

# Ventricular repolarization in overweight and normal weight healthy young men

*Kilolu ve normal kilolu olan sağlıklı genç erkeklerde ventriküler repolarizasyon*

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## ABSTRACT

**Objective:** The effects of body mass index (BMI) on ventricular repolarization in young men have not been studied in detail. The QT and JT intervals are measured to estimate the duration of the ventricular repolarization. As new repolarization parameters, the time intervals between the J point to the apex of the T wave (JTa), the apex and the end of T wave (TaTe) may be associated with arrhythmogenesis in clinical conditions. The aim of this study was to compare ventricular repolarization parameters in overweight and normal weight healthy young men.

**Methods:** Thirty-six overweight men (BMI -  $26.3 \pm 1.5$  kg/m<sup>2</sup>, mean age -  $20.6 \pm 1.5$  years) and 149 men within normal limits (BMI -  $21.9 \pm 1.5$  kg/m<sup>2</sup>, mean age -  $20.4 \pm 1.4$  yrs) were included in this cross-sectional controlled study. The body mass index of 25 to 29.9 kg/m<sup>2</sup> was defined as overweight and scores of 18.5 to 24.9 kg/m<sup>2</sup> were accepted as normal. Ventricular repolarization parameters including QT, JT, JTa, TaTe, RR intervals duration and heart rate-corrected values of QT (QTc), JT (JTc), JTa (JTac), and TaTe (TaTec) intervals duration were obtained from lead V<sub>2</sub> and considered to be representative of the ventricular repolarization process.

**Results:** We found similar ventricular repolarization parameters (QT, JT, JTa, TaTe, RR, QTc, JTc, JTac, and TaTec) in overweight and normal groups. Uncorrected and corrected ventricular repolarization parameters were not correlated with BMI.

**Conclusion:** Ventricular repolarization features in young men who are overweight in terms of BMI seem to show no significant difference when compared to normal weight men. (*Anadolu Kardiyol Derg 2008; 8: 27-31*)

**Key words:** Ventricular repolarization, overweight, body mass index, QT interval, arrhythmia

## ÖZET

**Amaç:** Sağlıklı gençlerde beden kitle indeksinin (BKI) ventriküler repolarizasyona etkisi ayrıntılı olarak çalışılmış değildir. Ventriküler repolarizasyon süresinin değerlendirilmesinde, QT ve JT intervali ölçülmektedir. J noktasından T dalgası tepesine kadar (JTa) ve T dalgası tepesiyle T dalgası sonu (TaTe) klinik koşullarda aritmi oluşumu ile ilişkili olabilir. Bu çalışmanın amacı, kilolu ve normal kilolu sağlıklı genç erkeklerde ventriküler repolarizasyon parametrelerini karşılaştırmaktır.

**Yöntemler:** Bu kesitsel, kontrollü çalışmaya, kilolu otuz altı (BKI  $26.3 \pm 1.5$  kg/m<sup>2</sup>, ortalama yaş -  $20.6 \pm 1.5$  yıl) ve normal ağırlıktaki (BKI -  $21.9 \pm 1.5$  kg/m<sup>2</sup>, ortalama yaş -  $20.4 \pm 1.4$  yıl) 149 erkek katıldı. Beden kitle indeksi 25-29.9 kg/m<sup>2</sup> arası olanlar kilolu ve 18.5-24.9 kg/m<sup>2</sup> arası olanlar normal kabul edildi. Ventriküler repolarizasyon sürecinin göstergesi olduğu düşünülen QT, JT, JTa, TaTe, RR ve kalp hızına göre düzeltilmiş değerler (QT için QTc, JT için JTc, JTa için JTac, ve TaTe için TaTec) V<sub>2</sub> derivasyonundan hesaplandı.

**Bulgular:** Kilolu ve normal gruplar arasında ventriküler repolarizasyon parametrelerinin (QT, JT, JTa, TaTe, RR, QTc, JTc, JTac, ve TaTec) benzer olduğunu saptadık. Kalp hızına göre düzeltilmemiş ve düzeltilmiş ventriküler repolarizasyon parametreleri beden kitle indeksi ile korelasyon göstermedi.

**Sonuç:** Beden kitle indeksi açısından kilolu sınıfta olan genç erkeklerin ventriküler repolarizasyon özellikleri, normal kilolu erkeklerden anlamlı farklılık göstermemektedir. (*Anadolu Kardiyol Derg 2008; 8: 27-31*)

**Anahtar kelimeler:** Ventriküler repolarizasyon, kiloluluk, beden kitle indeksi, QT aralığı, aritmi

## Introduction

The importance of the changes in ventricular repolarization in ventricular arrhythmias and sudden death is clearly determined (1). QT interval is a traditional electrocardiographic parameter for evaluation of ventricular repolarization. Within the last decade,

various new parameters have been used to evaluate ventricular repolarization. JT interval rather than QT interval is measured to estimate the duration of repolarization (2). It is generally accepted that ventricular myocardium is composed of epicardium layer, mid-myocardial M cells and endocardium layer. These cells and layers differ from each other by their repolarization properties (3).

M cells have longer action potential than the both epicardial and endocardial myocytes thus these cells permit more efficient contractions (4). The delayed repolarization of M cells may be responsible for the genesis of transmural voltage gradient during ventricular repolarization. The time interval between the apex and end of T wave (TaTe) represents transmural dispersion of repolarization across the ventricular wall (5). It has been suggested that TaTe may be associated with arrhythmogenesis in clinical conditions like long QT syndrome (6). Additionally, the interval from J point to the apex of the T wave (JTa) represents repolarization of epicardium in which the transmural voltage gradient reaches the maximal level.

Recently, increased frequency in cardiovascular events was observed in young population (7). The reason for increasing incidence of cardiovascular events is not known. It has not been clearly determined whether ventricular repolarization parameters differ between the young who have normal body mass index (BMI) and the young who are in overweight BMI class. World Health Organization estimates that there are about 180 million obese adults, and at least twice as many adults who are overweight, with a BMI of 25.0 to 29.9 (8). As much as 31% of the adult population is overweight in Turkey (9). This ratio is 64% for the adult US population (10). Additionally, the increased prevalence of overweight children and adolescents in US were demonstrated between 1999 and 2004 (10, 11). A previous study demonstrated that underweight (BMI<18.5) and obesity (BMI $\geq$ 30) during middle-age period (age of 50 years) were associated with the risk of death relative to the normal weight category (12). However, it was reported that overweight was not associated with excess mortality (12).

The aim of the present study was to investigate the ventricular repolarization parameters including QT, JT, JTa, TaTe, RR intervals duration and their heart rate-corrected values of QTc, JTc, JTac, and TaTec in overweight and normal weight healthy young male subjects.

## Methods

Thirty-six overweight (BMI- $26.3\pm 1.5$  kg/m<sup>2</sup>, mean age-  $20.6\pm 1.5$  years) and 149 normal weight (BMI -  $21.9\pm 1.5$  kg/m<sup>2</sup>, mean age -  $20.4\pm 1.4$  years) male students from Trakya University Medical Faculty participated voluntarily in this cross-sectional controlled study. The ages of all subjects ranged from 18 to 24 years.

We planned sample size of this study assuming higher mean difference value for QTc interval than in the other study (13). In order to detect a difference in QTc interval of 37 ms between groups, and common standard deviation of 55 ms, type I error of 5% and power of the study of 80%, the minimum sample size for each group was calculated as 36 subjects. We examined 36 overweight and 149 normal weight subjects.

The study was approved by the local ethics committee of Trakya University. The details of the study were explained to each subject and oral informed consent was obtained from the participants.

Participants underwent a comprehensive physical examination. Participants were excluded from the study if they had any conduction diseases (bundle branch block, bradycardia), took any drugs that might cause QT prolongation, had any family history of sudden death or any personal history of hypertension, diabetes or syncope.

All subjects were non-smokers. Blood pressures of all were within normal limits. No subjects declared any illnesses. The amounts of the training in a week were asked. All subjects had sedentary lifestyle and performed exercise no more than 1.5 hours in a week (14).

Height and weight of the participants were measured just before the electrocardiogram (ECG) recording. Height was measured without shoes. Weight was measured while the participants were wearing their underclothing. Body mass index was calculated by dividing weight in kilograms by the square of the height in meters and BMI of 25 to 29.9 was defined as overweight and scores of 18.5 to 24.9 were accepted as normal.

Standard 12-lead ECG was recorded (Cardioline Delta 1 Plus, Bologna, Italy) while the subjects resting in supine position. Paper speed of the ECG was 25 mm/sec and gain was 10 mm/mV. All the recordings were performed by the same investigator (AV). Ventricular repolarization parameters in lead V<sub>2</sub> were calculated from the data obtained from ECG. This lead was selected due to easy determination of end of the T-wave. The end of the T wave also was defined as the visual return to the TP baseline while excluding the U wave as performed in previous studies (15, 16). Measurements were obtained by the second investigator (LO). In order to improve the accuracy of the measurements calipers and magnifying lens were used. The QT interval was measured from the onset of the QRS complex to the end of the T wave. When U waves were present, the QT was defined as the nadir between T and U waves. The JT interval was also measured from the end of the QRS complex (J point) to the end of the T wave. The interval between the J-point and the apex of the T wave (JT<sub>a</sub>) was measured (Fig. 1). The TaTe interval was calculated as the difference between JT and JT<sub>a</sub> intervals.

The reproducibility of the measurements was tested by repeated measurements of 20 randomly selected ECGs from the

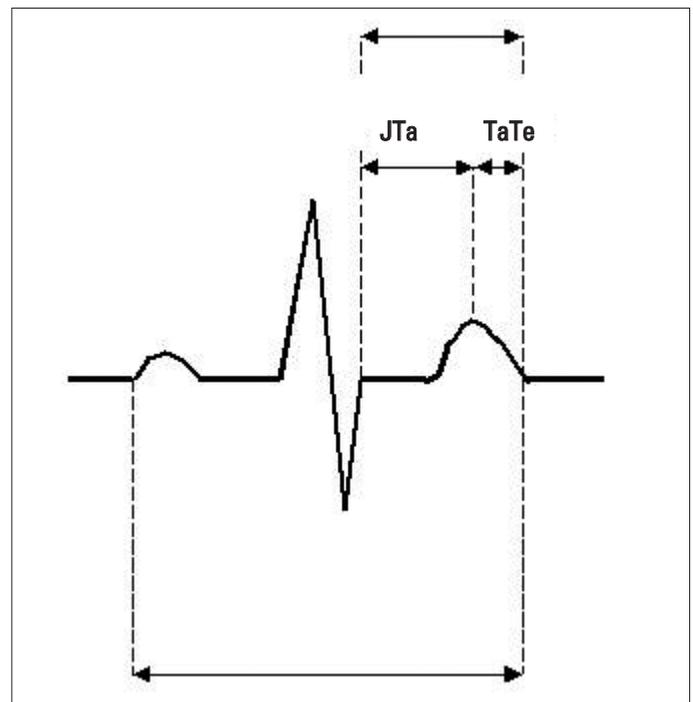


Figure 1. The key for measurements of the electrocardiographic intervals

participants of the present study. Intraclass correlation coefficient for JT, JTa, RR, QRS durations were 0.85, 0.93, 0.97 and 0.64 ms, respectively.

Heart rate-corrected QT, JT, JTa and TaTe intervals were calculated using the formula of Bazett (17). Generally accepted upper limit of normal for the Bazett QTc interval is 0.44 second. QTc interval was considered prolonged when the value calculated using the Bazett formula was >0.44 second.

**Statistical Analysis**

Statistica Axa 7.0 (Tulsa, Oklahoma-USA) statistical software package was used for statistical analyses. Statistical comparisons between overweight and normal groups were made using unpaired Student’s t-test for normally distributed variables. For non-normally distributed variables (V2QRS, V2JT, V2JTa, V2TaTe), non-parametric comparisons were made using the Mann–Whitney U test. Individuals having abnormal Bazett QTc values in overweight and normal-weight groups were compared by Chi-square test. Spearman’s correlation coefficient was used to test the relationship between ventricular repolarization parameters and BMI. A probability (P) value of less than 0.05 was considered statistically significant. Data are presented as mean±SD.

**Table 1. Demographic and anthropometric characteristics of subjects**

Characteristics	Overweight	Normal	p*
Age, years	20.6±1.5	20.4±1.4	0.550
Weight, kg	81.3±8.0	68.8±6.7	<0.001
Height, cm	175.5±6.7	176.9±6.5	0.253
BMI, kg/m <sup>2</sup>	26.3±1.5	21.9±1.5	<0.001
Heart rate, beats/min	76.6±15.6	76.9±14.8	0.844

Values are expressed as mean±SD  
\* - Unpaired Student’s t-test  
BMI - body mass index, NS - not significant

**Results**

Demographic variables of the subjects are shown in Table 1. Totally 185 ECG measurements were reviewed and analyzed. Thirty-six of these were grouped as overweight men’s ECG and 149 were normal-weight men’s ECG. Table 2 shows the mean values of selected ventricular repolarization parameters of both groups. Electrocardiographic parameters (V2QT, V2QTc, V2JT, V2JTc, V2JTa, V2JTac, V2TaTe, V2TaTec, V2RR, and V2QRS) were not found statistically different between the two groups (p>0.05 for all). Abnormal Bazett QTc intervals were observed in 8.3% (3 of 36) and 8.1% (12 of 149) of overweight and normal subjects, respectively (p>0.05). There were no significant correlations between the V2QTc, V2JTac, V2TaTec durations and BMI (Figures 2-4).

**Discussion**

In this study we focused on the differences in ventricular repolarization between overweight with a BMI of 25 to 29.9 and normal weight young men. Our findings demonstrated that QT and heart-rate corrected QT intervals were similar in overweight and normal weight men. Additionally, JTa, TaTe, JTac and TaTec durations did not differ between normal weight and overweight groups.

Previous studies investigated QT and QTc durations as the indices of ventricular repolarization in obese subjects (18-26). To our knowledge, this is the only study that investigated ventricular repolarization by using JTa, TaTe, JTac and TaTec durations in addition to QT and QTc durations in healthy overweight subjects.

It is generally accepted that ventricular myocardium is composed of at least three electrophysiologically distinct types as epicardium, deep subendocardial layer (M cells), and endocardium (3). Recently, JTa, TaTe, JTac and TaTec intervals as aspects of transmural dispersion of repolarization have drawn attention in epicardium, M cells, and endocardium layers (27). Thus, we added

**Table 2. Ventricular repolarization parameters in overweight (25 ≤ BMI < 30 kg/m<sup>2</sup>) and normal (18.5 < BMI ≤ 24.9 kg/m<sup>2</sup>) groups**

ECG parameters	Groups	Mean±SD	Median (Confidence Interval)	p*
V2QT, ms	Overweight	353.2±25.0	360.0 (344 – 361)	0.631
	Normal	356.2±35.5	356.0 (350 – 362)	
V2QTc, ms	Overweight	396.9±35.7	397.5 (384 – 409)	0.849
	Normal	398.2±37.6	399.0 (392 – 404)	
V2JT, ms	Overweight	261.5±23.7	260.0 (253 – 269)	0.863
	Normal	261.8±32.6	260.0 (256 – 267)	
V2JTc, ms	Overweight	293.9±31.5	290.9 (283 – 304)	0.823
	Normal	292.5±34.1	297.0 (287 – 298)	
V2JTa, ms	Overweight	167.2±18.5	160.0 (160 – 173)	0.629
	Normal	164.9±25.5	168.0 (160 – 169)	
V2JTac, ms	Overweight	187.4±19.4	183.5 (180 – 194)	0.417
	Normal	183.9±24.4	184.6 (179 – 187)	
V2TaTe, ms	Overweight	94.3±21.3	96.0 (87 – 101)	0.690
	Normal	95.8±25.5	92.0 (91 – 100)	
V2TaTec, ms	Overweight	106.4±25.9	106.6 (97 – 115)	0.859
	Normal	107.4±29.4	107.8 (102 – 112)	
V2RR, ms	Overweight	809.3±162.7	800.0 (754 – 864)	0.844
	Normal	815.3±164.6	800.0 (788 – 841)	

\* - Mann–Whitney U test

V2JT- mean JT interval; V2JTc- mean Bazett’s heart rate-corrected JT interval; V2JTa -mean JT interval between J point and peak of T wave; V2JTac- mean Bazett’s heart rate-corrected JTa interval; V2QT-mean QT interval; V2QTc- mean Bazett’s heart rate-corrected QT interval; V2TaTe - mean JT interval between peak of T wave and offset of T wave; V2TaTec- mean Bazett’s heart rate-corrected TaTe interval

these parameters to evaluate transmural dispersion of repolarization in our study. Similar JTa, TaTe, JTac and TaTec durations in both groups suggest that transmural dispersion of repolarization was not different in epicardium, M cells, and endocardium layers.

We are aware that ECG parameters we used are indirect measures of repolarization. Several other methods have also been used to demonstrate the abnormalities of ventricular repolarization from surface electrocardiogram such as QT dispersion, JT dispersion, T wave loop descriptions or T wave morphology dispersion (28). However, none of these methods is a direct assessment. It was stated that ECG based methods for the assessment of repolarization dynamics are either simplistic or significantly important (28).

In previous studies, the association between the duration of QTc interval and body weight has been widely recognized with different conclusions (15, 18-21, 23-26). The subjects that were examined in these studies were mostly obese (BMI >30) (18-20, 24-26, 29). However, the information on repolarization features in overweight (i.e. BMI = 25-29.9) subjects is limited (15, 21). For example, Nomura et al. (15) compared the ECG values of normal weight, overweight and obese coronary artery disease patients (average age 58 years) and no significant QT duration differences were observed between overweight and normal-weight coronary artery disease patients. In another study, that included school-aged (12-13 years old and 6-7 years old) children, no correlation was observed between BMI and the length of QT interval (21). Considering the studies reported no relation between repolarization and obesity, our study reported the results of overweight young adults, thus filling the gap of knowledge on the issue between school age children and elderly.

Many studies, however, reported significant association between the duration of QT interval and BMI (18-20, 24-26, 29), which showed that increase in relative body mass and fatness were accompanied by significant lengthening of the QTc interval. However, overweight subjects with a BMI lower than 30 kg/m<sup>2</sup> did not participate in these studies (18-20, 24-26, 29). Our study population is comprised of overweight and normal weight men.

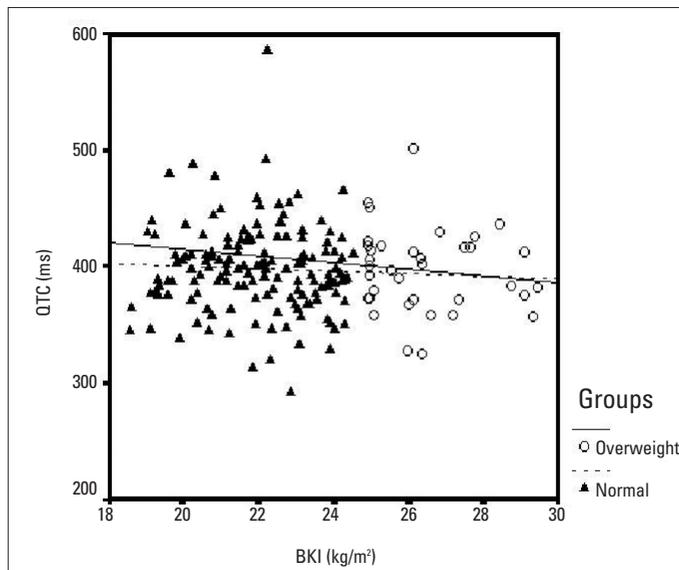


Figure 2. QTc interval on the ordinate versus body mass index (BMI) on the abscissa in normal and overweight groups (Spearman correlation,  $p=0.791$   $r=-0.019$ )

Our results showed that QTc interval duration in men who are overweight were not significantly different those of normal weight men.

Several putative mechanisms were suggested as responsible for the effect of BMI on the duration of QT interval. Autonomic dysfunction or imbalance may be one of the factors. Peterson et al. (31) observed depressed autonomic outflow in heart in obese subjects. Furthermore, Rossi et al. (32) reported cardiac autonomic dysfunction and reduced vagal tone in obese subjects. Other mechanisms may include functional and structural changes of the heart (33). However, no such studies were performed in overweight subjects. Considering the same mechanisms, we may interpret the results of our study as BMI of overweight is not sufficient enough to cause QT alterations in young population.

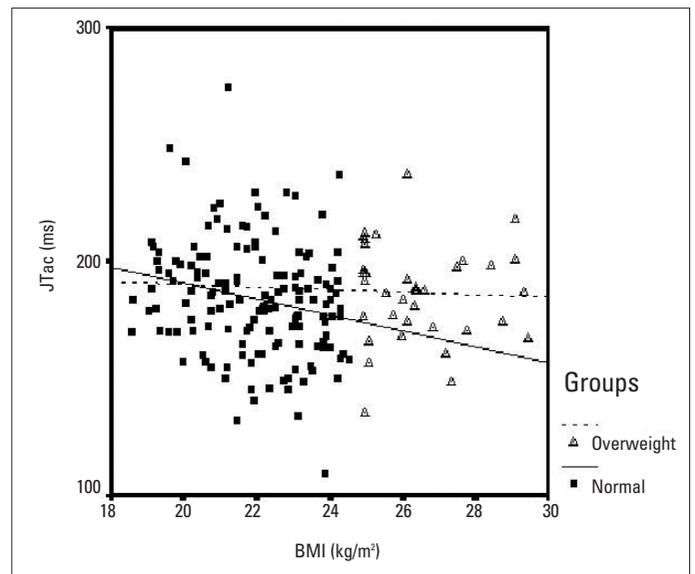


Figure 3. JTac interval on the ordinate versus body mass index (BMI) on the abscissa in normal and overweight groups (Spearman correlation,  $p=0.721$   $r=-0.260$ )

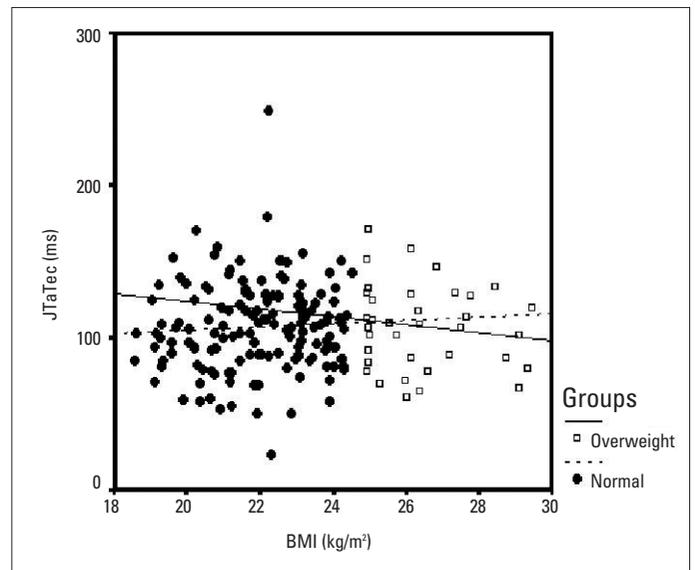


Figure 4. JTaTec interval on the ordinate versus body mass index (BMI) on the abscissa in normal and overweight groups (Spearman correlation,  $p=0.850$   $r=0.014$ )

### Limitations of the study

The main limitations of this study were that waist circumference, waist to hip ratio, fat mass and blood lipid profile of the participants were not measured. Thus, we could not evaluate whether our participants have central or visceral type obesity. Recently, central or visceral type obesity has been accepted as a predisposing factor for the development of cardiovascular disease, hypertension and type 2 diabetes mellitus relatively in young ages (34). Adding these parameters would increase the validity of this study. Secondly, another group of obese or severely obese young adults might add more specific value to the evaluation of these new parameters of ventricular repolarization. Additionally, this preliminary study may not be applicable to the general population as it was a very selected group that was studied i.e. medical students.

### Conclusion

The results of the present study demonstrate that ventricular repolarization parameters do not differ between men who are in overweight BMI class and the normal weight men in young age group. Overweight does not seem significantly affect ventricular repolarization in the absence of obesity.

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