Correlation between QTc interval and the values of waist-hip ratio measured in young healthy male and female adults

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Abstract

The study was conducted with male and female subjects, 32 in each study group. The WHR (Waist Hip Ratio) and QTc (Correction of QT interval) were measured and the correlation was obtained by statistical analysis. The WHR and QTc are both negatively correlated in both male and female subjects. But, this finding is statistically insignificant. On the other hand the mean QTc in male subjects is more than that in female subjects. This finding is statistically significant. The study might have yielded a better result if the sample size was more.

Keywords: Correction of QT interval, waist hip ratio, QTC interval, young healthy male & female adults. ECG, digital polyrite, pulse oxymeter

Introduction

The electrocardiogram (ECG) is useful and non-invasive tool for the diagnosis and prognosis of a wide range of cardiovascular diseases. ECG comprises of certain components like-P wave, QRS complex, T wave; an occasional U wave is also found sometimes in special cases (like delayed repolarisation of the Purkinje fibres or after-potentials in the ventricular walls). P wave denotes the atrial depolarisation while the QRS complex indicates the ventricular depolarisation. The T wave represents the ventricular repolarisation (Fig.1.1) [1].

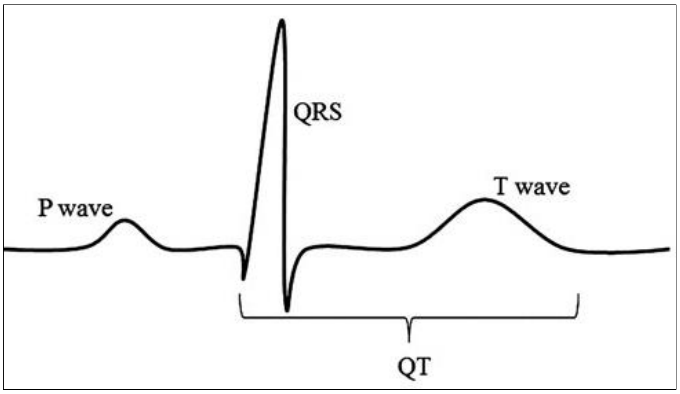

Fig 1: The normal picture of an electrocardiogram representing the different components

QT is a time interval on the electrocardiogram that represents the depolarisation and repolarisation of the ventricles and is represented in the electrocardiogram as the portion extending from the onset of the QRS complex to the end deflection of the T wave.[2] A lengthened QT interval is a marker for the potential of ventricular tachyarrhythmia like Torsades de pointes and a risk factor for sudden death.

The QT interval is modulated by the autonomic function and therefore is often corrected to be independent of heart rate.[3] This corrected QT is better known as QTc and is popularly measured by the Bazzett's Formula[4,5]. The QTc has far-reaching importance on various cardiovascular diagnoses like prolonged QTc causes premature action potentials during the late phases of depolarization. This increases the risk of developing ventricular arrhythmias or fatal ventricular fibrillations. Besides, the higher QTc are evident physiologically in females, older patients and short stature. Thus, the QTc has greater importance than normal QT.

On the other hand, waist-hip ratio is a major yet simple method to determine the obesity, a major risk factor in many diseases most notably the cardiovascular diseases in an individual. Obesity may be defined as an abnormal growth of the adipose tissue due to enlargement and/or increase in the number of the fat cell size i.e. hypertrophic and hyperplastic obesity respectively[6]. Besides, the Waist-hip ratio (WHR) is independent of the height of the individual. The purpose of this investigation is to find the dependence of the heart rate on the waist-hip ratio.

There is an increased incidence of various cardiovascular diseases in young adults and obesity is quite a common factor among these individuals.[7,8] In order to curb the epidemic spread of cardiovascular problem in the present day scenario, the lifestyle in young age should be checked.

In this study, male and female subjects, both have been selected for various reasons-

i) It has been found that QTc interval is different in different subjects of different body patterns under the same environmental conditions.
ii) Females usually have higher QTc, but it still differs in different subjects.
iii) It is desired to compare the QTc in male and female subjects.

The QTc interval and its relation with the waist hip ratio or indirectly with the obesity would improve the prognosis of various cardiovascular diseases that are common in our society.

Aims and Objectives

- To find out the correlation between WHR and QTc interval among young healthy male subjects.
- To find out the correlation between WHR and QTc interval among young healthy female subjects.

- To compare the QTc interval between male and female young healthy adults.

Materials and Methods

a) **Type of study:** Observational.
b) **Study design:** Cross-sectional.
c) **Study population:** Young healthy adults aged between 17 and 25 years.
d) **Study site:** Human Research Laboratory, Physiology Department, R.G. Kar Medical College and Hospital, Kolkata, West Bengal.
e) **Sample size:** 64 young healthy subjects; 32 males and 32 females.
f) **Selection Criteria:** Young healthy males and females aged 17-25 years.
g) **Exclusion criteria**

1) Hypertensive subjects.
2) Smoker Addicts.
3) Subjects with any cardiovascular diseases (CVD).
4) Subjects recovering from any major ailment.
5) Subjects with any sort of disease or disability.
6) Menstruating female subjects.
7) Subjects undergoing regular strenuous activities (including exercises).

h) Instruments required

1) Measuring tape.
2) Polyrite-D instrument and accessories.
3) Fingertip pulse oximeter.
4) Sphygmomanometer (OMRON HEM-401) and Stethoscope.
5) Wall mounted Stadiometer (BIOCON) and weighing scale.
6) Glucometer and kit.
7) Computerised Electrocardiograph.
8) Electrode jelly.

i) Data collection procedure

1) Questionnaire

A questionnaire regarding the history, the general examination, the systemic examinations as well as family history.

2) Investigations

i) Blood pressure and pulse monitoring.
ii) Blood glucose (random).

j) Ethical Consideration

Ethical clearance has been obtained from the “Institutional Ethical Committee (IEC)” of the R.G. Kar Medical College & Hospital.

k) Statistics

For Statistical analysis, latest version of the IBM SPSS (Statistical Package for the Social Sciences) software has been used.

l) Written Consent and confidentiality

The subjects were clearly explained about the various procedures that will be conducted before the study in their preferred language. Written consent were taken from them and were well assured of the confidentiality of their personal information.

m) Quality control

- **i) Selection of subjects:** The subjects were chosen as per the selection criteria as mentioned above and the pre-study criteria were strictly maintained.
- **ii) Laboratory preparation:** The conditions required for the experiment like the temperature of the laboratory.
- **iii) Measurement of WHR:** The waist hip ratio were measured following the WHO guidelines with a standard measuring tape.
- **iv)** Standard and latest Instrument & software-Polyrite-D (RMS) and Latest Software (Version 1.2.5.) and other standard instruments have been used to conduct the study.
- **v)** The accuracy of the apparatus and the instruments used were strictly maintained.

n) Pre-study criteria

- i) A modified questionnaire containing subject particulars, personal habits, family history and a detailed past history of any illness and treatment were recorded. General physical examinations were also done.
- ii) Pre-test instructions were given in the subject's preferred language and were requested to avoid consumption of any drugs or food (that could have altered the heart rate), 48 hours prior to the test.
- iii) The subjects were advised to have sound sleep the night before.
- iv) Tea, coffee, food or drugs (orally / other route) were not permitted three hours prior to the test.
- v) The subjects were advised to put on loose fitting clothes so that there was no sympathetic stimulation.

o) Procedure

- i) The room temperature of the laboratory was maintained between 18°C and 25°C and the room was reasonably lit in order to avoid unwanted sympathetic or parasympathetic activity.
- ii) The subjects were brought to the Research laboratory (after he/she has fulfilled all the pre-study criteria) and a written consent was obtained from the individual.
- iii) The WHR was measured in the individuals accurately. [WHR=waist circumference (in cm)/ hip circumference (in cm)]
- iv) The height (in centimetres) and weight (in kilograms) were measured using a standardised Stadiometer (BIOCON) and a standard weighing machine.
- v) The subjects were asked to rest comfortably for 30 minutes in supine posture.
- vi) The subjects' names, subject IDs, age, sex, contact number, height (in cms), any significant past history, any current medication, and the study conductor's name (my name) was saved in RMS Polyrite-D database.
- vii) The ECG from the Lead II was recorded for 10 minutes in supine position with the Help of Polyrite-D. The QTc was thus obtained along with the QT_{max} and QT_{min}. The study was conducted for 10 minutes instead of the usual 5 minutes as in the latter case, the complete variation in the various ECG parameters could not be obtained.

p) Correction of the QT interval QTc

The QT interval is dependent on the heart rate and is also influenced greatly by the autonomic nervous system. Various corrections are done to obtain the corrected QT, but the most used and nearly accurate is the Bazzett's Formula [5]. According to the formula,

$$QT_c = \frac{QT}{\sqrt{RR}}$$

The Bazzett's formula is now considered incorrect, because it overcorrects the heart rate at higher heart rates and under corrects the heart rate at lower heart rates. For this, according to the Framingham heart study, the linear regression model so obtained puts forward a formula for both male and female subjects [10] -

$$QT_{LC} = QT + 0.154\ (1 - RR)$$

Besides, the QTc can also be measured more accurately by Fridericia's cube-root formula [11] which states that-

$$QT = k \times \sqrt[3]{RR}$$

It is worthy of mention here that any correction formula is likely to insert an error in assessing the QTc [11].
The QTc can be measured by both 12-lead ECG and using a 24-hour Ambulatory Holter. But, it is still no clear which of the two is more accurate in measuring the QTc and establishing the correlation between the QTc and cardiac arrhythmias and other CVD [9].
The uncorrected QT is required for analysing and studying drug induced arrhythmia. But in our study, the subjects have been asked not to take any drugs 24 hours before the test. So, it is better to use QTc.

q) Measurement of the WHR

The waist hip ratio plays a pivotal role in the analysis of this study. In this study actually an effort has been made to find the correlation between the obesity and the values of QTc, which again determines underlying arrhythmias, Torsade de Pointes and various other cardiovascular diseases. The Waist-hip ratio is a reliable indicator of obesity and is simple to measure. Besides, the WHR is independent of the height of the individual, so, there would be no discrepancy in the values obtained from different individuals of different statures.
In our study, the waist hip ratio was measured according to the report-"Waist Circumference and Waist-Hip Ratio: Report of a WHO Expert Consultation Geneva, 8-11 December 2008'' [22].
The waist circumference has been measured along the midpoint between the lower part of the lowest palpable rib and the uppermost part of the iliac crest. But the circumference was measured either above or below the umbilicus, but not traversing it, as several reports have indicated erroneous results with the procedure being carried out at this level [13]. The hip circumference was measured along the largest girth of the buttock. NHANES III protocol has also been followed. The following criteria were kept in mind while measuring the WHR-

i) The subjects were asked to stand erect with legs placed close such that the weight was equally distributed between the two feet. The arms are to be placed on the sides.
ii) The subjects were asked to respire normally within the tidal volume and the circumference

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were measured at the end of expiration without forced inspiration or expiration.

iii) The measuring tape was not pulled tightly, rather it was snugged round the body.

iv) The subjects were advised to fast for at least 3 hours before the study was conducted.

v) Each measure was taken twice and the mean of the two was considered to be the most appropriate value.

vi) Since the abdominal wall tension has great impact on the circumference of the waist, the subjects were asked to inhale and exhale 2-3 times to maintain normal abdominal wall tension.

Observations

Table 1: Distribution of male subjects according to their age

Age category (Years)	Frequency (Number)	Percent	Valid Percent	Cumulative Percent
19	10	31.3	31.3	31.3
20	16	50.0	50.0	81.3
21	4	12.5	12.5	93.8
22	2	6.3	6.3	100.0
Total	32	100.0	100.0	

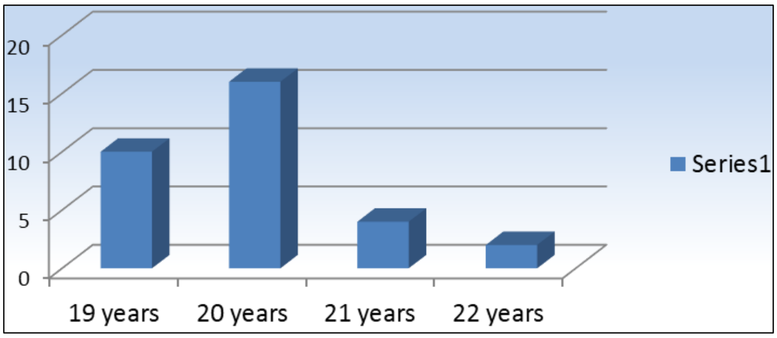

Fig 2: Bar diagram showing the distribution of male subjects according to their age.

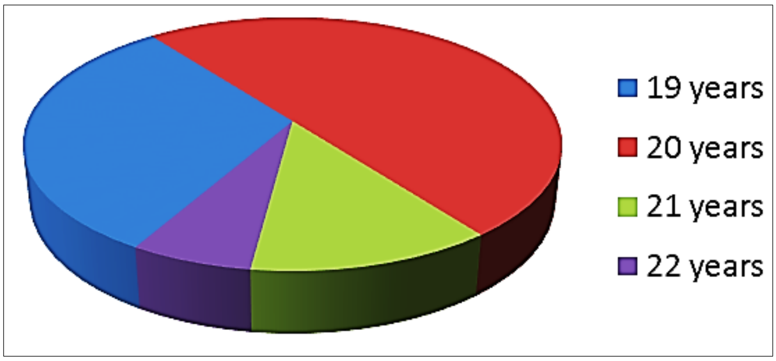

Fig 3: Pie diagram showing the distribution of male subjects according to their age.

Table 2: Distribution of female subjects according to their age

Age category (Years)	Frequency (Number)	Percent	Valid Percent	Cumulative Percent
18	1	3.1	3.1	3.1
19	4	12.5	12.5	15.6
20	15	46.9	46.9	62.5
21	11	34.4	34.4	96.9
22	1	3.1	3.1	100.0
Total	32	100.0	100.0	

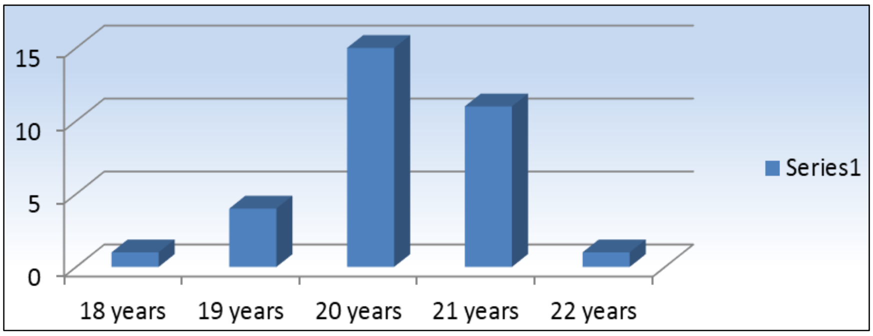

Fig 4: Bar diagram showing the distribution of female subjects according to their age.

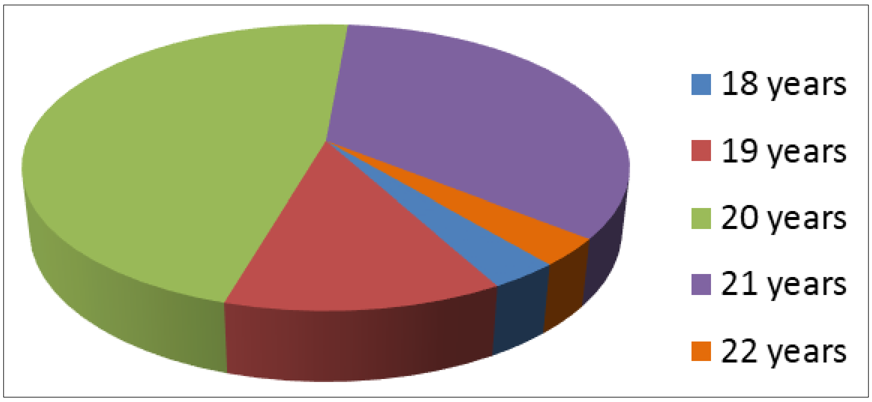

Fig 5: Pie diagram showing the distribution of male subjects according to their age.

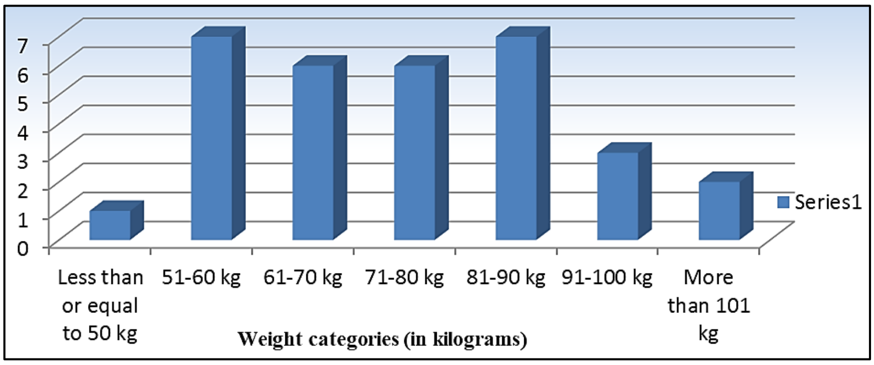

Fig 6: Bar diagram showing the distribution of male subjects according to their body weights.

Table 3: Distribution of the male subjects according to their body weights

Category of body weights (in kilograms)	Frequency (Number)	Percent	Valid Percent	Cumulative Percent
Less than or equal to 50 kg	1	3.1	3.1	3.1
51-60 kg	7	21.9	21.9	25.0
61-70 kg	6	18.8	18.8	43.8
71-80 kg	6	18.8	18.8	62.5
81-90 kg	7	21.9	21.9	84.4
91-100 kg	3	9.4	9.4	93.8
More than 101 kg	2	6.3	6.3	100.0
Total	32	100.0	100.0	

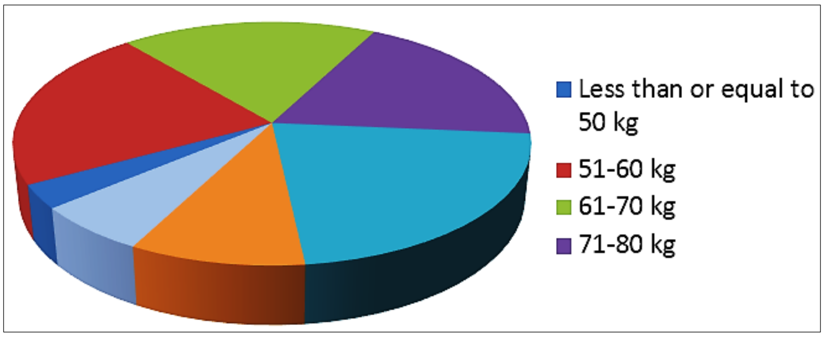

Fig 7: Pie diagram showing the distribution of male subjects according to their body weights.

Table 4: Distribution of female subjects according to their body weights

Category of body weights (in kilograms)	Frequency (Number)	Percent	Valid Percent	Cumulative Percent
40-49 kg	7	21.9	21.9	21.9
50-59 kg	12	37.5	37.5	59.4
60-69 kg	7	21.9	21.9	81.3
70-79 kg	5	15.6	15.6	96.9
Greater than 80 kg	1	3.1	3.1	100.0
Total	32	100.0	100.0	

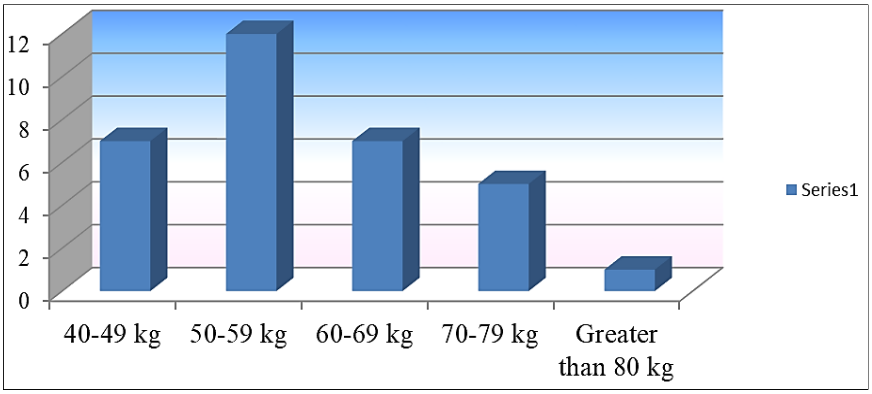

Fig 8: Bar diagram showing the distribution of female subjects according to their body weights

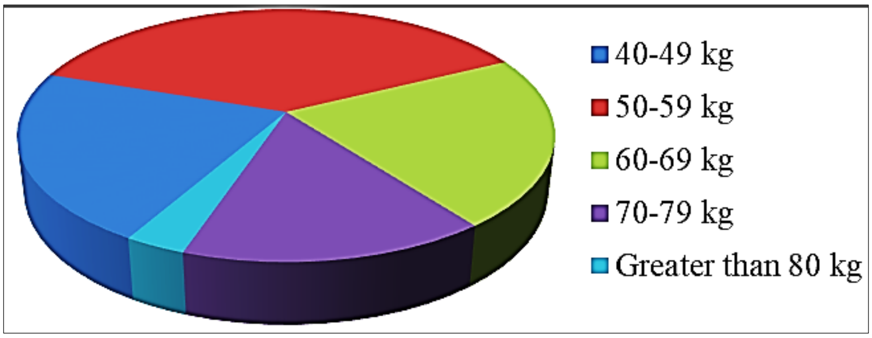

Fig 9: Pie diagram showing the distribution of female subjects according to their body weights.

Table 5: Distribution of male subjects according to their heights

Height category (in centimetres)	Frequency (Number)	Percent	Valid Percent	Cumulative Percent
150-159 cm	2	6.3	6.3	6.3
160-169 cm	10	31.3	31.3	37.5

Greater than 170 cm	20	62.5	62.5	100.0
Total	32	100.0	100.0	

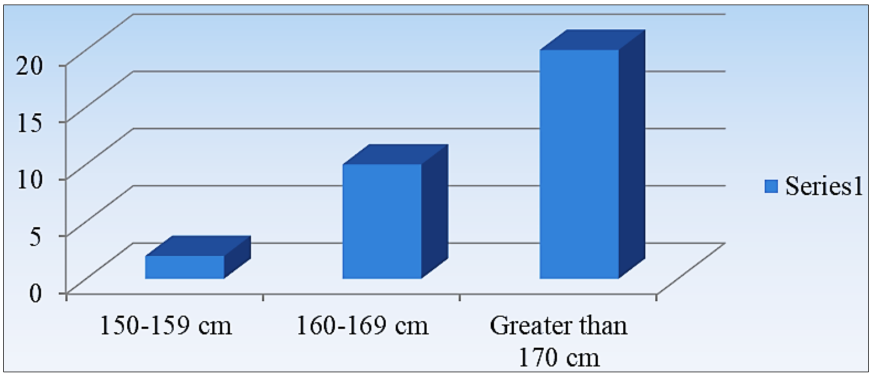

Fig 10: Bar diagram showing the distribution of male subjects according to their heights

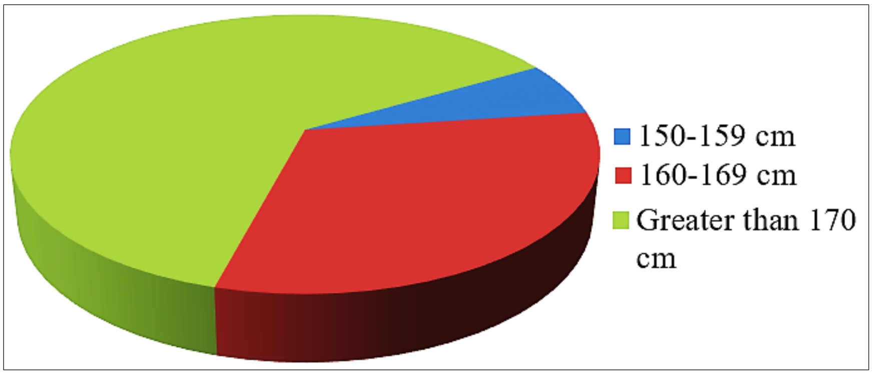

Fig 11: Pie diagram showing the distribution of male subjects according to their heights

Table 6: Distribution of female subjects according to their heights

Category of body weights (in centimetres)	Frequency (Number)	Percent	Valid Percent	Cumulative Percent
Less than or equal to 149 cm	1	3.1	3.1	3.1
150-159 cm	18	56.3	56.3	59.4
160-169 cm	12	37.5	37.5	96.9
170-179 cm	1	3.1	3.1	100.0
Total	32	100.0	100.0	

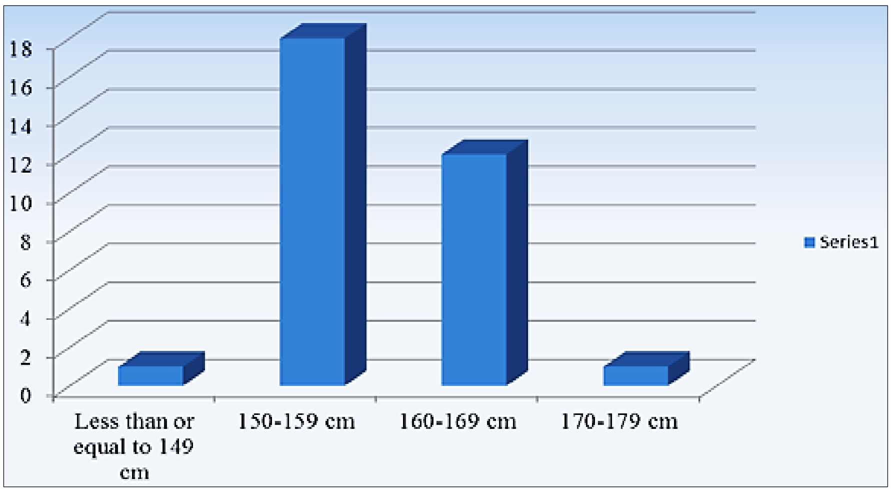

Fig 12: Bar diagram showing the distribution of female subjects according to their heights

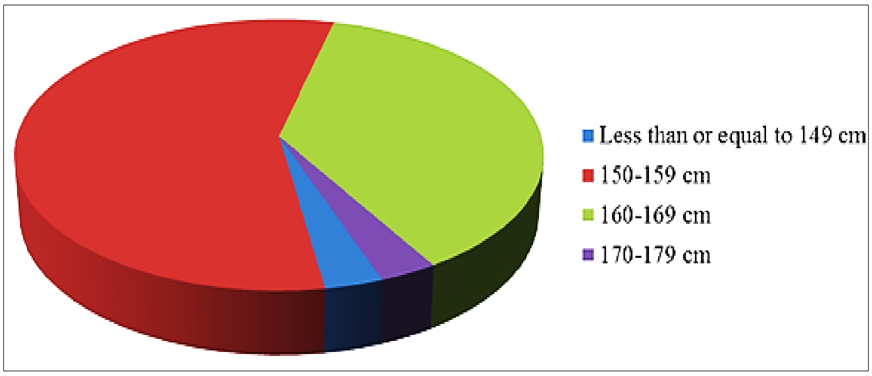

Fig 13: Pie diagram showing the distribution of female subjects according to their heights.

Table 7: Distribution of male subjects according to their QTc values

QTc values	Frequency	Percent	Valid Percent	Cumulative Percent
.070	2	6.3	6.3	6.3
.090	1	3.1	3.1	9.4
.110	2	6.3	6.3	15.6
.120	3	9.4	9.4	25.0
.130	1	3.1	3.1	28.1
.140	1	3.1	3.1	31.3
.170	3	9.4	9.4	40.6
.190	2	6.3	6.3	46.9
.200	5	15.6	15.6	62.5
.210	3	9.4	9.4	71.9
.220	2	6.3	6.3	78.1
.230	1	3.1	3.1	81.3
.240	1	3.1	3.1	84.4
.250	1	3.1	3.1	87.5
.260	1	3.1	3.1	90.6
.290	1	3.1	3.1	93.8
.760	1	3.1	3.1	96.9
.970	1	3.1	3.1	100.0
Total	32	100.0	100.0	

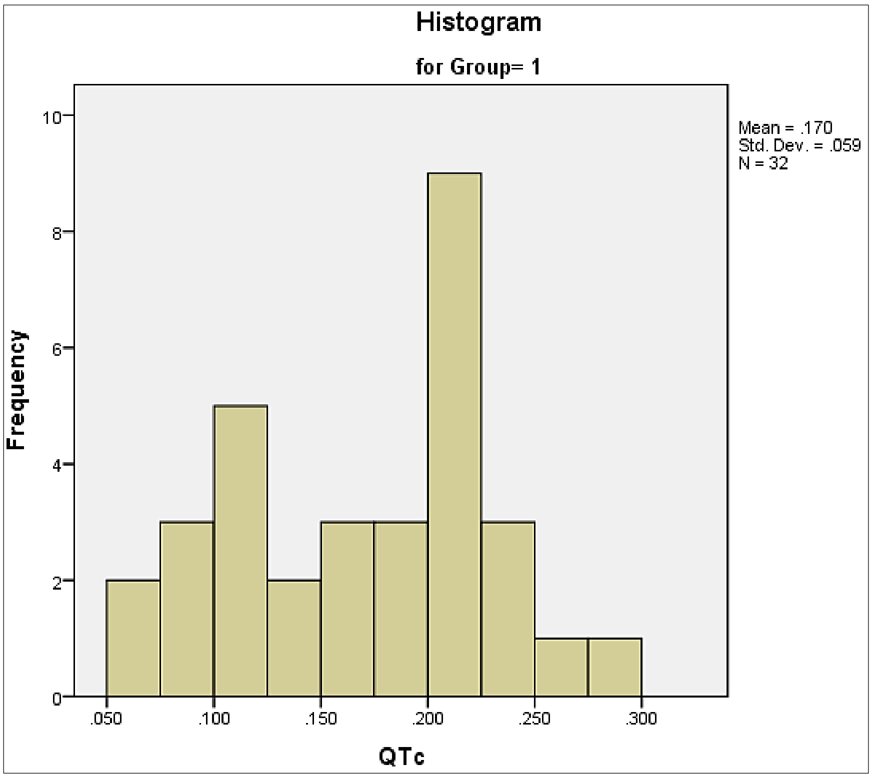

Fig 14: Histogram showing the distribution of the male subjects (denoted by Group=1) according to their QTc values.

Explanation

i) The above histogram shows the frequency of the male subjects with different QTc values.
ii) The mean of the QTc is 0.170 with a standard deviation of 0.059.
iii) N denotes the number of male subjects which is equal to 32.

Table 8: Distribution of female subjects according to their QTc values

QTc values	Frequency	Percent	Valid Percent	Cumulative Percent
.049	1	3.1	3.1	3.1
.058	1	3.1	3.1	6.3
.062	1	3.1	3.1	9.4
.063	1	3.1	3.1	12.5
.064	1	3.1	3.1	15.6
.065	1	3.1	3.1	18.8
.073	1	3.1	3.1	21.9
.074	1	3.1	3.1	25.0
.078	1	3.1	3.1	28.1
.084	1	3.1	3.1	31.3
.094	2	6.3	6.3	37.5
.096	1	3.1	3.1	40.6
.097	1	3.1	3.1	43.8
.101	1	3.1	3.1	46.9
.103	1	3.1	3.1	50.0
.106	1	3.1	3.1	53.1
.117	1	3.1	3.1	56.3
.121	1	3.1	3.1	59.4
.122	1	3.1	3.1	62.5
.128	1	3.1	3.1	65.6
.130	1	3.1	3.1	68.8

.133	1	3.1	3.1	71.9
.143	1	3.1	3.1	75.0
.148	1	3.1	3.1	78.1
.159	1	3.1	3.1	81.3
.184	1	3.1	3.1	84.4
.193	1	3.1	3.1	87.5
.198	1	3.1	3.1	90.6
.214	1	3.1	3.1	93.8
.218	1	3.1	3.1	96.9
.219	1	3.1	3.1	100.0
Total	32	100.0	100.0	

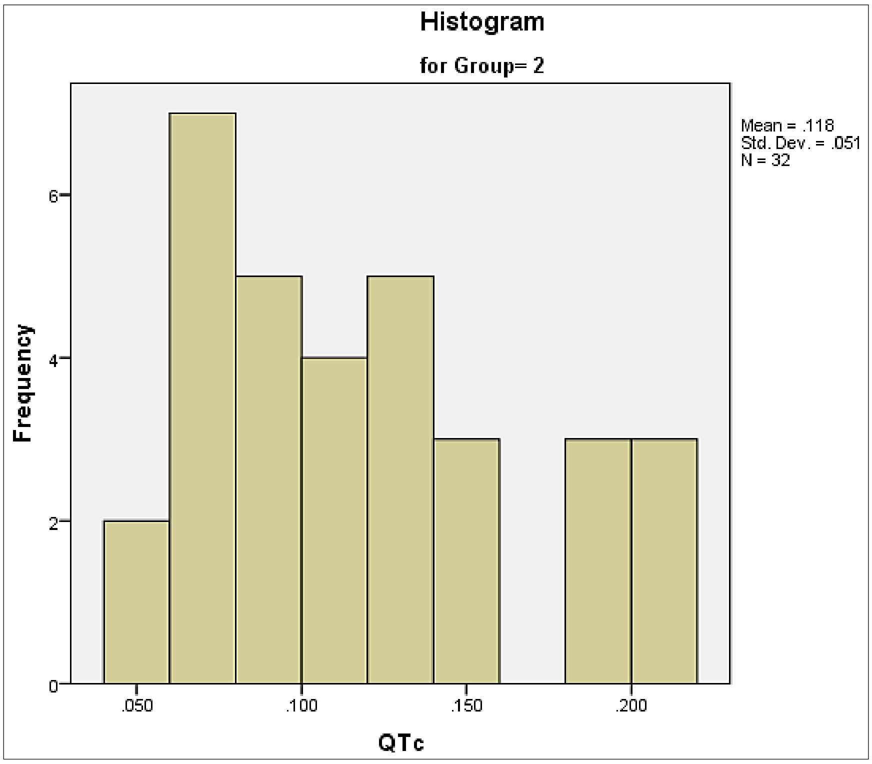

Fig 15: Histogram showing the distribution of the female subjects (denoted by Group=2) according to their QTc values.

Explanation

i) The above histogram shows the frequency of the female subjects with different QTc values.
ii) The mean of the QTc is 0.118 with a standard deviation of 0.051.
iii) N denotes the number of female subjects which is equal to 32.

Table 9: Distribution of male subjects according to their WHR values

WHR values	Frequency	Percent	Valid Percent	Cumulative Percent
.697	1	3.1	3.1	3.1
.711	1	3.1	3.1	6.3
.771	1	3.1	3.1	9.4
.789	1	3.1	3.1	12.5
.800	1	3.1	3.1	15.6
.806	1	3.1	3.1	18.8
.825	1	3.1	3.1	21.9
.838	1	3.1	3.1	25.0

.842	1	3.1	3.1	28.1
.846	1	3.1	3.1	31.3
.848	1	3.1	3.1	34.4
.849	1	3.1	3.1	37.5
.853	1	3.1	3.1	40.6
.854	1	3.1	3.1	43.8
.857	1	3.1	3.1	46.9
.863	2	6.3	6.3	53.1
.865	1	3.1	3.1	56.3
.878	1	3.1	3.1	59.4
.899	1	3.1	3.1	62.5
.921	1	3.1	3.1	65.6
.927	1	3.1	3.1	68.8
.930	1	3.1	3.1	71.9
.935	1	3.1	3.1	75.0
.950	1	3.1	3.1	78.1
.952	2	6.3	6.3	84.4
.955	1	3.1	3.1	87.5
.958	1	3.1	3.1	90.6
.959	1	3.1	3.1	93.8
.978	1	3.1	3.1	96.9
.989	1	3.1	3.1	100.0
Total	32	100.0	100.0	

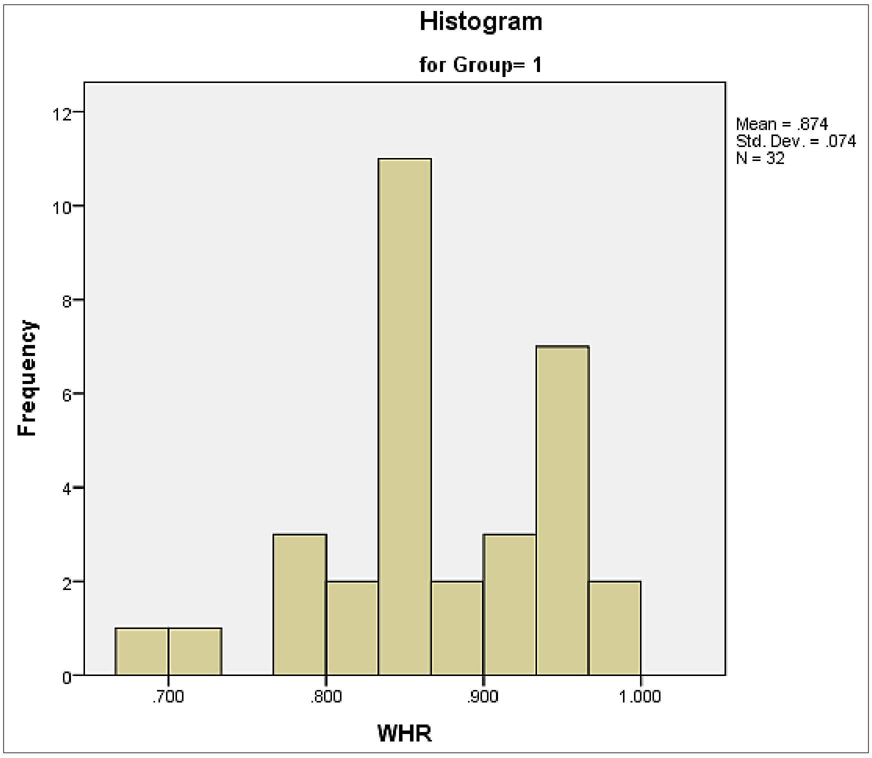

Fig 16: Histogram showing the distribution of the male subjects (denoted by Group=1) according to their WHR values

Explanation

i) The above histogram shows the frequency of the male subjects with different WHR values.
ii) The mean of the WHR is 0.874 with a standard deviation of 0.074.
iii) N denotes the number of male subjects which is equal to 32.

Table 10: Distribution of female subjects according to their WHR values

WHR values	Frequency	Percent	Valid Percent	Cumulative Percent
.623	1	3.1	3.1	3.1
.647	1	3.1	3.1	6.3
.673	1	3.1	3.1	9.4
.703	1	3.1	3.1	12.5
.714	1	3.1	3.1	15.6
.735	1	3.1	3.1	18.8
.736	1	3.1	3.1	21.9
.750	2	6.3	6.3	28.1
.755	1	3.1	3.1	31.3
.769	1	3.1	3.1	34.4
.779	1	3.1	3.1	37.5
.782	1	3.1	3.1	40.6
.799	1	3.1	3.1	43.8
.800	1	3.1	3.1	46.9
.811	1	3.1	3.1	50.0
.816	1	3.1	3.1	53.1
.818	1	3.1	3.1	56.3
.825	1	3.1	3.1	59.4
.829	2	6.3	6.3	65.6
.832	1	3.1	3.1	68.8
.833	1	3.1	3.1	71.9
.838	1	3.1	3.1	75.0
.839	1	3.1	3.1	78.1
.843	1	3.1	3.1	81.3
.857	1	3.1	3.1	84.4
.865	1	3.1	3.1	87.5
.897	1	3.1	3.1	90.6
.912	1	3.1	3.1	93.8
.929	1	3.1	3.1	96.9
.950	1	3.1	3.1	100.0
Total	32	100.0	100.0	

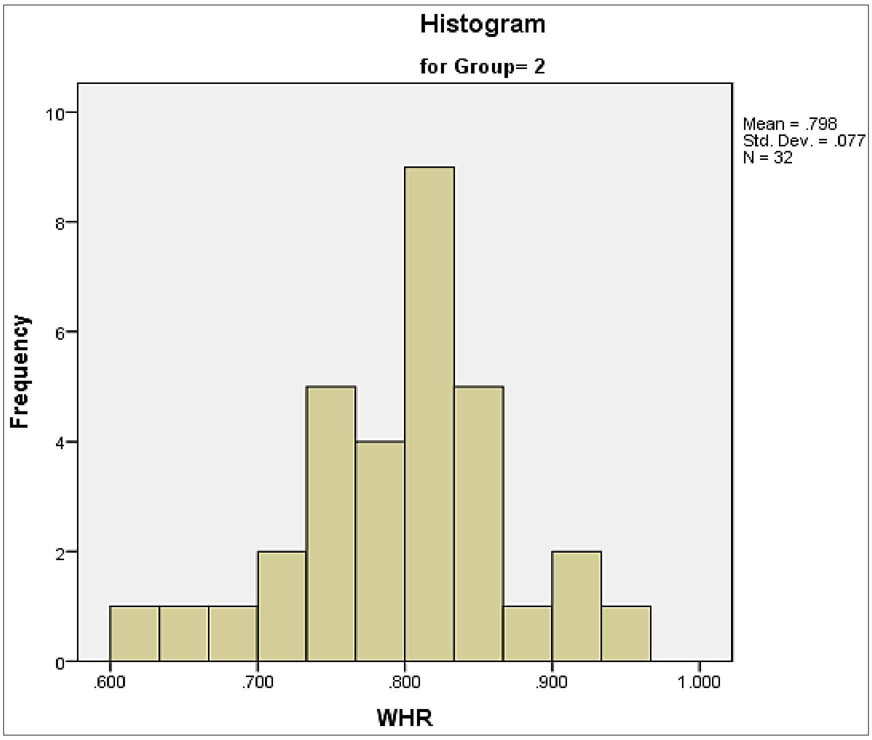

Fig 17: Histogram showing the distribution of the female subjects (denoted by Group=2) according to their WHR values.

Explanation

i) The above histogram shows the frequency of the female subjects with different WHR values.
ii) The mean of the WHR is 0.798 with a standard deviation of 0.077.
iii) N denotes the number of female subjects which is equal to 32.

Results

There is a negative correlation between the WHR and the QTc in young, healthy male subjects but it is not of statistical significance, i.e., with the increase in WHR in male subjects, there is a decrease in the value of QTc in them and vice versa as shown in Tables 11-12.
There is a negative correlation between the WHR and the QTc in young healthy female subjects but it is not of statistical significance, i.e., WHR and QTc values are inversely related as shown in Tables 13-14.
The mean QTc in males is significantly greater than that in female subjects as shown in Tables 15-18.

Discussion

a) Relation between the QTc and the WHR in male subjects

As the number of subjects were 32 males, i.e., less than 50, so, Shapiro Wilk method was used to find the distribution.

Table 11: Tests of Normality

	Group	Shapiro-Wilk
		Sig.
QTc	1	.115
WHR	1	.117

a. Lilliefors Significance Correction

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Since the p values are > 0.05, so, Pearson correlation is used.

Table 12: Pearson Correlation

	QTc
Pearson Correlation	-0.243
WHR Sig. (2-tailed)	0.181

It is found that there is a negative correlation between the QTc and the WHR in case of males and it is statistically insignificant (p>0.05).

b) Relation between the QTc and the WHR in female subjects

As the number of subjects were 32 males, i.e., less than 50, so, Shapiro Wilk method was used to find the distribution.

Table 13: Tests of Normality

	Group	Shapiro-Wilk
		Sig.
QTc	2	.017
WHR	2	.750

a. Lilliefors Significance Correction

Since, the p value in case of the QTc is < 0.05, so, the distribution is not normal. So, the Pearson correlation cannot be used. So, the Spearman's correlation has been used.

Table 14: Spearman's rho correlation

	QTc
Spearman's rho	-0.109
WHR Sig. (2-tailed)	0.554

It is found that there is a negative correlation between the WHR and the QTc in the female subjects and the relation is not statistically significant (p>0.05).

c) Relative QTc in the male and the female subjects

The mean of the QTc in the male and female study groups were determined.

Table 15: Mean of the QTc

Gender	Mean QTc	Standard Error	Standard deviation	Median
Males	0.16994	0.010398	0.058820	0.19200
Females	0 .11838	0.008935	0.050543	0.10450

The mean QTc of the male subjects obtained is greater than that of the female subjects.
Since the number of the subjects was less than 50, so, Shapiro Wilk method was used to test the normality of the study group. In this case, male study group has been denoted as Study group 1 and the female study group has been denoted as Study group 2 and using the latest version of the IBM SPSS software, the normality of the QTc was determined, the result of which has been given below-

Table 16: Tests of Normality

	Group	Shapiro-Wilk
		Sig.
QTc	1	.115
	2	.017

Lilliefors Significance Correction

Since the *p value* of the test in Group 2 is less than 0.05, so log distribution of the QTc has been done and then then the normality was tested by Shapiro Wilk method again.

Table 17: Tests of Normality

	Group	Shapiro-Wilk
		Sig.
QTCLOGN	1	.011
	2	.364

a. Lilliefors Significance Correction

Since in this case, again the p value for the Group 1 is <0.05, so the distribution is not normal. Thus, we have used the Mann-Whitney U test to determine the significance.

Table 18: Test Statistics [a]

	QTc
Mann-Whitney U	262.500
Asymp. Sig. (2-tailed)	.001

a. Grouping Variable: Group

The p value obtained in the Mann-Whitney U is 0.001 which is less than 0.05, so, the result is significant statistically.

d) QTc in the subjects

In our study, we have sought the help of young healthy adults within the age group of 17 and 25 years. All the subjects were chosen randomly, i.e., subjects of all types of body pattern were selected. Since we have excluded subjects with any cardiovascular diseases, so the value of the QTc obtained in each case was far below the upper limit of the QTc being 0.4 seconds that is usually associated with CVD.

e) Influence of the body weight on the WHR

It was also noted that body weight of an individual has very little effect on the QTc. Individuals with same body weights but with different WHR had a great difference in their QTc. Besides, WHR is an authentic parameter of obesity and body weight is not, this is because, it has been found that in two individuals with different body weights, the one with greater body weight may or may not have the greater WHR. In female subjects also we found that the same result, that the body weights of both are same, but their WHR are different widely. Thus, it has proven the authenticity of WHR over body weight in determining the obesity of an individual.

f) Limitations

1) The sample size was considerably small as compared to the sample size of taken in the studies as mentioned in the reference.

2) Perhaps subjects with constant weight but with different WHR would have yielded a better result.
3) It is clear that the QTc is influenced greatly by various subject factors like the mental state of the subject- mental stress, anxiety or calm. The patient's food habit, sleep habit may have influence on the QTc. Even though the room was dimly lit and other parameters were met, but still it is impossible to control one's thoughts and mind.
4) The time period for the study was two months which was actually a short time with respect to the desired sample size for this study.
5) Many subjects fulfilling the inclusion criteria refrained from giving consent and thus the number of subjects obtained was low.

g) Result that was expected

So, in this case we found that the QTc interval was greater in males than in their female counterparts. But this was not expected as in the male subjects, the QTc should be lower because, testosterone has action on shorter ventricular repolarisation. In a study, it was stated that QTc interval was significantly shorter ($p=0.0007$) at higher testosterone levels (common in male subjects). The duration of the action potential, i.e., the duration of the QT interval is mostly affected by the alterations in phase 2 and phase 3 of the action potential curve. In the phase 2, the L-type calcium channels play the dominant role and in phase 3, the delayed rectifier potassium channel currents (consisting of the slowly activating and the rapidly activating channel types) play the important role. Testosterone decreases the calcium channel current and increases the potassium channel current and thus decreases the action potential duration.[1] In female subjects (we had chosen non-menstruating females), estrogen plays an important role. Oestrogen decreases the potassium channel current and thus lengthens the QT interval.

It was expected there would a significant correlation between WHR and QTc in males and females. But the expected result was not obtained.

The probable reason why the correlation is not as expected may be due to the small sample size that we could obtain. Besides, many subjects were eliminated as they were in the exclusion criteria. In a study "Relationship between corrected QT interval and cardiovascular risk factors in young healthy adults: the Kangwha study-Ahn SV[1], Kim HC, Hur NW, Ha KS, Jang HS, Kim JB, Suh I" it was found that there was a strong positive correlation ($P < 0.05$) between the WHR and the QTc in males while there was a strong positive correlation between the QTc and their systolic blood pressure. Perhaps a higher sample size would have yielded better expected result.

h) Probable reason for the negative correlation between the WHR and QTc in males and females

1. With increase in WHR, there is increase in obesity. Thus, there is increased cardiac workload and increased demand of oxygen and nutrients to the tissues. Besides, there is a strong necessity for the removal of the waste products. This causes increased heart rate which causes quick depolarisation followed by quick repolarisation. This in turn causes QT shortening.
2. Increased WHR, i.e., increased obesity causes decreased blood supply to the cardiac muscles due to the narrowing of the coronary blood vessels. Thus, this leads to ventricular remodelling. This leads to increased depolarisation and repolarisation within a certain period of time. This causes the shortening of the QTc.

i) Future complications

The subjects which we had selected were within the age group of 17-25years. These subjects comprised of both the obese, the thin as well as the subjects with fit physique. But among them the subjects who are obese, have gained weight only recently and thus have no complications. But, perhaps in the near future there would be such complications which would lead to the situation where the WHR and QTc would vary together. This may be because, any subject who has become obese only recently, there would increase in the body weight and thus, the individual would require more energy for any activity. Thus, there is a need for increased oxygen, nutrients and there is also increased necessity for removal of the waste products generated during the process. This would lead to increased cardiac output and increased heart rate, i.e., increased chronotropy. This would lead to shortening of the QT value.

Next, increased obesity causes decreased blood supply to the cardiac muscles due to the narrowing of the coronary blood vessels.

Thus, this would lead to ventricular remodelling as a compensatory measure. This would lead to increased depolarisation and repolarisation within a certain period of time. This would cause the shortening of the QTc. (Chart No.1)

But in the long run, due to increased musculature of the ventricles, there is increased demand of oxygen and nutrients and there is narrowing of the coronary blood vessels. This amounts to severe problem of coronary insufficiency. Thus there is decreased cardiac output and heart rate, i.e., decreased chronotropy as well as inotropy. Due, to decreased chronotropy, there is a prolongation in QT value because of the widening of the QRS complex. Besides, due to decreased inotropy, there is decreased height of the R wave. All this would lead to prolongation in the QT value. In this situation, there is increase in QTc with increase in WHR. But, this may happen only on chronic suffering. (Chart No.2)

Acute condition

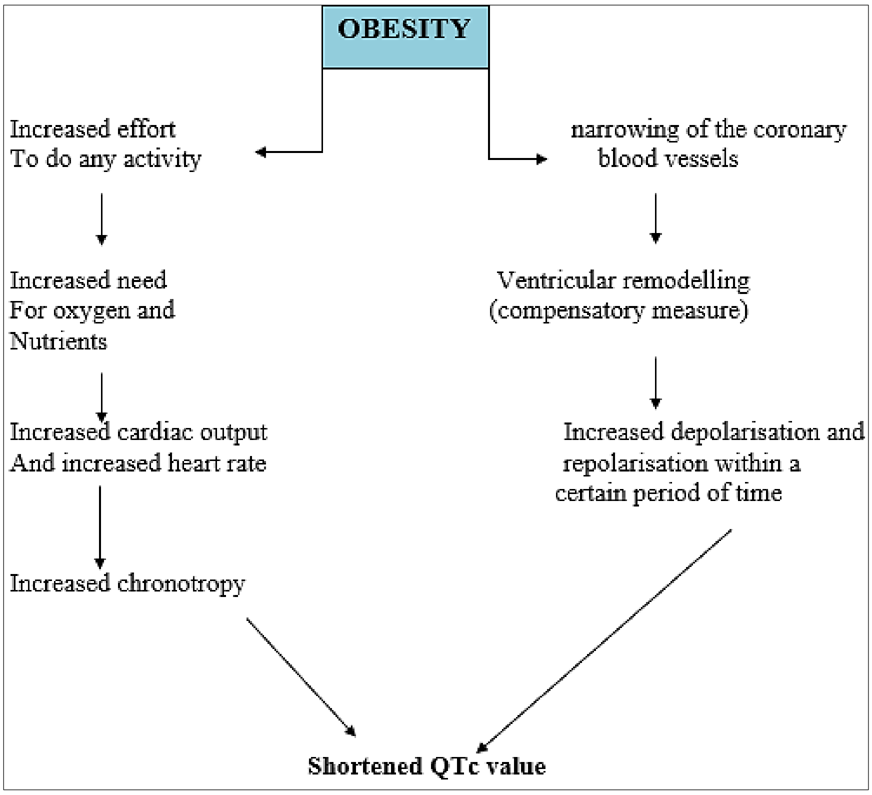

Chart 1: Chart showing the possible relation between the WHR (obesity) and QTc value in acute conditions

Chronic condition

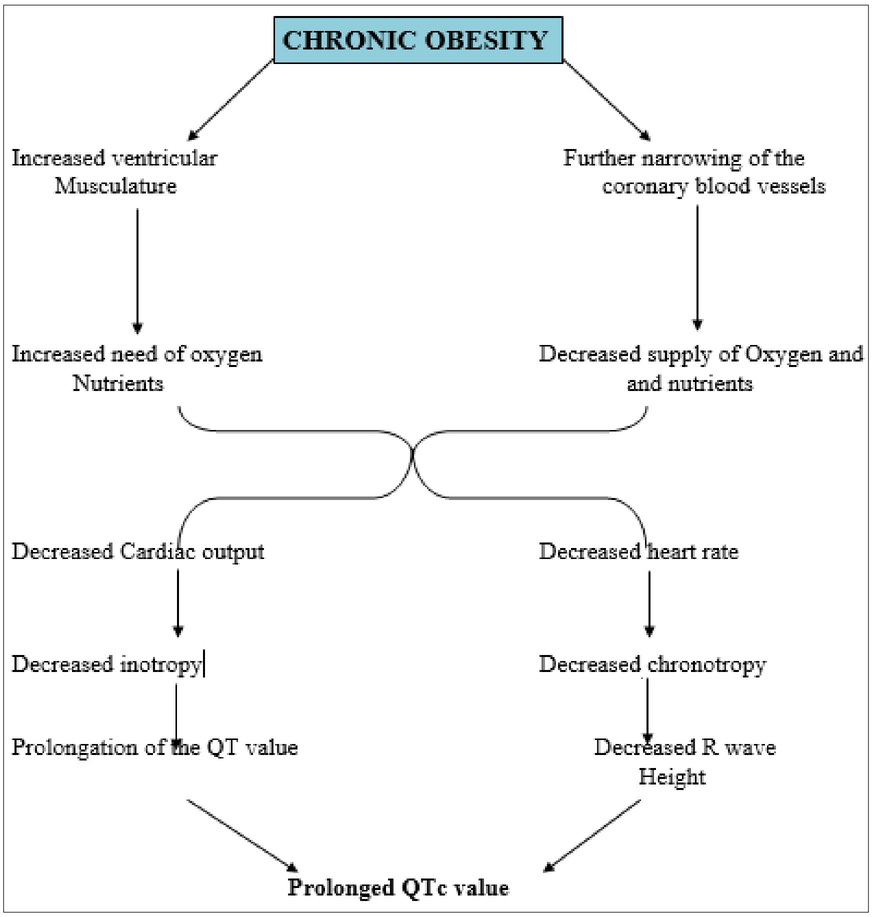

Chart 2: Chart showing the possible relation between the WHR (Obesity) and QTc value in chronic obesity cases

Summary

Purpose of the study: To determine the correlation between the WHR and QTc in male and female subjects and also to compare the QTc interval between male and female young healthy adults.

Brief Description: The WHR and the QTc of the subjects (32 male and 32 female subjects) were obtained and their correlation and significance of them were analysed using IBM SPSS.

Results

i) In males, the WHR and QTc are negatively related (r= - 0.243) and it is statistically not significant. (p= 0.181).
ii) In females, the WHR and QTc are negatively related (r= - 0.109) and it is statistically not significant. (p= 0.554).
iii) The mean QTc is significantly greater in males than that in females. (p= 0.001).

Since the result obtained is not similar to that expected, the question arises whether the apprehended result could be obtained with a larger sample size in both the study groups. If the study was conducted by keeping all the other parameters, other than the WHR and QTc constant, then, the result would have been otherwise.

Conflict of Interest: None.

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