# RELATIONSHIP BETWEEN HEART RATE RECOVERY, P-R AND Q-T INTERVALS AMONG YOUNG HEALTHY STUDENTS OF BAYERO UNIVERSITY KANO, NIGERIA

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**Received**: 17th January, 2023 **Accepted**: 8th June, 2023 **Published:** 30th June, 2023

## ABSTRACT
**Background:** Heart rate recovery (HRR) is a measure of the number of heart beats a person drops from the peak end of exercise to a specific time after cessation of exercise. Although it has been reported that abnormally low HRR is linked to a higher risk of some cardiovascular diseases, data is scanty on the relationship between HRR, cardiac conductivity and risk of arrhythmia. This study therefore, assessed the correlation between HRR, P-R and Q-T interval in young healthy individuals.
**Method**: A total of 46 young healthy participants matched for age and with normal BMI, were recruited into the study. They were subjected to 3 minutes of moderate exercise and their heart rates were recorded at the peak end of the exercise and 1 and 2 minutes from the cessation of the exercise. The latter values were subtracted from the peak heart rate to obtain the HRR in 1 (HRR-1) and 2 minutes (HRR-2). P-R and Q-T intervals of the participants were measured using 12-LEAD ECG. Data were analyzed with IBM SPSS version 25.0 and relationships between HRR, P-R and Q-T intervals were assessed using Pearson's correlation.
**Results:** Q-T interval was found to be negatively correlated with HRR-1 ($r = -0.314$, $p = 0.03$) and HRR-2 ($r = -0.380$, $p = 0.001$) but no significant correlation was found between P-R, HRR-1 and HRR-2.
**Conclusion:** HRR-1 and HRR-2 are negatively correlated with Q-T interval indicating that low heart rate recovery is associated with the risk of having prolonged Q-T, cardiac arrhythmia and sudden cardiac death.
**Key words**: Heart rate recovery, relationship, P-R interval, Q-T interval.

## INTRODUCTION
Heart rate is the number of heartbeats per minute. The heart rate is based on the number of contractions of the ventricles in one minute which ranges between 60-100 beats per minute (Shaffer *et al*., 2014). Heart Rate Recovery (HRR) is the difference between the peak heart rate at the end of exercise and the heart rate at a specific time after cessation of exercise (van de Vegte *et al*., 2018). It is measured in beats per minute (bpm), and it is an important predictor of cardiovascular fitness and cardiovascular disease (CVD) including coronary artery disease (van de Vegte *et al*., 2018). It can be measured at 10 seconds, 30 seconds, 1 minute and other specific points after cessation of exercise to assess the number of heart beats a person drops from the end of the exercise to the point of measurement (van de Vegte *et al*., 2018; Mongin *et al*., 2023). Heart rate recovery is the reflected balance of the reactivation of the Parasympathetic Nervous System (PNS), withdrawal of the sympathetic nervous system, and possibly circulating catecholamine.

It has been known that the PNS is the main contributor to inter-individual HRR differences (Shaffer *et al* 2014; van de Vegte *et al*., 2018).

Q-T interval is the time taken from the beginning of ventricular depolarization to the end of ventricular repolarization represented by the interval from the beginning of QRS complex to the end of the T wave on an electrocardiogram (ECG) (Postema and Wilde 2014). Abnormal Q-T interval especially prolonged Q-T, is associated with an increased risk of developing arrhythmia and sudden cardiac death (SCD) (Mandyam *et al*., 2013: Postema and Wilde 2014). Another important measure of electrocardiogram is the P-R interval which is the time taken from the beginning of P-wave to the beginning of the QRS complex on ECG (Kwok *et al*., 2016; Rasmussen *et al.*, 2017). It indicates the time taken for the electrical impulses generated to be conducted from the atria to the ventricles and normally ranges from 0.12 – 0.2 seconds (Kwok *et al*., 2016). Abnormally shortened or prolonged P-R indicates fast or slow conduction respectively as seen in first and second degree heart blocks where the P-R interval is abnormally prolonged (Kwok *et al*., 2016; Rasmussen *et al*., 2017).

Although several studies have linked heart rate recovery with various markers of cardiovascular fitness (Dimkpa, 2009; Ciolac *et al*., 2011; van de Vegte *et al*., 2018), there is a paucity of data on the relationship between heart rate recovery and electrocardiogram parameters such as P-R and Q-T interval especially in young healthy individuals which could be used to predict the risk of cardiac arrhythmia including sudden cardiac death in the young and therefore provide the opportunity for taking adequate and effective measures of prevention. This study therefore aimed to assess the relationship between heart rate recovery at one and two minutes with P-R and Q-T intervals in young healthy individuals.

## MATERIALS AND METHODS

Ethical clearance:

Ethical clearance was obtained from the Kano State Ministry of Health on the 6th February, 2023 with reference number **SHREC/2022/3793**. In addition to this, all participants signed an informed consent form before the commencement of the study.

Study area:

This study was conducted at Bayero University Kano, Nigeria which is located within latitude 11.9868º N and longitude 8.4810ºE Gwale Local Government Area of Kano State in the North-Western part of Nigeria.

Study Population

The population was both male and female healthy students of Bayero University, the age range of 18 – 30 years, having normal BMI of 18.5 – 24.9. A self-administered questionnaire was used to obtain their Bio-data including age, sex and tribe. Individuals that were able to meet the criteria but have a known history of smoking, presented with or have previous history of cardiovascular diseases, were excluded from the study.

Sample Size Estimation and Sampling Technique

The sample size was estimated using the Cochran Formula $\mathbf{n = p(1-p)\ Z^2\ /e^2}$ (Cochran, 1977) where n = Sample size, p = population proportion (p = 0.03 used in this study), e = acceptable sampling error (e = 0.05) and z = z value at 95% reliability level (z = 1.96). After substituting the values in the formula, the minimum sample was estimated to be 44 and therefore 46 participants were randomly selected for the study by using a simple random sampling technique (balloting).

Assessment of Heart Rate Recovery of the Participants

Resting heart rate (RHR) of each participant was measured using a pulse oximeter and recorded. The participants were then subjected to 3 minutes of moderate exercise using an ego-bicycle and their heart rates were again measured immediately at the end of the exercise, 1 minute after stopping the exercise and 2 minutes post exercise.

The heart rate recovery in 1 minute (HRR-1) was calculated by subtracting the heart rate recorded at 1 minute after the cessation of exercise from the maximum heart rate recorded immediately at the end of the exercise. Similarly, the heart rate recovery in 2 minutes (HRR-2) of each participant was also estimated by subtracting the heart rate recorded 2 minutes after cessation of exercise from the maximum heart rate recorded immediately at the end of the exercise.

Estimation of P-R and Q-T intervals

These parameters were obtained by conducting a resting Electrocardiogram (ECG) assessment of each participant using a standard 12-LEAD ECG machine standardized at 10mm/mv and 25 mm/sec. Therefore based on this standardization, each millimeter on the ECG paper is equivalent to 0.04 seconds. The intervals were therefore calculated by multiplying their length in millimeter with 0.04 seconds.

Data Analysis

Data were summarized as MEAN ± SD and analyzed using IBM SPSS version 25.0. Relationships between heart rate recovery (HRR-1 and HRR-2), P-R and Q-T intervals were assessed using Pearson's correlation with $p < 0.05$ indicating a significant correlation.

## RESULTS

The mean age, BMI and resting heart rate of the participants were found to be 22.15 ± 2.67, 20.78 ± 1.72 and 69.78 ± 9.69 respectively as shown in table 1 below. Similarly, the HRR-1, HRR-2, P-R and Q-T intervals of the participants were averagely found to be 8.28 ± 6.62, 12.20 ± 7.64, 0.35 ± 0.03 and 0.20 ± 0.03 respectively.

Table 1: Showing the average age, BMI, RHR, HRR-1, HRR-2, P-R & Q-T of the participants (MEAN±SD, n = 46).

| **Parameters** | **Mean±SD** |
|---|---|
| Age(yrs) | 22.15±2.67 |
| BMI(kg/m$^2$) | 20.78±1.72 |
| RHR | 69.78±9.69 |
| HRR-1 | 8.28±6.62 |
| HRR-2 | 12.20±7.64 |
| Q-T | 0.35±0.03 |
| P-R | 0.20±0.03 |

**Keys:** BMI: Body Mass Index, RHR: Resting Heart Rate, HRR-1: Heart rate recovery in 1 minute, HRR-2: Heart recovery in 2 minutes.

The results of Pearson's correlation between P-R interval, HRR-1 and HRR-2 are displayed in Table 2 below. No significant correlations were found between HRR-1 and P-R interval ($r = -0.03$, $p = 0.84$) and also between HRR-2 and P-R interval ($r = -0.142$, $p = 0.35$). However, a significant negative correlation was found between HRR-1 and Q-T ($r = -0.314$, $p = 0.03$), as well as between HRR-2 and Q-T ($r = -0.380$, $p = 0.001$) as shown in Table 3 below.

Table 2: Relationship between HRR (HRR-1 & HRR-2) and P-R Interval

| **PARAMETERS** | **r** | **P-value** |
|---|---|---|
| HRR-1 VS P-R | -0.03 | 0.84 |
| HRR-2 VS P-R | -0.142 | 0.35 |

**Keys**: HRR-1: Heart rate recovery in 1 minute, HRR-2: Heart rate recovery in 2minutes

Table 3: Relationship between HRR (HRR-1 & HRR-2) and Q-T Interval

| PARAMETERS | r | P-value |
|---|---|---|
| HRR-1 VS Q-T | -0.314 | 0.03* |
| HRR-2 VS Q-T | -0.380 | 0.01* |

**Keys**: HRR-1: Heart rate recovery in 1 minute, HRR-2: Heart rate recovery in 2 minutes
* indicate a significant relationship

## DISCUSSION

In this study, the relationship of Heart rate recovery with Q-T and P-R interval were assessed during moderate exercise among young healthy individuals in Bayero University Kano. These parameters are important markers for cardiovascular fitness and also for detecting cardiovascular diseases (Jin *et al*., 2013; Fan *et al*., 2020). The study involved young participants with normal BMI as shown in Table 1. This is done to exclude the effect of age and BMI on the HRR and the ECG parameters as it is known that ageing is associated with increased cardiovascular risk (Sniderman and Furberg, 2008).

Although the mean HRR-1 of the participants in this study was observed to be below the normal value of HRR-1 (≥12b/min) **(**Lachman *et al*., 2018**)**, this may not indicate abnormal results because usually those HRR-1 values are calculated after intense work out or exercise associated with high peak heart rates resulting in a large difference between the peak heart rate and the heart rate 1-minute post exercise. While in this work, a moderate exercise was used which is usually associated with moderate increase in heart rate and therefore little bit lower difference between the peak heart rate and the heart rate 1-minute post-exercise.

The results from this study showed a significant negative correlation between heart rate recovery in 1 minute (HRR-1) and Q-T interval implying that when HRR-1 decreases, Q-T interval will increase. This implied that abnormally low values of HRR-1 which indicates lower cardiovascular fitness may be associated with prolonged Q-T intervals and therefore high risk of cardiac arrhythmia and sudden cardiac death, as these are known to be linked with prolonged Q-T interval (Behzadi *et al*., 2018**)**. Similarly, HRR-2 was also found to be negatively correlated with Q-T interval, implying that low HRR-2 is associated with increased Q-T interval. This has further strengthened the finding that abnormally low HRR is associated with Prolonged Q-T interval and therefore increased risk of cardiac arrhythmia. These results have shown that HRR can be used to predict Q-T interval and assess the risk of cardiac arrhythmia and sudden cardiac death. On the other hand, no significant correlation was found between HRR (HRR-1 and HRR-2) with P-R interval. This has shown that HRR is not a good marker in assessing or predicting cardiac conductivity.

Although there is a dearth of literature on the direct relationship of HRR with Q-T and P-R interval. However, similar studies were conducted in other countries that relate heart rate recovery (HRR) and other markers of cardiovascular fitness. The findings in this work are similar to that of Qiu *et al*. (2017), who conducted a study in India on HRR and Risk of Cardiovascular events and All-Cause Mortality, which showed that abnormal HRR is consistently associated with increased risk of cardiovascular Events and all-cause mortality in the general population.

The findings of this study agreed with the study of Ghaffari *et al*. (2011) in Iran on the relationship between abnormal heart rate recovery after exercise and coronary artery disease severity, the study showed that abnormal HRR is related to the extent and severity of coronary artery involvement, the calculated risk score for the exercise test, and smoking.

Patients with abnormal HRR were found to have a lower functional capacity and lower peak heart rates, and they used less of their Heart rate reserve at peak exercise. Our Findings are also similar to that of Tang *et al*. (2009) who conducted a study in China and found that, post-exercise heart rate recovery independently predicts mortality risk in patients with chronic heart failure. He also demonstrated that heart rate recovery measured 1 minute after cessation of exercise is significantly associated with increased risk of mortality or urgent cardiac transplantation in ambulatory patients with chronic heart failure referred for exercise testing.

## CONCLUSION

HRR-1 and HRR-2 are negatively correlated with Q-T interval indicating that low heart rate recovery is associated with the risk of having prolonged Q-T, cardiac arrhythmia and sudden cardiac death. Therefore HRR can be used as an important marker that can be used to predict Q-T interval and assess the risk of cardiac arrhythmia.

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