



## Comparison of electrocardiographic parameters of racing and non-racing horses in Sokoto Nigeria

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### Abstract

The study was conducted due to the economic importance of horses and shortage of information on electrocardiographic parameters of horses in Sokoto, Nigeria. This study established the normal electrocardiographic parameters of racing and non-racing horses in Sokoto and statistically compared the values. The study used forty horses comprising of 20 racing and 20 non-racing horses with mean age of  $8 \pm 0.5$  years and average weight of  $200 \pm 2.0$  kg. ECG was recorded using the base apex system with the animals in standing position using single lead channel ECG recorder (EDAN VE-100 manufactured by Edan instruments China). The paper speed was set at 25mm/s while the sensitivity of the machine was adjusted to 10 mm/mV. The durations and amplitudes of P, R and T, the durations of Q and S and the durations of PR, QRS and QT intervals were all determined. These parameters were determined for the three standard limb leads (I, II and III) as well as the augmented limb leads (aVR, aVL and aVF). Descriptive statistics using SPSS version 16 was used to calculate the means and standard error of mean at 95 % confidence interval. One-way ANOVA was used to compare between the values of the racing and non-racing horses. The highest values of P amplitude, R amplitude, Q amplitude, QRS complex and P-R interval were recorded in racing horses, while highest T wave amplitude was recorded in non-racing horses. Highest duration of P wave, T wave and QRS was recorded in racing horses while highest duration of Q wave was recorded in non-racing horses. Significant difference was found in the T amplitude in racing horses in lead aVF. The mean heart rate for the racing and non-racing horses was  $80.3 \pm 8.4$  and  $63.1 \pm 9.2$  beats/minute respectively. Higher values recorded in racing horses indicates that exercise has influence on electrical activities in horses.

**Publication History:**  
Received: 05-10-2019  
Accepted: 23-12-2019

**Keywords:** *Electrocardiograph, Non-racing horses, Parameters, Racing horses, Sokoto*

## Introduction

Horse is a prestigious animal in northern Nigeria as it is an important animal kept by traditional rulers. It signifies the strength and wealth of traditional rulers. They are used for durbar ceremonies and "Eid" celebrations in most parts of Northern Nigeria. Horses all over the world are used for racing apart from other activities. In Sokoto State, horse-racing competition, popularly referred to as *Sukuwa*, is an important event that attracts people from all parts of the country and other neighboring countries like Niger Republic. In Sokoto State, horses racing competitions have great economic importance as they are used for where millions of Naira and other valuables are worn as prizes, thereby generating income for the state.

Exercise has great impact on cardiovascular function and predisposes racing animals to greater risk of cardiac malfunction (Young, 2004). Some of these include cardiac arrhythmias and can be detected using electrocardiography. The electrocardiogram is the most commonly used examination tool for the diagnosis of alterations in the cardiac rhythm (Tilley, 1992). It is used as a means of evaluating performance in horses (Lightowler & Piccione, 2004). Horses have high vagal tone that predisposes them to higher incidence of cardiac dysrhythmias at rest than any other domestic species (Hamlin, 1972; Young, 2004), making the recording of an exercise horse ECG an indispensable part of a cardiac diagnostic work-up (Senta *et al.*, 1970). Despite the role played by horses in the economy of the people of the state, little attention is given to race horses in terms of their heart conditions. Horse racing is a tradition and a growing culture in Sokoto State. Most equine owners complain of clinical signs relating to arrhythmia, yet there is limited information on the electrocardiographic parameters of horses in Sokoto, despite their economic importance. This study sought to establish a baseline electrocardiographic parameter of racing and non-racing horses for clinical and research purposes, and to compare between the Electrocardiogram (ECG) of the racing and non-racing so as to provide information that will be useful in diagnosing cardiac arrhythmia in horses.

## Materials and Methods

The research was conducted using forty local horses with mean age of  $8 \pm 0.5$  years and average weight of  $200 \pm 2.0$  kg. The horses were managed intensively in the stable of the Sultan of Sokoto's palace. The stable was made of thatch roof and the horses were fed on wheat bran, forages and grains and water was provided *ad libitum*. Electrocardiogram (ECG) was

recorded via the base-apex system with the animals restrained in standing position on a rubber mat using single lead channel ECG recorder (EDAN VE-100 manufactured by Edan instruments China). The paper speed was set at 25mm/s while the sensitivity of the machine was adjusted to 10mm/mV. The sites of alligator clips attachment were moistened with methylated spirit. The yellow electrode was placed above the left cardiac apex caudal to the olecranon; the red electrode was placed cranially to the right shoulder next to the jugular vein; the green electrode was placed above the left tibio-femoral patellar joint and the black electrode was placed on the proximal cranial region of the left forelimb as described by Ca'Assia *et al.* (2017). After lead placement, the animal was allowed to calm down and the ECG was recorded for a period of five minutes. The heart rate record was obtained from the ECG strip.

## Results

The values of Amplitude and Duration of P-wave, Q-wave, R-wave, T-wave and QRS-Complex and the duration of P-R and Q-T intervals for non-racing and racing horses in Lead I, II and III as well as aVR, aVL and aVF are presented in Tables 1 and 2 respectively. Analysis of the various waves in non-racing horses revealed higher value of P-wave amplitude in lead II but lowest in lead aVL. The P-wave duration was highest in lead aVR and lowest in lead I. Highest Q-wave duration was recorded in leads I and aVR with uniform duration in the remaining leads. T-wave amplitude was highest in lead II but lowest in aVL, while the duration was highest in aVR but lowest in leads aVL and aVF. Highest R-wave amplitude was obtained in lead aVR but lowest record was obtained in lead III. However, R-wave duration was highest in leads I and III but lowest and equal values were recorded in the remaining leads. QRS complex duration revealed equal higher values in leads I, III, aVR and aVL but equal lower values in leads III and aVF. Duration of P-R interval was highest in leads I, aVR and aVL but lowest in lead III. Highest Q-T interval was recorded in lead III but lowest in lead II. The lead record of racing horses revealed highest P-wave amplitude in lead II but lowest in aVL while the duration was highest in lead I but lowest in lead aVL. Q-wave duration was uniform in all the leads. R-wave amplitude was highest in lead II but lowest in lead aVL while the R-wave duration was highest in lead II but lowest in aVR. Highest value of T-wave amplitude was recorded in lead aVF but lowest in lead aVL while the T-wave duration was highest in lead II but lowest in

**Table 1:** Mean  $\pm$  SEM values of Amplitude and duration of P, R and T and the durations of Q, QRS-Complex, P-R and Q-T intervals for non-racing horses in Lead I, II and III, aVR, aVL and aVF

|                     |           | Lead I          | Lead II         | Lead III        | aVR             | aVL             | aVF             |
|---------------------|-----------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| <b>P-Wave</b>       | Amplitude | 0.16 $\pm$ 0.02 | 0.39 $\pm$ 0.05 | 0.26 $\pm$ 0.02 | 0.26 $\pm$ 0.03 | 0.14 $\pm$ 0.03 | 0.32 $\pm$ 0.03 |
|                     | Duration  | 0.05 $\pm$ 0.01 | 0.08 $\pm$ 0.01 | 0.08 $\pm$ 0.01 | 0.09 $\pm$ 0.01 | 0.06 $\pm$ 0.01 | 0.08 $\pm$ 0.01 |
| <b>Q-Wave</b>       | Duration  | 0.05 $\pm$ 0.01 | 0.04 $\pm$ 0.00 | 0.04 $\pm$ 0.00 | 0.05 $\pm$ 0.01 | 0.04 $\pm$ 0.00 | 0.04 $\pm$ 0.00 |
| <b>R-Wave</b>       | Amplitude | 0.83 $\pm$ 0.11 | 0.86 $\pm$ 0.16 | 0.60 $\pm$ 0.10 | 0.78 $\pm$ 0.11 | 0.70 $\pm$ 0.06 | 0.66 $\pm$ 0.11 |
|                     | Duration  | 0.09 $\pm$ 0.01 | 0.08 $\pm$ 0.01 | 0.08 $\pm$ 0.01 | 0.09 $\pm$ 0.01 | 0.08 $\pm$ 0.01 | 0.08 $\pm$ 0.01 |
| <b>T-Wave</b>       | Amplitude | 0.38 $\pm$ 0.11 | 0.69 $\pm$ 0.12 | 0.35 $\pm$ 0.07 | 0.61 $\pm$ 0.09 | 0.29 $\pm$ 0.04 | 0.43 $\pm$ 0.07 |
|                     | Duration  | 0.10 $\pm$ 0.02 | 0.10 $\pm$ 0.01 | 0.09 $\pm$ 0.01 | 0.11 $\pm$ 0.01 | 0.08 $\pm$ 0.01 | 0.08 $\pm$ 0.01 |
| <b>QRS-Complex</b>  | Duration  | 0.12 $\pm$ 0.00 | 0.12 $\pm$ 0.01 | 0.10 $\pm$ 0.01 | 0.12 $\pm$ 0.01 | 0.12 $\pm$ 0.00 | 0.10 $\pm$ 0.01 |
| <b>P-R Interval</b> | Duration  | 0.28 $\pm$ 0.01 | 0.25 $\pm$ 0.02 | 0.26 $\pm$ 0.02 | 0.28 $\pm$ 0.01 | 0.28 $\pm$ 0.02 | 0.27 $\pm$ 0.01 |
| <b>Q-T Interval</b> | Duration  | 0.37 $\pm$ 0.02 | 0.36 $\pm$ 0.01 | 0.42 $\pm$ 0.02 | 0.38 $\pm$ 0.02 | 0.40 $\pm$ 0.02 | 0.41 $\pm$ 0.02 |

**Table 2:** Mean  $\pm$  SEM values of Amplitude and Duration of P, R and T and the durations of Q, QRS-Complex P-R and Q-T intervals for racing horses in Lead I, II and III, aVR, aVL and aVF

|                     |           | Lead I          | Lead II         | Lead III        | aVR             | aVL             | aVF             |
|---------------------|-----------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| <b>P-Wave</b>       | Amplitude | 0.22 $\pm$ 0.04 | 0.40 $\pm$ 0.02 | 0.29 $\pm$ 0.03 | 0.26 $\pm$ 0.03 | 0.15 $\pm$ 0.05 | 0.33 $\pm$ 0.02 |
|                     | Duration  | 0.10 $\pm$ 0.03 | 0.09 $\pm$ 0.01 | 0.08 $\pm$ 0.01 | 0.08 $\pm$ 0.01 | 0.06 $\pm$ 0.01 | 0.09 $\pm$ 0.01 |
| <b>Q-Wave</b>       | Duration  | 0.04 $\pm$ 0.00 | 0.04 $\pm$ 0.00 | 0.04 $\pm$ 0.00 | 0.04 $\pm$ 0.00 | 0.04 $\pm$ 0.00 | 0.04 $\pm$ 0.00 |
| <b>R-Wave</b>       | Amplitude | 0.87 $\pm$ 0.10 | 1.07 $\pm$ 0.14 | 0.66 $\pm$ 0.14 | 0.75 $\pm$ 0.13 | 0.63 $\pm$ 0.10 | 0.92 $\pm$ 0.14 |
|                     | Duration  | 0.08 $\pm$ 0.01 | 0.09 $\pm$ 0.01 | 0.08 $\pm$ 0.01 | 0.07 $\pm$ 0.01 | 0.07 $\pm$ 0.01 | 0.08 $\pm$ 0.01 |
| <b>T-Wave</b>       | Amplitude | 0.40 $\pm$ 0.06 | 0.67 $\pm$ 0.10 | 0.53 $\pm$ 0.11 | 0.56 $\pm$ 0.08 | 0.32 $\pm$ 0.09 | 0.68 $\pm$ 0.09 |
|                     | Duration  | 0.09 $\pm$ 0.01 | 0.11 $\pm$ 0.01 | 0.09 $\pm$ 0.01 | 0.11 $\pm$ 0.01 | 0.07 $\pm$ 0.02 | 0.11 $\pm$ 0.01 |
| <b>QRS-Complex</b>  | Duration  | 0.12 $\pm$ 0.01 | 0.12 $\pm$ 0.01 | 0.11 $\pm$ 0.01 | 0.12 $\pm$ 0.01 | 0.12 $\pm$ 0.00 | 0.11 $\pm$ 0.01 |
| <b>P-R Interval</b> | Duration  | 0.27 $\pm$ 0.02 | 0.27 $\pm$ 0.02 | 0.29 $\pm$ 0.02 | 0.27 $\pm$ 0.02 | 0.26 $\pm$ 0.02 | 0.24 $\pm$ 0.01 |
| <b>Q-T Interval</b> | Duration  | 0.38 $\pm$ 0.02 | 0.38 $\pm$ 0.02 | 0.45 $\pm$ 0.03 | 0.38 $\pm$ 0.03 | 0.36 $\pm$ 0.03 | 0.42 $\pm$ 0.02 |

lead aVL. Duration of QRS complex was highest and equal in leads I, II, aVR and aVL but lowest in lead and aVF. Highest value of R-R interval was obtained in lead III but lowest in aVF. The duration of Q-T interval was highest in lead III and lowest in lead aVL. Comparison of the various waves between racing and non-racing horses is presented in Table 3. P-wave duration and amplitude were highest in racing horses in Lead I and Lead II respectively. Highest value of Q-wave duration was recorded in non-racing horses in Lead I. Racing horses had higher record of R-wave duration and amplitude in Lead II. T-wave amplitude was highest in non-racing horses in Lead II while the duration was highest in racing horses in Lead II. QRS duration exhibited uniformity in Leads I, II, and aVL. Highest records of P-R and Q-T durations were obtained in racing horses in Lead III. Percentage of positive and negative deflections of various waves is presented in Figure 1. Both positive and negative deflections of P and T-waves as well as QRS complex were recorded in both racing and non-racing horses. Positive P-wave deflection was predominant in both racing and non-racing horses while positive T-wave was predominant in non-racing horses but negative T-wave

predominated in racing horses. However, negative QRS complex was predominant in both racing and non-racing horses. Various forms of QRS complexes were recorded in both racing and non-racing horses with qR predominant in both racing and non-racing horses as indicated in Figure 2.

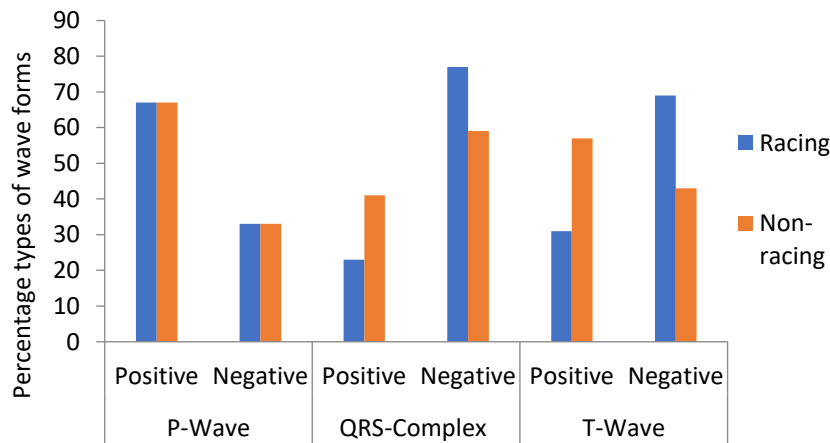
### Discussion

The mean and standard error of mean values of heart rate for the racing and non-racing horses were 80.3  $\pm$  8.4 and 63.1  $\pm$  9.2 beats/minute respectively. The values recorded of P amplitude, P-R interval, R amplitude and Q-T duration in non-racing horses were lower than that recorded by Mantovani *et al.* (2013) and this could be attributed to the difference in the breed of horses used and could also be due to the difference in the management system. It could also be related to the difference in environmental factors such as climate and topography. Highest P-wave amplitude and duration were found in racing horses in leads II and I respectively. This could be an adaptive response to sporting activities due to increased venous return to enhance oxygen supply to

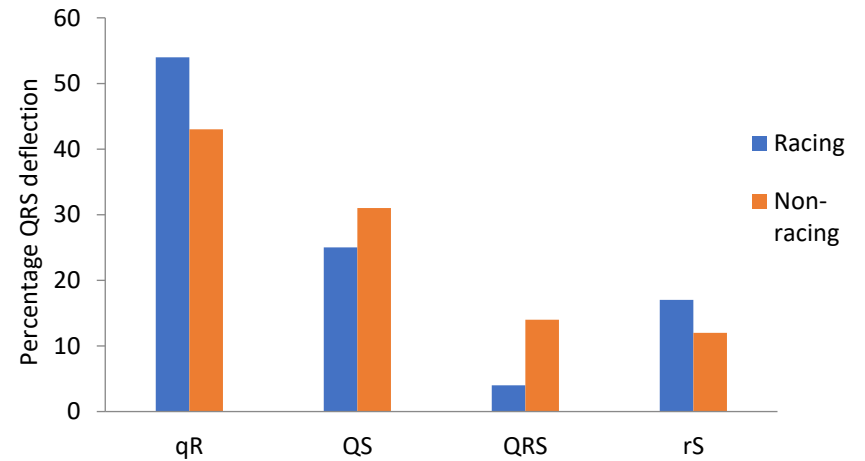
**Table 3:** Comparison of values of Amplitude and Duration of P, Q, R, T and the durations of QRS-Complex P-R and Q-T intervals for racing and non-racing Horses in Lead I, II and III

|            |     | Lead I     |           | Lead II    |           | Lead III   |           | aVR        |           | aVL        |           | aVF                    |                        |
|------------|-----|------------|-----------|------------|-----------|------------|-----------|------------|-----------|------------|-----------|------------------------|------------------------|
|            |     | Non-racing | Racing    | Non-racing | Racing    | Non-racing | Racing    | Non-racing | Racing    | Non-racing | Racing    | Non-racing             | Racing                 |
| <b>P</b>   | Amp | 0.16±0.02  | 0.22±0.04 | 0.39±0.05  | 0.40±0.02 | 0.26±0.02  | 0.29±0.03 | 0.26±0.03  | 0.26±0.03 | 0.14±0.03  | 0.15±0.05 | 0.32±0.03              | 0.33±0.02              |
|            | Dur | 0.05±0.01  | 0.10±0.03 | 0.08±0.01  | 0.09±0.01 | 0.08±0.01  | 0.08±0.01 | 0.09±0.01  | 0.08±0.01 | 0.06±0.01  | 0.06±0.01 | 0.08±0.01              | 0.09±0.01              |
| <b>Q</b>   | Dur | 0.05±0.01  | 0.04±0.00 | 0.04±0.00  | 0.04±0.00 | 0.04±0.00  | 0.04±0.00 | 0.05±0.01  | 0.04±0.00 | 0.04±0.00  | 0.04±0.00 | 0.04±0.00              | 0.04±0.00              |
| <b>R</b>   | Amp | 0.83±0.11  | 0.87±0.10 | 0.86±0.16  | 1.07±0.14 | 0.60±0.10  | 0.66±0.14 | 0.78±0.11  | 0.75±0.13 | 0.70±0.06  | 0.63±0.10 | 0.66±0.11              | 0.92±0.14              |
|            | Dur | 0.09±0.01  | 0.08±0.01 | 0.08±0.01  | 0.09±0.01 | 0.08±0.01  | 0.08±0.01 | 0.09±0.01  | 0.07±0.01 | 0.08±0.01  | 0.07±0.01 | 0.08±0.01              | 0.08±0.01              |
| <b>T</b>   | Amp | 0.38±0.11  | 0.40±0.06 | 0.69±0.12  | 0.67±0.10 | 0.35±0.07  | 0.53±0.11 | 0.61±0.09  | 0.56±0.08 | 0.29±0.04  | 0.32±0.09 | 0.43±0.07 <sup>a</sup> | 0.68±0.09 <sup>a</sup> |
|            | Dur | 0.10±0.02  | 0.09±0.01 | 0.10±0.01  | 0.11±0.01 | 0.09±0.01  | 0.09±0.01 | 0.11±0.01  | 0.11±0.01 | 0.08±0.01  | 0.07±0.02 | 0.08±0.01              | 0.11±0.01              |
| <b>QRS</b> | Dur | 0.12±0.00  | 0.12±0.01 | 0.12±0.01  | 0.12±0.01 | 0.10±0.01  | 0.11±0.01 | 0.12±0.01  | 0.12±0.01 | 0.12±0.00  | 0.12±0.00 | 0.10±0.01              | 0.11±0.01              |
| <b>P-R</b> | Dur | 0.28±0.01  | 0.27±0.02 | 0.25±0.02  | 0.27±0.02 | 0.26±0.02  | 0.29±0.02 | 0.28±0.01  | 0.27±0.02 | 0.28±0.02  | 0.26±0.02 | 0.27±0.01              | 0.24±0.01              |
| <b>Q-T</b> | Dur | 0.37±0.02  | 0.38±0.02 | 0.36±0.01  | 0.38±0.02 | 0.42±0.02  | 0.45±0.03 | 0.38±0.02  | 0.38±0.03 | 0.40±0.02  | 0.36±0.03 | 0.41±0.02              | 0.42±0.02              |

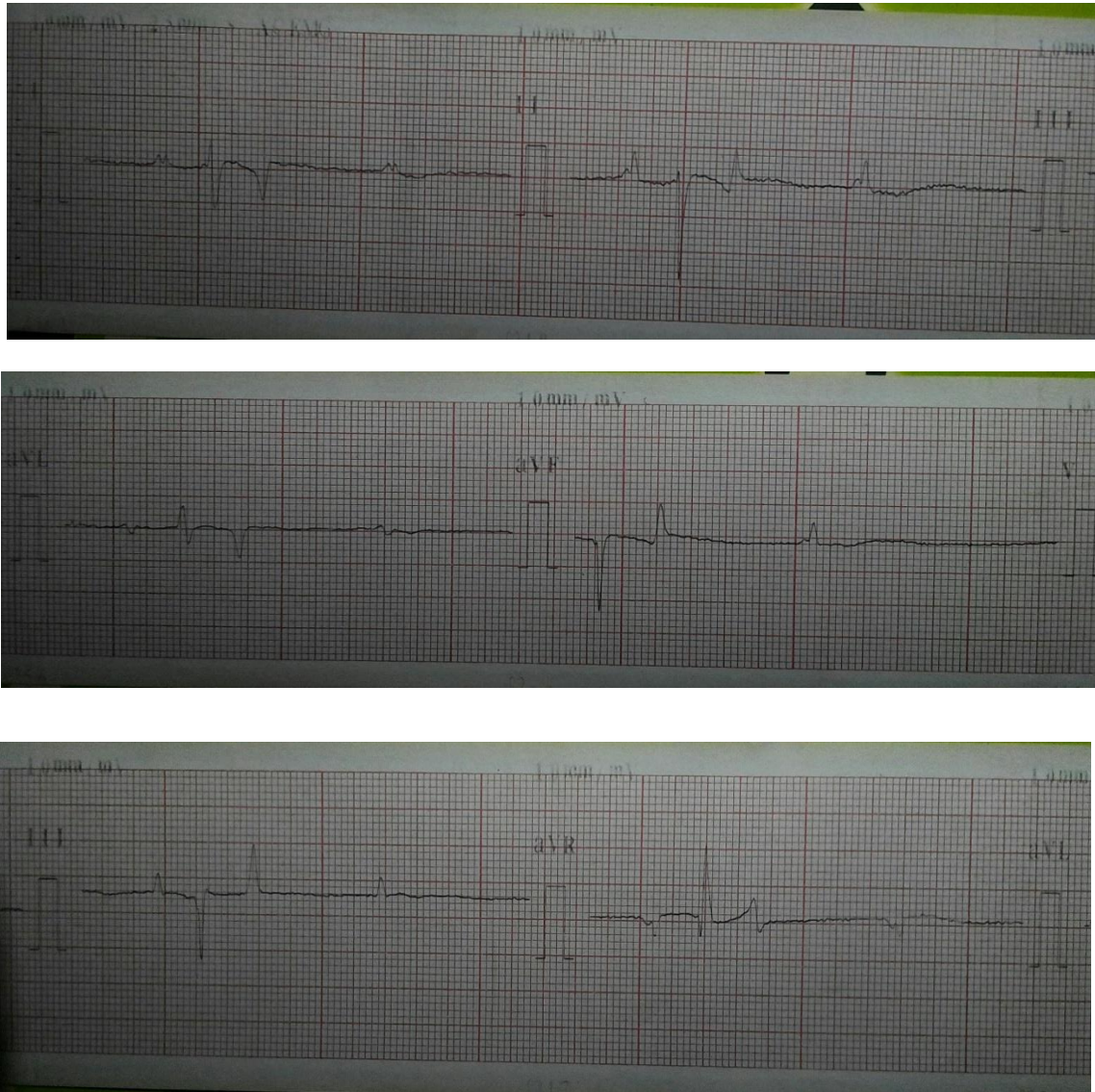
Means with the same superscript on the same row are significantly different (p<0.05)



**Figure I:** Percentage type of deflections of P-Wave, T-Wave and QRS-Complex of racing and non-racing Horses



**Figure II:** Percentage types of QRS complexes in racing and non-racing horses



**Figure 3:** ECG tracing of racing horses in Sokoto

generate energy required for racing activities. Although the difference is not significant, this finding is consistent and similar to the studies of Dojana *et al.* (2008). Q-wave duration was highest in lead I in non-racing horses while highest record of R-wave amplitude was found in racing horses in lead I. R-wave duration was highest in non-racing horses in leads I and aVR, but highest in racing horses in lead II with no statistically significant difference. Highest amplitude of T wave was recorded in racing horses. This conforms with the findings of Rose & Davis (1978); Evans (1991); Dojana *et al.* (2008). which could imply that racing horses have longer ventricular repolarisation period to allow for increased

ventricular filling to increase cardiac output and enhance distribution and supply of oxygen for energy generation to power the racing activities. Highest duration of P-R interval was recorded in racing horses; although not significant but was similar to the finding of Dojana *et al.* (2008). This could be attributed to adaptation to racing that promotes endurance and ability to tolerate racing activity thereby enhancing vagotonia. Highest duration of Q-T interval was also recorded in racing horses although not significant. QRS duration did not show any significant difference between racing and non-racing horses. QRS values were similar to those found by Dezfouli *et al.* (2006).

In conclusion, exercise affects electrocardiographic values most especially the T wave in racing horses and could signify adaptation to increased circulatory demand during racing activities. It is therefore recommended that the ECG of racing horses should be measured at different seasons of the year to ascertain if the changes could be attributed to seasonal variation.

#### Conflicts of Interest

The authors declare no conflict of interest.

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