Research Article / Araştırma Makalesi

The Relationship Between Body Mass Index And Index of Cardiac Electrophisiological Balance

Vücut Kitle İndeksi ile Kardiyak Elektrofizyolojik Denge İndeksi Arasındaki İlişki

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Abstract

Background: The relationship between obesity and changes in electrocardiographic wave duration were demonstrated previously. The aim of our study was to examine the relationship between body mass index (BMI) and index of cardiac electrophysiological balance (ICEB)/corrected index of cardiac electrophysiological balance (ICEBc).
Materials and Methods: A total of 353 consecutive patients with no comorbidities other than obesity admitted to an outpatient cardiology clinic between September and November 2023 were enrolled in the study. The patients were divided into 5 groups according to their BMI as follows: BMI <20 kg/m^2 was defined as group 1, BMI 20–24.99 kg/m^2 as group 2, BMI 25–29.99 kg/m^2 as group 3, BMI 30–39.99 kg/m^2 as group 4 and BMI >40 kg/m^2 as group 5. Electrocardiographic parameters ICEB/ICEBc levels were compared among the groups.
Results: The mean age of the participants was 32.6±10.61 years, and 199 (56.4%) were female. The mean ICEB values of groups were 4.36±0.53, 4.17±0.53, 4.04±0.52, 4.27±0.55 and 4.18±0.47, respectively and there was a significant difference among the groups (p=0.014). In addition, the mean ICEBc values were 5.03±0.69, 4.81±0.63, 4.6±0.56, 5.05±0.68, and 5.05±0.52, respectively and there was a significant difference among the groups (p<0.001). It was found that low and high BMI groups were associated with a significant increase in ICEB and ICEBc values in the subgroup analyses.
Conclusions: As a result of our study, it was observed that low and high BMI values may be associated with an increase in ICEB and ICEBc values. It should be kept in mind that ICEB and ICEBc values may be high in cardiac evaluation in relatively thin and obese individuals.

Keywords: Body mass index, Index of cardiac electrophysiological balance, Electrocardiography

Öz

Amaç: Obezite ile elektrokardiyografik dalga sürelerindeki değişiklikler arasındaki ilişki daha önce gösterilmiştir. Çalışmamızın amacı, vücut kitle indeksi (VKİ) ile kardiyak elektrofizyolojik denge indeksi (ICEB)/düzeltilmiş kardiyak elektrofizyolojik denge indeksi (ICEBc) arasındaki ilişkiyi incelemektir.
Materyal ve Metod: Eylül-Kasım 2023 tarihleri arasında obezite dışında ek hastalığı olmayan toplam 353 kişi (199 kadın, 154 erkek, ortalama yaş 32,6 ± 10,611 yıl) çalışmamıza ardışık olarak dâhil edildi. Tüm hastalar VKİ'ye göre 5 gruba ayrıldı. VKI<20 kg/m^2 olan katılımcılar grup 1, VKİ 20-24,99 kg/m^2 olanlar grup 2, VKİ 25-29,99 kg/m^2 olanlar grup 3, VKİ 30-39,99 kg/m^2 olanlar grup 4 ve VKİ>40 kg/m^2 olanlar ise grup 5 olarak tanımlandı. Gruplar arasında elektrokardiyografik parametreler ICEB/ICEBc düzeyleri karşılaştırıldı.
Bulgular: Çalışmaya dahil edilen hastaların yaş ortalaması 32.6±10.6 idi ve 199'u (%56,4) kadın idi. Grupların ortalama ICEB'i sırasıyla 4.36±0.53, 4.17±0.53, 4.04±0.52, 4.27±0.55 ve 4.18±0.47 idi ve gruplar arasında anlamlı farklılık mevcuttu (p=0.014). Benzer şekilde grupların ICEBc değerleri sırasıyla 5.03±0.69, 4.81±0.63, 4.6±0.56, 5.05±0.68 ve 5.05±0.52 idi ve gruplar arasında anlamlı bir farklılık vardı (p<0.001). Yapılan subgurup analizlerinde; düşük ve yüksek VKİ guruplarının ICEB ve ICEBc değerlerinde anlamlı artışla ilişkisi olduğu görüldü.
Sonuç: Çalışmamız sonucunda düşük ve yüksek VKİ değerlerinin ICEB ve ICEBc değerlerinde artışla ilişkisinin olabileceği görüldü. Nispeten zayıf ve obez bireylerin kardiyak değerlendirmesinde ICEB ve ICEBc değerlerinin yüksek olabileceği akılda bulundurulmalıdır.

Anahtar Kelimeler: Vücut kitle indeksi, Kardiyak elektrofizyolojik denge indeksi, Elektrokardiyografi

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Introduction

Obesity is a major public health concern that is increasing globally. In 2016, an estimated 39% of people over the age of 18 were overweight worldwide, and 13% were obese. Numerous comorbidities, including dyslipidemia, coronary artery disease, hypertension (HT), obstructive sleep apnea syndromes, and type 2 diabetes mellitus (DM), are intimately linked to obesity (1, 2).

According to the Framingham Heart Study, obesity alone is a powerful predictor of sudden cardiac death (SCD) (3). Ventricular arrhythmias, which cause SCD, are a global concern and affect not only people with obesity but also those with other heart-related disorders. Identifying individuals who are particularly vulnerable to ventricular arrhythmias is a crucial aspect of cardiology. Malignant arrhythmias in people with obesity can arise for a variety of reasons, including hypertrophy, fibrosis, cardiomyopathy, cardiac remodeling, an elevated inflammatory response, and neurohormonal activation (4). Moreover, sluggish electrical current conduction caused by fat infiltration in the heart can result in ventricular arrhythmias (5). Determining plausible objective indicators for these fatal arrhythmias is therefore imperative. Surface electrocardiography (ECG) is currently a widely available, easy-to-use instrument for this purpose. The complicated electrical phenomena known as ventricular repolarization (VR) have been linked to an increased risk of ventricular arrhythmias in a number of clinical contexts (6).

Many preventive therapies, such implantable cardioverter defibrillators and anti-arrhythmic medications, aimed at reducing the likelihood of SCD rely on the identification of high-risk individuals. The risk of ventricular arrhythmia is assessed using a variety of ECG measures, namely, the intervals from the peak to the end of the T-wave, the corrected QT (QTc) interval, and the QT dispersion. Notwithstanding its usefulness in predicting ventricular arrhythmias, the primary constraint of QT length is its dependence on heart rate.

The index of cardiac electrophysiological balance (ICEB), which defined as the QT/QRS ratio measured using the surface ECG, is a novel electrocardiographic marker and can be used to predict ventricular arrhythmias. (7). It has been proposed that the ICEB represents the ultimate depiction of the balance between cardiac repolarization and depolarization and is a surrogate marker of cardiac wavelength (λ), where λ = effective refractory period conduction velocity (7). For this reason, some ventricular arrhythmic events are associated with either increased or reduced ICEB levels. ICEB is one example of a novel depolarizaton–repolarization marker that incorporates λ (8-12). While only the cardiac action potential repolarization phase is calculated with the QT interval, ICEB is used to calculate the action potentials of the cardiac repolarization and depolarization phases. As a result, ICEB is more accurate than the QT parameter in estimating the probability of cardiac arrhythmia (7). According to recent research, an increased ICEB may be a reliable indicator of the onset of ventricular arrhythmias even in the absence of cardiac involvement (13) and malignant ventricular arrhythmia was found to be associated with high ICEB levels (14). The main benefits of ICEB/ICEBc measurements are its noninvasiveness, affordability, and usefulness.

In our study, we aimed to investigate whether obesity alone has an effect on ICEB/ICEBc values.

Materials and Methods

Study population

This study was conducted retrospectively at a single tertiary healthcare center. A total of 353 consecutive patients with no comorbidities other than obesity who had been admitted to our institution's cardiology outpatient clinic with nonspecific symptoms between September and November 2023 were enrolled in the study. The hospital records were scanned retrospectively. The patients were divided into 5 groups according to their body mass index (BMI). The BMI was calculated as the body mass divided by the square of the body height. The participants with a BMI <20 kg/m^2 were categorized in group 1, those with a BMI of 20–24.99 kg/m^2 were allocated to group 2, with a BMI of 25–29.99 kg/m^2 in the group 3, those with a BMI of 30–39.99 kg/m^2 in group 4 and the participants with a BMI >40 kg/m^2 made up group 5.

The participants' ECG recordings and clinical and demographic data were obtained from their medical records. None of the research participants had ever had a serious clinical issue. Each participant underwent a thorough physical examination as well as an echocardiogram and an ECG analysis to determine any potential heart conditions. The study's exclusion criteria were a history of acute infections, endocrine abnormalities, chronic medication usage, chronic renal injury, DM, hypertension, cerebrovascular disease, and chronic inflammatory disease. Every participant had sinus rhythm. The formula for calculating BMI was weight in kilograms divided by height in meters squared. The protocol of the study (549/13.10.2023) was accepted by our institutional ethics committee and conformed with the standard set of guidelines in the Declaration of Helsinki.

Electrocardiography and Echocardiography

The ECG equipment (SCHILLER CARDIOVIT AT-102 G2, Feldkirchen, Germany) was calibrated at a rate of 25 mm/s and a gain of 10 mm/mV. Two cardiologists, who were blinded to the participants' clinical data examined the ECG results. Sinus rhythm was seen in every instance. After examining each sample digitally, measurements were taken using specialized software (Adobe Photoshop, version 19.1.9, T) to achieve the required magnification. The mean of three measurements was obtained for each lead. We analyzed heart rate, P duration, PR interval, QRS duration, QT inter-

val, QTc interval, ICEB, and ICEBc. Traditionally, the QT interval is measured manually starting from the QRS complex commencement and ending at the T wave and isoelectric line crossing point. In this study, the QT interval was calculated to the lowest point on the curve connecting the T and U waves in the event of a U wave. The Bazett formula (QTc = QT/VRR) was used to measure the QTc interval. The ICEB was ascertained using the QT/QRS ratio, and the ICEBc was determined using the QTc/QRS ratio. Two cardiologists obtained transthoracic echocardiographic pictures using a GE Vivid 5 ultrasound machine (5-1 MHz multifrequency probe, GE Medical Systems, Milwaukee, USA) in compliance with current European and American recommendations (15) and by following established protocols.

Statistical Analysis

The data analysis was performed using SPSS version 24.0. We presented the categorical variables as numbers and percentages, whereas the continuous variables were expressed as mean ± SD. To determine the distribution of the variables, we used the Kolmogorov–Smirnov test. One-way ANOVA was conducted to analyze the continuous variables with a normally distributed distribution, and the Kruskal–Wallis test was applied to analyze the continuous variables with non-normal distributions in more than two groups. The Mann-Whitney U test or Student t-test was used for comparisons of continuous variables between two groups. Chi-square tests were used to analyze the categorical parameters. Univariable and multivariable logistic regression analysis were performed to investigate ICEB and ICEBc predictors. Parameters with p<0.05 in univariable logistic regression analysis were included in multivariable logistic regression analysis. While performing logistic regression analyses, patients were grouped according to the median values of the ICEB and ICEBc values (4.16 and 4.86, respectively). Pearson od Spearman correlation coefficients were used for correlation analysis. P-values <0.05 were considered statistically significant.

Results

Our study included 353 patients: 34 in group 1, 98 in group 2, 82 in group 3, 63 in group 4, and 76 in group 5. The mean age of the study population was 32.6±10.61 years, and the total number of female participants was 199 (56.4%). The mean BMIs of groups 1–5 were 18.72±1.25, 22.84±1.48, 26.86±1.36, 34.65±3.24 and 44.63±4.11respectively. Baseline characteristics and laboratory data of the groups are summarized in Table 1.

Table 1. Baseline characteristics of the study population

Variables	Group 1 (n=34)	Group 2 (n=98)	Group 3 (n=82)	Group 4 (n=63)	Group 5 (n=76)	p
Age (years)	24.15±8.4	29.8±9.66	35.79±10.65	36.05±10.27	33.7±10.09	**<0.001**
Female (%)	25 (76.5)	42 (42.9)	26 (31.7)	44 (69.8)	62 (81.6)	**<0.001**
Smoking (%)	8 (23.5)	42 (42.9)	36 (43.9)	15 (39.5)	34 (44.7)	<0.196
Height (cm)	167.6± 10.23	170.7±7.39	170.7±9.61	164.3±8.25	163.5±8.87	**<0.001**
Weight (kg)	52.8 ±7.66	66.78±7.9	78.57±9.72	93.03±11.03	120.2±14.9	**<0.001**
BMI kg/m²	18.72±1.25	22.84±1.48	26.86±1.36	34.65±3.24	44.63±4.11	**<0.001**
Glucose (mg/dl)	88.19±12.09	89.2±11.2	94.29±16.45	97.13±20.29	103.8±43.56	**0.002**
Urea (mg/dl)	23.81±5.682	27.27±8.3	27.87±7.89	26.74±7.3	26.38±7.62	0.142
Creatinine (mg/dl)	0.70±0.138	0.75±0.14	0.82±0.17	0.69±0.13	0.66±0.13	**<0.001**
Na (mmol/ml)	139.9±2.521	139.2±2.24	140±2.13	139.6±1.83	139.05±2.27	**0.041**
K (mmol/ml)	4.27±0.286	4.2±0.36	4.28±0.28	4.32±0.32	4.52±0.31	**<0.001**
Mg (mg/dl)	2.03±0.167	20±0.13	2.05±0.12	2.03±0.17	1.93±0.14	**<0.001**
Leukocytes (10^3/Ul)	8.20±2.506	8.02±2.57	8.41±1.92	8.91±2.39	9.67±2.46	**<0.001**
Hemoglobin (g/dl)	13.77±1.5	14.61±1.9	14.76±1.88	13.88±1.69	13.86±1.73	**0.001**
Platelets (10^3/Ul)	279.6±44.69	257.5±62.15	281.6±60.99	296.3±64.2	327.5±78.01	**<0.001**
EF (%)	60.74±1.797	60.54±2.08	60.43±1.96	60.4±1.36	59.97±1	0.16
IVS(cm)	0.84± 1.089	0.88±1.04	0.94±0.11	0.99±0.12	1.01±0.08	**<0.001**
LVDD (cm)	4,27 ± 0.308	4.35±0.27	4.47±0.31	4.48±0.27	4.54±0.29	**<0.001**
LAD (cm)	2,96±0.345	3.2±0.28	3.41±0.33	3.49±0.37	3.51±0.28	**<0.001**

EF:Ejection fraction, IVS: Interventricular septum thickness, LVDd: Left ventricul enddiastolic diameter, LAD: Left atrial diameter, BMI: Body-mass index

The ECG findings and ICEB/ICEBc of the participants are shown in Table 2. The mean ICEB and ICEBc of the total study sample were 4.18±0.54 and 4.85±0.64, respectively. We found that QTc (p<0.001), ICEB (p=0.014) and ICEBc (p<0.001) values were significantly different among the groups. In post-hoc analysis of ANOVA, it was detected that the ICEB value of the group 1 and group 4 were significantly higher than the group 3 (p=0.024, and p=0.044, respectively) Also, the ICEBc values of the group 1, group 4, and group 5 were significantly higher than the group 3 (p=0..006, p<0.001, and p<0.001, respectively)

In this study, we also compared the clinical and electrocardiographic parameters between the males and females.

The ECG findings according to gender in this study are shown in Table 3. It was observed that female subjects had significantly higher QTc (421.9±23.56 vs. 408.9±21.41, p<0.001), ICEB (4.29±0.5 vs. 4.03±0.53, p<0.001) and ICEBc (5.13±0.56 vs. 4.56±0.59, p<0.001) values, while lower PR (138.3±15.9 vs. 144.9±19.6, p=0.001), QRS (83.18±8.94 vs. 90.83±9.91, p<0.001) and QT values (353.9±28.22 vs. 362.1±27.72, p=0.007) when compared to the male subjects.

Table 2. ECG findings of the study population

Parameters	Group 1 (n=34)	Group 2 (n=98)	Group 3 (n=82)	Group 4 (n=63)	Group 5 (n=76)	p
HR (bpm)	81.06±15.14	80.5±12.19	78.49±12.45	84.73±13.8	88.53±12.98	**<0.001**
P axis	58.06±17.49	54.26±16.8	40.93±23.35	40.4±19.28	44.21±13.88	**<0.001**
QRS axis	63.97±15.85	52.59±29.85	34.46±30.81	24.62±29.73	28.7±34.6	**<0.001**
T axis	41.53±24.53	37.23±20.07	29.5±27.07	24.46±20	22.34±22.57	**<0.001**
P wave	98.38±12.25	102.12±12.35	103.8±12.22	102.4±14.97	106.1±14.05	0.061
PR segment	135.8±13.46	137.3±19.25	141.7±17.6	143.7±18.05	146.1±16.75	**0.005**
QRS duration (ms)	83.56±9.04	86.07±10.07	91.17±10.14	84.13±9.69	85.11±8.4	**<0.001**
QT duraton (ms)	360.91±31.5	354.7±26.29	364.5±29.23	356.1±27.96	353.3±27.5	0.077
QTC duration (ms)	414.7±19.5	408.7±22.55	414.3±22.41	419.4±23.05	426.3±24.45	**<0.001**
ICEB	4.36±0.53	4.17±0.53	4.04±0.52	4.27±0.55	4.18±0.47	**0.014**
ICEBc	5.03±0.69	4.81±0.63	4.6±0.56	5.05±0.68	5.05±0.52	**<0.001**

ICEB: Index of cardiac electrophysiological balance, ICEBc: Corrrected index of cardiac electrophysiological balance

Table 3. Baseline characteristics according to the sex

Parameters	Male (n=154)	Female (n=199)	p value
EF	60.41±1.94	60.37±1.54	0.809
IVS	0.96±0.12	0.93±0.12	**0.05**
LVDD	4.54±0.29	4.36±0.29	**<0.001**
LAD	3.40±0.33	3.31±0.38	**0.015**
Age	32.95±11	32.33±10.32	0.582
BMI	27.33±6.57	32.39±10.36	**<0.001**
P	106.3±14.6	100.5±11.55	**<0.001**
PR	144.9±19.6	138.3±15.9	**0.001**
QRS	90.83±9.91	83.18±8.94	**<0.001**
QT	362.1±27.72	353.9±28.22	**0.007**
QTc	408.9±21.41	421.9±23.56	**<0.001**
ICEB	4.03±0.53	4.29±0.5	**<0.001**
ICEBc	4.56±0.59	5.13±0.56	**<0.001**
Smoker	95(%61.7)	65 (%32.7)	**<0.001**

Table 4. Pearson correlatioon analysis of BMI and ECG findings

Parameters	Pearson correlation coefficient (r)	p value
ICEB	-.016	0.765
ICEBc	0.150	**0.005**
QT	-.081	0.130
QTc	0.267	**<0.001**

Correlation analysis was performed to determine the correlation between body mass index and electrocardiographic variables. The analyses showed a weak correlation between BMI and ICEBc (r=0.150, p=0.005), and a moderate correlation between BMI and QTc (r=0.267, p<0.001). No correlation was found between BMI and QT and ICEB (Table 4).

Logistic regression analysis was performed to investigate the relationships between BMI and the ICEB and ICEBc values (Table 5). BMI, gender, hemoglobin levels, and smoking status were the detected as the possible predictors of ICEB and ICEBc in univariable logistic regression analysis. However, only female gender was identified as an independent predictor of ICEB (OR: 2.516, 95%CI: 1.184-5.347, p=0.016) and ICEBc (OR: 6.703, 95%CI: 2.926-15.356, p<0.001) in multivariate analysis.

Table 5. Independent determinants of ICEB/ICEBc in univariable and multivariable logistic regression analyzes model

Univariable			**Multivariable**	
ICEB				
Parameters	HR, 95% CI	p value	HR, 95% CI	p value
BMI	1.025, 1.001-1.049	0.038	0.989, 0.945-1.055	0.959
Hgb	0.817, 0.723-0.923	0.001	0.941, 0.770-1.150	0.554
Sex	2.696, 1.747-4.162	<0.001	2.516, 1.184-5.347	**0.016**
Smoker	1.808, 1.086-3.011	0.023	1.123, 0.625-2.016	0.698
Age	1.018, 0.998-1.039	0.075		
LVEF	1.016, 0.900-1.147	0.794		
Sodium	1.006, 0.969-1.046	0.740		
Potassium	1.113, 0.597-2.075	0.737		
Magnesium	0.267, 0.071-1.010	0.052		
ICEBc				
BMI	1.041, 1.016-1.065	<0.001	1.018, 0.960-1.079	0.556
Hgb	0.762, 0.671-0.865	<0.001	1.018, 0.960-1.079	0.543
Sex	6.176, 3.845-9.918	<0.001	6.703, 2.926-15.356	**<0.001**
Smoker	2.923, 1.691-5.051	<0.001	1.554, 0.821-2.543	0.176
Age	0.997, 0.978-1.017	0.784		
LVEF	1.076, 0.951-1.218	0.246		
Sodium	1.004, 0.967-1.043	0.840		
Potassium	1.120, 0.601-2.089	0.722		
Magnesium	0.340, 0.091-1.275	0.110		

Discussion

In this study, we demonstrated a elationship between BMI and QTc, ICEB and ICEBc values. Numerous studies have demonstrated a U-shaped relationship between mortality and BMI, with greater mortality rates seen among people in both the lowest and highest BMI categories. On the other hand, adults with overweight and non-severe obesity have shown superior short- and long-term outcomes (16). As a result, while people with obesity are more likely to experience cardiovascular events, their prognoses are better in the event that an incident does occur. This is known as “the obesity paradox.” In our study, the ICEB and ICEBc levels yielded results that were consistent with the obesity paradox. ICEB value of the group 1 and group 4 were significantly higher than the group 3. Also, the ICEBc values of the group 1, group 4 and group 5 were significantly higher than the group 3. Furthermore, while the QRS and QT interval values were similar in the groups with underweight, obesity, and morbid obesity, significant differences were observed in the QTc intervals. Significant differences in the participants’ ICEB and ICEBc values were associated with prolonged QTc intervals.

An increasing volume of data are pointing to a link between obesity, especially central obesity, and delayed VR, as demonstrated by prolonged QTc intervals or QT interval dispersion, and strong evidence has been provided to indicate that obesity is linked to QTc interval prolongation (17-21). In terms of the relationship between obesity and QT interval dispersion, the research is conflicting. Similarly, in our study, while a significant increase was observed in the QTc intervals with for the lowest and highest BMI categories, no significant change was observed in the QT intervals. In light of these findings, obesity ought to be regarded as a possible substrate for the development of ventricular tachyarrhythmias and a risk factor for delayed VR.

Obesity is a frequent cause of LVH in individuals with both normotensive and HT obesity. Studies that have previously demonstrated QTc interval prolongation, higher QT intervals, or QTc dispersion have also indicated that individuals with overweight or obesity have a larger left ventricle diameter and thickness than normal weight controls (22-24). Likewise, noteworthy correlations between obesity and left ventricular diameter and thickness (p<0.001, p<0.001, respectively) were detected in our investigation.

There are many possible reasons for the proarrhythmic effects of obesity. These may include an increase in left ventricular diameter and mass, an increase in epicardial fat tissue, QRS fragmentation causing heterogeneous conduction, oxidative stress, fibrosis, a decrease in connexin proteins, and the restructuring of ion channels. The general cause of

obesity-related arrhythmias has also been associated with QTc prolongation.

Studies involving men and women with obesity have shown that men tend to have less VR delay than women (25). It is unclear why this is the case. Given that women have been the dominant gender in the majority of mixed-gender research, selection bias may have contributed in part. Similarly, in our study, the QTc interval (p<0.001), ICEB (p<0.001), and ICEBc (p<0.001) values were higher among the women than the men, while the QT intervals (p<0.001) and QRS duration (p=0.007) were higher in the men. We still do not fully understand the etiological reasons for the gender differences observed on ECG. However, a number of mechanisms may be responsible for these variations. Different sex hormones, body compositions, and heart structures are a few of the hypothesized explanations for the variations in electrocardiogram results between men and women. The differences in ECG in our study may have been influenced by the fact that the women's BMI results were noticeably higher than those of the men.

Numerous anatomical and functional alterations brought on by obesity are crucial to arrhythmogenesis. Obesity is known to cause left atrial dilatation and dysfunction. It has been demonstrated that the risk of paroxysmal atrial fibrillation increases 1.39 times with a 5 mm increase in left atrial cross diameter (LAD) (26). A noteworthy correlation between BMI and LAD was found in our investigation. In the groups with obesity, the LAD was greater and correlated with BMI (p<0.001).

Increased adiposity also causes changes in ECG findings, namely, P waves with a longer duration, amplitude, and terminal force (27). Notwithstanding, in our study, although there was a comparable rise in PR distance across the groups, there was no significant difference in P wave duration.

Conclusion

The effects of obesity on ECG is well known, especially on QT and QTc intervals, which are a predictor of malignant ventricular arrhythmias and may cause poor cardiovascular outcomes and sudden death. As a result of our study, it was observed that low and high BMI values may be associated with an increase in QTc, ICEB and ICEBc values. It should be kept in mind that QTc, ICEB and ICEBc values may be high in cardiac evaluation in relatively thin and obese individuals.

Limitations

In clinical practice, a major drawback of BMI assessments is that they ignore adiposity, the relative weight of lean mass, which consists mostly of skeletal muscle, and the distribution of fat in a given area. Considering that the waist–hip ratio has a stronger correlation with traditional risk factors, such as HT, dyslipidemia, cardiovascular disease, and type 2 DM (28), than BMI, the lack of data on the participants' waist–hip ratios is an important limitation of our study. A further limitation of our study is that normal ICEB and ICEBc levels do not have a well-acknowledged reference range, although based on research data, Robyns et al. (29) suggested a tentative reference value of 4.24 with a range of 3.14–5.35. Lastly, it has been demonstrated that the duration of obesity affects LV structure and function (30); however, we did not have data on the duration of obesity of the participants with obesity in our study.

Ethical Approval: *The protocol of the study (549/13.10.2023) was accepted by our institutional ethics committee and conformed with the standard set of guidelines in the Declaration of Helsinki.*

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