to overweight individuals (78.83±3.00 vs 90.0±3.4; p<0.01) (Table 1).

Table 2 showing comparison of P wave between 3 groups. There is no statistically significant difference between 3 groups in P wave duration (0.08±0.002, 0.081±0.004 and 0.083±0.06; p =0.08).There is no statistically significant increase in P wave duration in obese when compared to normal (0.08±0.002 vs0.083±0.06; p<0.07). The P wave amplitudes (in mm) were 1.00±0.00, 1.01±0.05 and 1.03±0.06 among normal, overweight and obese individuals respectively. There was no statistically significant difference among the three groups (p = 0.12).

PR intervals (in seconds) were 0.15±0.009, 0.16±0.00 and 0.17±0.01 among normal, overweight and obese individuals respectively (Table 3). There was statistically significant increase in PR

interval among normal, overweight and obese groups ($p<0.01$). There was no statistically significant increase in PR interval in overweight when compared to normal individuals ($p=0.36$), but there is a significant increase in PR interval between normal and obese groups ($p<0.01$) and overweight and obese groups ($p<0.01$).

The durations of QRS complex were 0.08±0.003, 0.07±0.003 and 0.08±0.009 among normal, overweight and obese individuals respectively (Table 3, Figure 2). There was no statistical difference in duration of QRS complex among the three groups ($p = 0.24$).

Axis measurements (in degrees) were 65.23±7.29, 50.20±8.49 and 36.40±11.86 among normal, overweight and obese individuals respectively (Table 3). The QRS axis showed decrease in both overweight and obese when compared to normal individuals though there was no statistical significance when three values were compared($p = 0.81$).

There was statistically significant decrease in QRS axis in obese individuals when compared to normal (36.40±11.86 vs 65.23±7.29; $p<0.01$) and when compared to overweight (36.40±11.86 vs 50.20±8.49; $p<0.01$) groups. QT interval values (in seconds) were 0.33±0.02, 0.35±0.03 and 0.37±0.02 among normal, overweight and obese individuals respectively (Table 3, Figure 2). There was statistically significant increase in QT interval among overweight and obese individuals when compared to normal individuals ($p<0.01$). Also, there was statistically significant increase in QT interval in obese individuals when compared to normal (0.37±0.02 vs 0.33±0.02; $p=0.02$) and when compared to overweight (0.37±0.02 vs 0.35±0.03; $p=0.04$) individuals and also statistically significant increase in QT interval among overweight when compared to normal (0.35±0.03 vs 0.33±0.02; $p<0.01$) individuals.

QT interval values (in seconds) were 0.38±0.01, 0.39±0.006 and 0.40±0.01 among normal, overweight and obese individuals respectively (Table 3, Figure 2). There was statistically significant increase in QT interval among overweight and obese individuals when compared to normal individuals ($p<0.01$).

There was statistically significant increase in QT interval in obese individuals when compared to overweight (0.40±0.01 vs 0.39±0.006; $p<0.01$) and when compared to normal individuals (0.40±0.01 vs 0.38±0.01; $p<0.01$) and also statistically significant increase in QT interval in overweight individuals when compared to normal (0.39±0.006 vs 0.38±0.01; $p<0.01$) individuals.

Discussion

Many physiological factors affect the electrocardiographic waveforms. In this study, statistically significant increase in heart rate was found in both overweight and obese when compared to normal individuals. There was a positive correlation between body mass index and heart rate. Similar findings were reported by multiple studies, Alberto Salvadori *et al*,[4] Hugh R. Peterson *et al*,[5] Krzyszt of Narkiewicz *et al*[6] and Gilles Paradis *et al.*[7]

Activation of the sympathetic nervous system occurs early in the course of obesity and the autonomic nervous system is an important contributor to the regulation of both the cardiovascular system and energy expenditure as mentioned in multiple studies mentioned above. These studies also showed that heart rate increases with increase in percentage of body fat. A 10% increase in body weight is associated with a decline in parasympathetic tone accompanied by a rise in mean heart rate and conversely, heart rate declines during weight reduction. This is of importance because higher heart rate is associated with increased mortality rates.[8]

P Wave

P wave duration and amplitude

measurements did not show any statistically significant difference in overweight and obese individuals when compared to normal individuals.

PR Interval

In this study, PR interval showed statistically significant increase in overweight and obese individuals when compared to normal individuals. Similar findings were reported by Frank S *et al*[9] and Paul Poirier[2] in their study.

The reason for increased PR interval is not yet known and further studies are required to find the cause for increased PR interval in overweight and obese.

QRS Complex

The duration of QRS complex did not show any statistically significant difference in overweight and obese individuals when compared to normal individuals.

QRS Axis

In this study, QRS axis showed statistically significant decrease in obese individuals when compared to normal and overweight individuals. However, there was no statistically significant decrease in overweight individuals when compared to normal individuals.

The decrease in QRS axis in obese individuals is attributed to upward shift of diaphragm resulting in more horizontal position of heart and also to increased cardiac workload.[1,2]

Similar findings were reported by Hamoda MGA *et al*[1], Paul Poirier[2], Alpert MA *et al.*[10]

QT Interval

In this study, QT interval showed statistically significant increase in overweight and obese individuals when compared to normal individuals.

This was attributed to various factors primarily caused by obesity like left ventricular hypertrophy, left ventricular diastolic dysfunction, increased degree of myocardial repolarization in homogeneity, changes in sympathetic- vagal balance, increase in catecholamine levels, increase in free fatty acid levels which affect repolarization.[11]

Similar findings were reported by Bilora F *et al*[12], Seyfeli E *et al*[13], Carella MJ *et al*[14] and Boban Mathew *et al.*[11]

QT_c Interval

In this study ,QT_c interval showed statistically significant increase in overweight and obese individuals when compared to normal individuals.

This may be due to increased heart rate and also due to increased degree of myocardial repolarization in homogeneity, increase in free fatty acid levels which affect repolarization.[52]

Similar findings were reported by Frank S *et al*[9], Paul Poirier[2], Seyfeli E *et al*[13], Alaa El-Gamal *et al*[15], Carella MJ *et al*[14], Boban Mathew *et al.*[11].

Conclusion

- There was statistically significant increase in heart rate in overweight and obese individuals when compared to controls. There was also statistically significant increase in heart rate in obese when compared to overweight individuals.
- There was statistically significant increase in PR interval among overweight and obese individuals when compared to normal individuals. There was statistically significant increase in PR interval in obese individuals when compared to normal and overweight individuals.
- The QRS axis showed decrease in both

overweight and obese when compared to normal individuals though there was no statistical significance when three values were compared.

There was statistically significant decrease in QRS axis in obese individuals when compared to normal individuals and also when compared to overweight individuals.

- There was statistically significant increase in QT and QT_c intervals among overweight and obese individuals when compared to normal individuals.

There was statistically significant increase in QT andQT_c intervals in obese individuals when compared to overweight and normal individuals and also statistically significant increase in QT and QT_c intervals in overweight individuals when compared to normal individuals.

Though our study is by no means exhaustive, it does provide a glimpse into the variety of adaptations/alterations in cardiovascular system with increase in body mass index which bring about changes in ECG in the absence of any cardiac disease. Although we understand to some extent these changes and also since few studies have been done on this aspect, further research is needed to study the effect of body mass index on electrocardiogram.

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References

1. Hamoda MGA, Caldwell MA, Stotts NA, Drew BJ. Factors to consider when analyzing 12 lead electrocardiograms for evidence of acute myocardial ischaemia. *Am J Crit Care*. 2003; 12: 9-18.
2. Poirier P. Abdominal obesity: an important risk factor in clinical and interventional cardiology. *Official Journal of the International Chair on Cardiometabolic Risk*. 2008; 2(1): 7-14.
3. Clinical Guidelines on identification, evaluation and treatment of overweight and obesity in adults: The evidence report: National Institutes of Health. *Obes Res.* 1998; Suppl 2: 51S-209S.
4. Salvodori A, Fanari P, Mazza P, Agosti R, Longhini E. Work capacity and cardiopulmonary adaptation of the obese subjects during exercise testing. *Chest.* 1992; 101: 674-679.
5. Peterson HR, Rothschild M, Weinberg CR, Fell RD, Mcleish KR, Pfeifer MA. Body fat and the activity of the autonomic nervous system. *N Engl J Med.* 1988; 318: 1077-1083.
6. Narkiewicz K, Vande PJH, Cooley RL, Dyken ME, Somers VK. Sympathetic activity in obese subjects with and without obstructive sleep apnoea. *Circulation.* 1998; 98: 772-776.
7. Paradis G, Lambert M, O'Loughlin J, Lavallee C, Aubin J, Delvin E. Blood pressure and adiposity in children and adolescents. *Circulation.* 2004; 110: 1832-1838.
8. La Rovere MT, Bigger JT, Marcus FI, Mortara A, Schwartz PJ. Baroreflex sensitivity and heart rate variability in prediction of total cardiac mortality after myocardial infarction. ATRAMI (Autonomic Tone and Reflexes After Myocardial Infarction) Investigators. *Lancet.* 1998; 351: 478-484.
9. Frank S, Colliver JA, Frank A. The electrocardiogram in obesity; statistical analysis of 1029 patients. *J Am Coll Cardiol.* 1986; 7: 295-99.
10. Alpert MA, Terry BE, Cohen MV, Hamm CR, Fan TM, Massey CV, *et al*. The electrocardiogram in morbid obesity. *Am J Cardiol.* 2000; 85: 908-910.
11. Mathew B, Francis L, Kayalar A, Cone J. Obesity: effects on cardiovascular disease and its diagnosis. *The Journal of the American Board of Family Medicine.* 2008; 21(6): 562-568.
12. Bilora F, Vettore G, Barbata A, Pastorello M, Petrobelli F, San Lorenzo I. Electrocardiographic findings in obese subjects. *Minerva Gastroenterol Dietol.* 1999;

45(3): 193-197.

13. Seyfeli E, Duru M, Kuvandik G, Kaya H, Yalcin F. Effect of weight loss on QT_c dispersion in obese subjects. *Anadolu Kardiyol Derg*. 2006; 6: 126-129.
14. Carella MJ, Mantz SL, Rovner DR, Willis PW, Gossain VV, Bouknight RR *et al*. Obesity, adiposity and lengthening of QT interval: improvement after weight loss. *International Journal of Obesity*. 1996; 20(10): 938-942.
15. Gamal AE, Gallagher D, Nawras A, Gandhi P, Gomez J, Allison DB *et al*. Effects of obesity on QT, RR and QT_c intervals. *Am J Cardiol*. 1995; 75(14): 956-959.