RESEARCH PAPER

Prolongation of Ventricular Depolarization Time (QRS Duration) in Young Adults with Obesity: A Cross-Sectional Study

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ABSTRACT

Background: Obesity is a known risk factor for cardiovascular disease, but its effect on ventricular depolarization in healthy young adults is not fully understood. QRS duration on ECG reflects the time required for ventricular depolarization. This study examined whether general obesity (BMI) and central adiposity (WHR) are associated with QRS duration in healthy young adults.

Methods: This cross-sectional study was conducted in a South Indian town over 4 months. We enrolled 150 healthy young adults (18-30 years) and divided them equally into three groups (n=50 each) using Asia-Pacific BMI criteria: normal weight (18.5-22.9 kg/m²), overweight (23-24.9 kg/m²), and obese (≥25 kg/m²). All groups were matched for age and sex. QRS duration was measured from Lead II of a standard 12-lead ECG. BMI and WHR were calculated. Data were analyzed using one-way ANOVA, Tukey's post-hoc test, and Pearson's correlation.

Results: QRS duration increased progressively with higher BMI. The normal weight, overweight, and obese groups had mean QRS durations of 81.94±9.77 ms, 83.92±10.46 ms, and 93.72±10.99 ms, respectively ($F = 18.31$, $p < 0.001$). The obese group had significantly longer QRS than both normal weight and overweight groups ($p < 0.001$ for each), while no difference was found between normal weight and overweight groups ($p = 0.61$). Both BMI ($r = 0.387$, $p < 0.001$) and WHR ($r = 0.285$, $p < 0.001$) showed significant positive correlations with QRS duration.

Conclusion: Healthy young adults with obesity have prolonged QRS duration, indicating early subclinical ventricular electrical remodeling. Both general and central obesity contribute to this change. QRS duration is a low-cost, non-invasive ECG parameter that can be used for early risk stratification and to motivate weight management in young obese individuals.

Keywords: QRS duration, Obesity, Body Mass Index (BMI), Waist-to-Hip Ratio (WHR), Electrocardiography (ECG), Young adults

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INTRODUCTION

Overweight and obesity are now major drivers of non-communicable diseases and premature death worldwide [1]. BMI and WHR are commonly used anthropometric indices to assess obesity. BMI reflects total body fat, while WHR specifically indicates central or abdominal adiposity [2].

Although the WHO has defined standard BMI categories, evidence indicates that Asian populations develop cardiometabolic complications at lower BMI thresholds [3,4]. Therefore, many researchers now use the Asia-Pacific BMI criteria for Asian populations: normal weight 18.5-22.9 kg/m², overweight 23-24.9 kg/m², and obese ≥25 kg/m² [5,6].

Obesity is a well-established risk factor for cardiac arrhythmias and sudden cardiac death [7]. QRS duration on ECG represents the total time for ventricular depolarization, measured from the start of the Q wave to the J point. Prolonged QRS duration, even in the absence of bundle branch block, is associated with increased risk of heart failure, post-infarction mortality, and all-cause mortality in diabetic patients [9-11]. Other ECG abnormalities, such as QT prolongation and left axis deviation, have also been reported in obesity [8,12]. However, the specific impact of obesity on QRS duration in young healthy adults remains poorly characterized.

Selecting appropriate BMI cut-offs is particularly important for Asian populations because they improve the prediction of hypertension and other comorbidities [14]. BMI alone has limitations in capturing fat distribution, so measuring central adiposity is also necessary [15,16]. Previous studies have shown that body composition influences ventricular electrical activity [17], and longitudinal studies have identified factors associated with QRS prolongation over two decades [18]. We hypothesized that higher adiposity would be associated with longer QRS duration.

AIM AND OBJECTIVES

Aim: To evaluate the association between obesity markers and QRS duration in healthy young adults.

Objectives:

1. To compare QRS duration among normal-weight, overweight, and obese young adults.
2. To determine the correlation between BMI and QRS duration.
3. To determine the correlation between WHR and QRS duration.

MATERIALS AND METHODS

Study Design and Setting

This was a community-based cross-sectional descriptive study conducted in a South Indian town over 4 months.

Participants

A total of 150 healthy young adults aged 18-30 years were randomly selected from the community. Based on Asia-Pacific BMI criteria [6], they were equally divided into three groups (n=50 each): normal weight (18.5-22.9 kg/m²), overweight (23-24.9 kg/m²), and obese (≥25 kg/m²). All groups were matched for age and sex (25 males and 25 females per group). Only healthy individuals without any known acute or chronic illness were included.

Exclusion Criteria

Individuals with a history of smoking, tobacco chewing, alcohol use, or any diagnosed illness – including hypertension, diabetes mellitus, cardiac, pulmonary, liver, thyroid, or neoplastic disorders – were excluded. Those with prior myocardial infarction, stroke, peripheral vascular disease, or those taking medications that could alter cardiac or pulmonary function were also excluded.

Ethical Approval and Informed Consent

The Institutional Ethical Committee approved the study protocol. Written informed consent was obtained from all participants after a full explanation of the study's nature, purpose, and confidentiality measures.

Methodology

Height (cm) and weight (kg) were measured using a stadiometer and digital weighing scale, respectively. BMI was calculated as weight/height² (kg/m²). Waist and hip circumferences (cm) were measured with a non-flexible tape, and WHR was calculated. A standard 12-lead resting ECG was recorded in the supine position after 10 minutes of rest. Paper speed was 25 mm/s (1 mm = 0.04 s) and calibration was 10 mm/mV. QRS duration was measured in Lead II from the start of the Q wave (or first deflection after the P wave) to the J point. All measurements were performed by a single blinded investigator to minimize bias.

Statistical Analysis

Data were analyzed using SPSS version 23. Continuous variables are presented as mean ± standard deviation (SD). One-way ANOVA was used to compare QRS duration across the three groups, followed by Tukey's post-hoc test for pairwise comparisons. Pearson's correlation coefficient (r) was calculated to assess linear relationships between obesity markers (BMI, WHR) and QRS duration. A p-value <0.05 was considered statistically significant. Effect size (η^2) was also reported.

RESULTS

Participant Characteristics

Table 1 shows the baseline characteristics of the 150 participants. Age and sex were well matched across groups. BMI and WHR progressively increased as expected.

Table 1: Baseline Characteristics of Study Participants (N=150)

Variable	Normal-Weight (n=50)	Overweight (n=50)	Obese (n=50)
Age (years)	23.34 ± 4.07	24.12 ± 3.74	24.06 ± 3.86
Sex (Male, n, %)	25 (50%)	25 (50%)	25 (50%)
Body Mass Index (BMI, kg/m²)*	20.77 ± 1.2	24.01 ± 0.65	29.02 ± 2.49
Waist-Hip Ratio (WHR)*	0.86 ± 0.07	0.93 ± 0.09	1.11 ± 0.21

*Data are mean ± SD unless otherwise specified. *p < 0.001 for inter-group differences by study design.*

QRS Duration across BMI Groups

The comparison of QRS duration between the three groups is presented in Table 2. A statistically significant difference was found between the groups ($F(2,147)=18.31$, $p < 0.001$, $\eta^2=0.20$), indicating that adiposity level explains 20% of the variance in QRS duration.

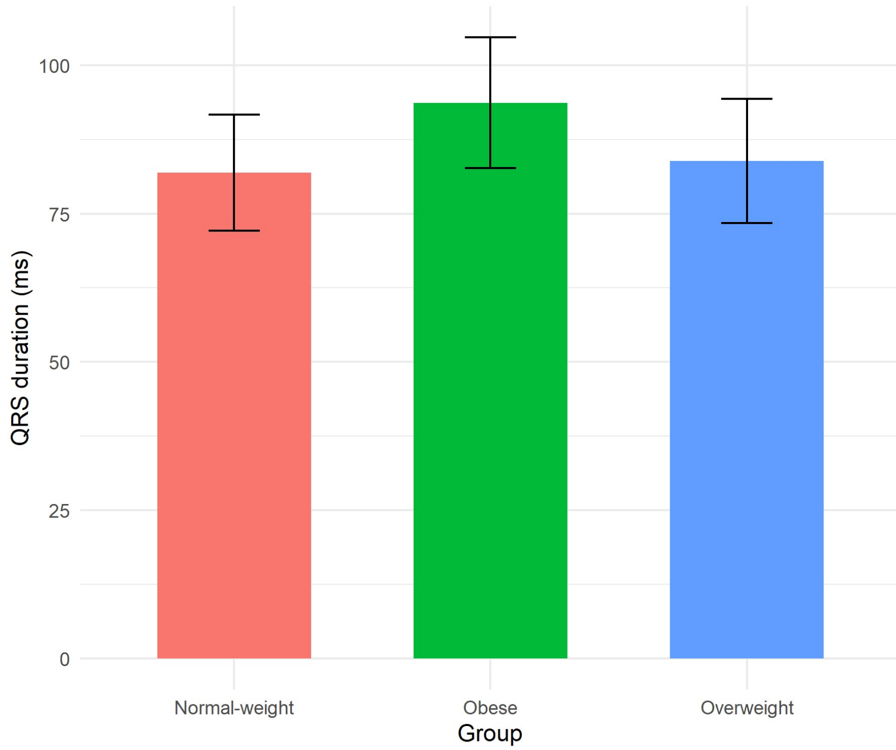

Figure 1- Mean QRS duration (± SD) across BMI categories. **p < 0.001 vs. normal-weight and overweight (one-way ANOVA, Tukey post-hoc)

Table 2: Comparison of QRS Duration across Groups

Variable	**Normal-Weight (n=50)**	**Overweight (n=50)**	**Obese (n=50)**	**F-value**	**p-value***	**Effect Size (η²)**
QRS Duration (ms)	81.94 ± 9.77	83.92 ± 10.46	93.72 ± 10.99	18.31	<0.001	0.20

Data are mean ± SD. One-way ANOVA.

Post-Hoc Comparisons

Table 3 shows pairwise comparisons. The obese group had significantly longer QRS duration than both the normal weight and overweight groups ($p < 0.001$ for each). No difference was found between the normal weight and overweight groups ($p = 0.61$).

Table 3: Post-Hoc Analysis (Tukey) for QRS Duration

Comparison (QRS Duration)	**Mean Difference (ms)**	**95% CI for Difference**	**p-value***
Overweight vs. Normal-weight	1.98	-3.30 to 7.26	0.61
Obese vs. Normal-weight	11.78	6.50 to 17.06	<0.001
Obese vs. Overweight	9.80	4.52 to 15.08	<0.001

Tukey's post-hoc test. Statistically significant comparisons are bolded.

Correlations

Table 4 shows a moderate positive correlation between BMI and QRS duration ($r = 0.387$, $p < 0.001$). Table 5 shows a weaker but still significant positive correlation between WHR and QRS duration ($r = 0.285$, $p < 0.001$).

Table 4: Correlation of BMI with QRS Duration (N=150)

Variable 1	Variable 2	Pearson's r	p-value*
Body Mass Index (BMI)	QRS Duration	0.387	<0.001

Table 5: Correlation of WHR with QRS Duration (N=150)

Variable 1	Variable 2	Pearson's r	p-value*
Waist-to-Hip Ratio (WHR)	QRS Duration	0.285	<0.001

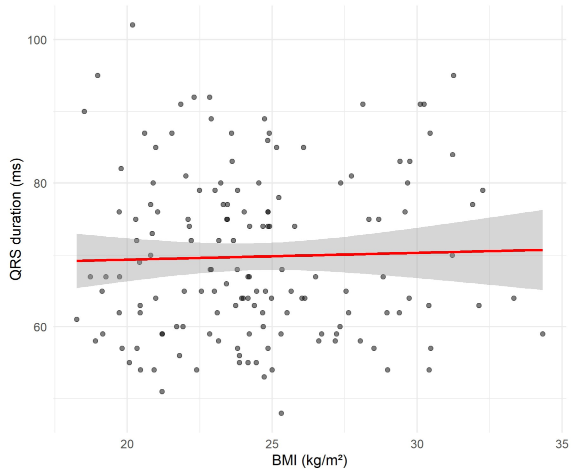

Figure 2- Positive correlation between BMI and QRS duration (r = 0.387, p < 0.001). Regression line with 95% CI shown

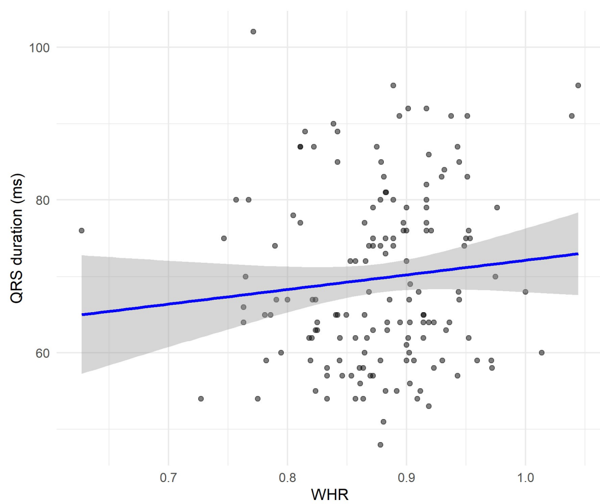

Figure 3- Positive correlation between WHR and QRS duration (r = 0.285, p < 0.001). Regression line with 95% CI shown

DISCUSSION

Our study demonstrates a stepwise prolongation of QRS duration with increasing obesity severity in healthy young adults. Although all QRS values remained within clinically normal ranges, the differences were significant. This indicates that subclinical electrical remodeling occurs in the ventricles even before any symptoms appear. The absence of a significant difference between normal weight and overweight groups suggests a threshold effect: the adverse electrical consequences of adiposity become evident only after crossing the BMI threshold of 25 kg/m² (obesity by Asia-Pacific criteria).

These findings are consistent with previous reports. Rao et al. (2021) [13] found a positive correlation between BMI and QRS duration independent of age and sex. Other investigators have also linked obesity phenotypes to adverse ECG markers, including prolonged QRS duration and

P-wave indices, indicating early subclinical cardiac damage [19,20]. Studies in children and adolescents have shown that QRS duration increases with BMI [25]. Our study extends these observations to young adults in a South Asian context, using the more sensitive Asia-Pacific BMI criteria.

The clinical relevance of our findings is supported by studies linking prolonged QRS duration to poor outcomes, including heart failure and mortality [9-11]. The rising prevalence of overweight and physical inactivity among young adults further underscores the need for early intervention [21,22].

Several mechanisms may explain the prolonged QRS duration in obesity. Epicardial fat infiltration can create conduction delays [24]. Obesity is also a pro-inflammatory state, which can affect gap junction function between cardiac myocytes [27]. The increased hemodynamic load and cardiac output associated with excess fat mass can lead to myocardial hypertrophy and altered depolarization patterns [28,29,30]. Our correlation analysis showed a stronger relationship between BMI and QRS duration than between WHR and QRS duration. This suggests that total fat mass may have a greater effect on global ventricular depolarization than fat distribution in this young cohort.

Limitations and Future Directions

The cross-sectional design prevents causal inferences. We did not perform echocardiography to exclude subclinical left ventricular hypertrophy. Future studies should include echocardiography and metabolic profiling to distinguish metabolically healthy obesity from metabolically unhealthy obesity [29,30]. Longitudinal studies are needed to determine whether QRS prolongation in obese youth predicts future cardiovascular events.

CONCLUSION

Healthy young adults with obesity have significantly prolonged QRS duration, indicating early subclinical ventricular electrical remodeling. Both general obesity (BMI) and central adiposity (WHR) are positively correlated with this change. Since QRS duration is inexpensive and easily measured from a routine ECG, it can serve as an early screening tool to identify young obese individuals at risk for future cardiac conduction abnormalities, motivating early lifestyle interventions.

Conflict of interest: None
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