DOI Number: 10.5958/2320-608X.2019.00031.3

Effect of Obesity on Electrocardiographic Parameters in Children : A Comparative Study

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ABSTRACT

Background: Obesity is becoming a global epidemic in both adults and children and is the leading preventable cause of death worldwide due to cardiovascular disease. Obesity is closely associated with wide variety of Electrocardiographic (ECG) abnormalities including ischemic ECG observations.

Objectives: Present study was designed to assess the ECG changes in obese asymptomatic male childrens and to compare with that of normal male children group.

Materials and method: Study was done in 50 apparently healthy obese male children between the age group of 5-18 years and 100 normal male children of the same age group .. A 12 lead ECG was recorded using computerized ECG machine and analysed for Heart rate, PR interval, QTc interval, QRS axis. Results were compared by Student's unpaired *t* test and analysed.

Results : Results in this study showed ECG variations which include significant increase in heart rate, prolongation of QTc interval and leftward shift of QRS axis in obese children group compared to non obese children. There was significant increase in PR interval in obese children compared to non obese group. However all the changes in ECG observed were within normal limits.

Conclusion: Variety of ECG changes occur even in asymptomatic obese children and obesity increases the risk for cardiovascular diseases, these ECG changes with respect to the baseline values should be known as early as possible so that early interventional measures could be taken to decrease the future risk of cardiovascular diseases.

Keywords : *ECG ; Obesity; QT_C interval.*

INTRODUCTION

The prevalence of overweight and obesity in children is a growing global health concern according to the World Health Organization. [1] It is well established that obesity is a strong risk factor for cardiovascular morbidity and mortality.[2]

Obesity is defined as a state of increased body weight, due to adipose tissue accumulation that is of sufficient magnitude to produce adverse health effects. There are two types of obesity, diffuse and central or visceral. Visceral fat is more metabolically active than subcutaneous fat, hence is associated with a much higher risk for several diseases.[3]

Obesity is associated with a heterogeneity of metabolic abnormalities (*e.g.*, dyslipidemia, low HDL levels,insulin resistance, hyperglycaemia, hypertension, pro-inflammatory state)[4] where each of them predispose patients to numerous cardiac complications like coronary heart disease, heart failure, stroke and even sudden death.[5,6]

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Bad lifestyle habits started in childhood have been proved to persist through adulthood, favouring the development of cardiovascular risk factors.[7]

Etiology of obesity is multi-factorial which includes genetic, environmental and psychological factors. Changing diet (high fat energy diet) and decreasing physical activity (sedentary life style) are believed to be the two most important causes for childhood obesity.[8]

Body Mass Index (BMI), Waist Circumference(WC) and Height Weight Ratio(HWtR) are measures of obesity and are efficient risk factor predictors of CVD in children. BMI is a measure of relative size based on the mass and height of an individual.[6,9]

Obesity has potential to affect Electrocardiogram, most of which reflect alterations in cardiac morphology. Obesity is closely associated with wide variety of Electrocardiographic (ECG) abnormalities including ischemic ECG observations which often lead to cardiovascular events.[10]

Furthermore, there is currently little evidence of an association between obesity and ECG variables in children.

ECG recording is a simple and non-invasive technique. Hence this study is taken up to detect the Electrocardiographic changes in asymptomatic obese children and to study prevalence of such abnormal ECG findings and predict the possibility of future cardiovascular diseases as early as possible, so that corrective measures at a very early stage are more likely to be beneficial.

MATERIALS AND METHOD

The study was undertaken in 50 apparently healthy obese male children between age group of 5-18 years and 100 normal male children of same age group who were selected randomly from schools in and around Davangere.

The study protocol and the procedures were approved by the institutional Ethics Committee (IEC) and Institutional Ethics Committee (IEC) clearance was obtained before beginning the study. We approached schools in and around Davangere and nature and purpose of the study was explained. A written fully informed consent was obtained from parents or legal guardians of all subjects.

Subjects participating in this study were screened for the presence of inclusion and exclusion criteria and dropped, if any exclusion criteria were present such as children above 18 years and below 5 years of age, chronic renal diseases, thyroid diseases, severe anemia, electrolyte imbalance, history of previous surgery and medications, history of chronic illness like diabetes mellitus, hypertension, tuberculosis etc., and other conditions that are likely to influence the study are excluded.

A detailed physical and systemic examination of individual subjects was done in the morning using a pre-structured Proforma. Resting pulse rate is recorded from the Radial artery and blood pressure is recorded using a mercury sphygmomanometer with the appropriate sized cuff in seated position.

Anthropometric measurements like body height in centimeters, weight in kilograms were measured by using the standard protocols while the participants are barefoot and in light clothes. Waist circumference was measured with a horizontally placed non-elastic flexible tape in the middle of the distance between the lowest rib and the iliac crest following normal expiration.

BMI for a person is calculated as their body mass divided by the square of their height i.e Weight (kg)/ height² (m^2). Overweight and obesity were defined by the recommended standard BMI cut off values by the International Obesity Task Force, according to age and gender. BMI within range 25-29.9 kg/m^2 is considered as overweight. And BMI more than 30 kg/m^2 is obesity.[11]

A Standard 12 lead ECG were recorded during the resting state in supine position using computerized NIVIQURE Digital ECG machine and data stored in a personal computer for subsequent processing. Special emphasis was given on heart rate(beats per minute), PR interval(in seconds), QT interval(in seconds), QTc interval(in seconds), QRS axis change (in degrees) and all parameters were analyzed.

Standard ECG reference values will be taken from Wagner G .S: Interpretation of normal electrocardiogram.[12]

Plan of Analysis and Statistical Tools:

Continuous variables were expressed as mean ± standard deviation (SD) and Categorical data as frequencies and percentages. Differences between groups

was compared using two-tailed unpaired student's t-test. Comparisons of categorized variables between groups was performed using the χ^2 test. Pearson's correlation coefficients were used to explore correlation between ECG variables and obesity-associated measurements, including BMI, WC and WHtR. The linear associations between variables were further examined using multivariate linear regression analysis. All tests of statistical significance were two-sided and $P < 0.05$ was considered to indicate a statistically significant difference, $P<0.001$ as : HS-Highly significant and $P>0.05$ as : NS-Not Significant. The statistical analyses was conducted with SPSS 20.0.

RESULTS

The results obtained were expressed as mean ± standard deviation. The study showed the following results.

Table 1: Comparison of incidence of occurrence of abnormal Heart rate (bpm) in obese and controls

Heart Rate (bpm)	Groups				Chi Square Test
	Obese		Control		
	Frequency	Percent	Frequency	Percent	
Normal	43	86	96	96	4.91, P<0.03
Abnormal	7	14	4	4	
Total	50	100	100	100	

Table 2: Comparison of incidence of occurrence of abnormal PR interval (seconds) in obese and controls

PR interval (sec)	Groups				Fisher's Exact Test
	Obese		Control		
	Frequency	Percent	Frequency	Percent	
Normal	42	84	100	100	P<0.000
Abnormal	8	16	0	0	
Total	50	100	100	100	

Table 3: Comparison of incidence of occurrence of abnormal QTc interval (seconds) in obese and controls

QTc interval (sec)	Groups				Chi Square Test
	Obese		Control		
	Frequency	Percent	Frequency	Percent	
Normal	28	56	77	77	7.00, P<0.008
Abnormal	22	44	23	23	
Total	50	100	100	100	

Table 4: Comparison of incidence of occurrence of abnormal QRS axis (degrees) in obese and controls

QRS axis (degrees)	Groups				Fisher's Exact Test
	Obese		Control		
	Frequency	Percent	Frequency	Percent	
Normal	47	94	100	100	P<0.03
Abnormal	3	6	0		
Total	50	100	100	100	

Table 5: Comparison of Heart rate (bpm), PR interval (sec), QT_C interval (sec), QRS axis (degrees) between obese group and controls

Groups		N	Mean	Std. Deviation	t Value	P Value	Significance
Heart rate (bpm)	Obese	50	87.80	9.53	1.98	P<0.05	Significant
	Control	100	84.06	11.55			
PR interval (sec)	Obese	50	0.15	0.04	5.23	P<0.000	Highly significant
	Control	100	0.12	0.02			
QT_C interval (sec)	Obese	50	0.44	0.04	3.64	P<0.000	Highly significant
	Control	100	0.41	0.06			
QRS axis (degrees)	Obese	50	54.68	25.76	2.06	P< 0.04	Significant
	Control	100	51.43	21.87			

DISCUSSION

The obese and non-obese children were comparable with respect to age, sex, height. Obese subjects, however, had significantly higher BMI, higher body surface area.[6,9]

We observed obesity in children is closely associated with wide variety of ECG changes.

In our study HR were significantly higher in obese children compared to controls. This increase in HR could be supported by the fact that obesity is associated with change in autonomic activity, which includes significant reduction in parasympathetic activity and significant increase in sympathetic activity.[13] Autonomic Nervous System is associated with the regulation of Energy and Body fat content. Increased sympathetic activity in overweight and obesity may be a compensatory mechanism to burn fat and minimize further accumulation of fat and weight gain, but at the cost of increased sympathetic discharge to heart, kidneys and peripheral vasculature.[14]

This result is consistent with other studies.

Guo-Zhe Sun and his colleagues in their study 'association between obesity and ECG variables in children' observed that higher heart rate existed in obese group when compared to normal weight subjects.[6]

Narumi Nagai and his co-workers observed that obese children group had significantly higher resting heart rate compared with the non-obese group.[14]

Stuart Frank and his colleagues in their study found increase in heart rate with increasing obesity.[15]

Significant increase in PR interval was noticed in obese children compared to controls.

Observing the QTc interval in this study, there was prolongation of QTc interval in obese children which is highly significant compared to controls. This is explained on the fact that increase in QTc is due to cardiac autonomic neuropathy in obesity which may result in sympathetic imbalance and QTc interval prolongation.[10]

Furthermore, studies have suggested that an elevated cardiac output in obesity, due to an increased stroke volume and overall greater body mass, may contribute to altered autonomic nervous system balance which could have increased QTc interval in this study.[16]

In addition, it could also be also suggested that diabetes mellitus, hyperinsulinemia and insulin resistance due to obesity may induce cardiovascular disease and may play a role in prolonged QTc interval.[17]

Length of QT interval represents the time interval between the start of the ventricular depolarisation and the completion of its repolarization; prolongation of

this interval means delayed repolarization of ventricular myocardium and is considered a precursor of malignant arrhythmias and sudden death.[18]

Guo-Zhe Sun and his colleagues in their study observed prolongation of QTc interval in obese group when compared to normal weight children.[6]

El-Gamal et al reported in their study that prolongation of QTc interval was significantly associated with relative body mass and fatness.[16]

Theodora W and his colleagues showed that subjects with high waist circumference were associated with longer corrected QT interval.[19]

QRS axis serves as a sign for left ventricular hypertrophy and bundle branch block.[20]

In our study significant leftward deviation of the QRS axis was observed in obese children as compared to controls. Although this deviation was statistically significant, probably is not clinically important. But these changes above the baseline values must be considered when evaluating electrocardiographic changes in pathological condition in obese subjects.

There occurs significant increase in stroke volume, cardiac output in obese children, indicating increased cardiac workload [21] leading to an increase in cardiac mass that is proportional to degree of obesity which is an explanation for the progressive shift of the mean QRS vector toward the left or it could be due to change in the anatomic position of the heart in the thorax which is due to the fact that heart is displaced in obesity because of the rise of diaphragm, which may be due to excessive fat accumulation[15] and also may be due to the increased distance between the heart and the recording electrodes which is due to the fat accumulation.[15]

This result is consistent with other studies.

Stuart Frank et al in their study noticed leftward shift of frontal QRS axis in obese group and the mean frontal plane QRS axis (QRS vector) tended to shift to the left as percentage of overweight increased.[15]

Guo-Zhe Sun and his colleagues observed results indicating that in children and adolescents, general and abdominal obesity is associated a leftward shift of frontal QRS axis.[6]

Fraley MA et al observed leftward shifts in electrocardiographic axes as markers of left ventricular hypertrophy in obese individuals.[22]

CONCLUSION

Obesity is associated with wide variety of electrocardiographic (ECG) abnormalities. Furthermore, most of these reflect alterations in cardiac morphology. Some serve as markers of risk for sudden death. Many of these ECG abnormalities are reversible with substantial weight loss, finding the cause of obesity and preventing obesity in early years is currently a critical issue in the Pediatric public health research field.

Acknowledgement: Authors are grateful to the Dr.S.B Murugesh, Principal, JJM Medical College, Davangere for his support and encouragement in all aspects of this study. We also would like to thank our statistician. We are grateful to all the children who participated in this study and the teachers in the schools of Davangere city for their kind support.

Conflict of Interest: None to declare.

Institutional Ethical committee clearance: Obtained.

Source of support : None Declared

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