ELECTROCARDIOGRAPHIC T-WAVE VECTORIAL DIRECTIONS IN PHILIPPINE THOROUGHBRED RACEHORSES

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ABSTRACT

Eighty apparently healthy island-born Thoroughbred racehorses were evaluated using the base-apex lead system of electrocardiography to characterize common T wave vectorial directions. In addition, age, sex, exercise frequency and best time record were evaluated to check if they have an influence on T wave vectorial directions. The racehorses exhibited three T wave vectorial directions – upward (53%), downward (16%) and bidirectional (31%). None of the factors like age, sex, exercise frequency and best time record contributed significantly to the changes in T wave vectorial direction. This is the first known report of common T wave vectorial directions in racehorses in the Philippines.

Keywords: electrocardiography, performance, racehorse, T wave

INTRODUCTION

Horses have been bred or adapted to a large variety of uses. These include leisure, draft, food and sport. As sporting animals, Thoroughbred racehorses run at high speed (18 m/s, 64 km/h) over distances of 800 to 5000 meters, making them superior athletes (Hinchcliff, 2005). The athletic ability of the horse can be attributed to physiological adaptations. Some of these adaptations can be acquired as a response to training, exercise, diet, environment as well as naturally-occurring factors like genetic superiority (Hinchcliff, 2008).

In the Philippines, the degree or extent of training given to racehorses depends mainly on the trainer's knowledge and experience without taking into consideration its cardiovascular capacity (Gicana, 2010). In addition, there are no known local published studies with regards to poor performance, sudden deaths and other cardiovascular abnormalities in racehorses.

Several foreign studies have reported utilization of electrocardiography (ECG) to diagnose cardiovascular problems and evaluate racing performance of Thoroughbred racehorses (Holmes *et al*., 1966; Rezakhani, 2005; Evans, 1991). In particular, some of these cardiovascular problems were related to abnormal T wave morphology (Muñoz *et al*., 2003; Steart *et al*., 1983).

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According to Khan (2008), normal morphology of T waves can be described as upright. Muñoz (2003), reported that abnormal T waves may be inverted or very tall in appearance. However, Kobluk (1995) and Colahan (1999) stated that changes in T waves are extremely variable and may not be consistently associated with a particular clinical entity.

The conflicting debate on whether T wave vectorial direction has a direct impact on exercise and performance of the horse has not been settled. The absence of a documented report under tropical condition with regards to the most common T wave vectorial direction necessitates the need for a local study. Furthermore, this study aims to characterize the different T wave vectorial directions and determine if these can be influenced by factors such as age, gender, exercise frequency and best time record. The values presented in this study can serve as a baseline data for cardiopulmonary screening in athletic animals, particularly horses. This will further help the practicing veterinarian to diagnose exercise intolerance and poor performance. Furthermore, this study can assist the trainers in their quest for developing superior athletes.

MATERIALS AND METHODS

Eighty (80) apparently healthy island-born Thoroughbred racehorses from San Lazaro Leisure Park were evaluated using a randomized design. The horses were classified based on gender (male and female) and age (less than 5 years old, 5-10 years old, greater than 10 years old). Exercise frequency (six or seven times a week) and best time record (less than 1.35, 1.35-1.40, greater than 1.40 min) were all noted and related if these can influence T wave vectorial direction in these animals. The weight of each animal (in kg) was determined through approximation technique using hearth girth and body length measurements. This was calculated by multiplying hearth girth (in^2) with body length (in) and dividing their product by 660 (in^3) as described by Speirs and Wrigley (1997). The frequency of exercise, past vaccinations and history of medical illness of each animal were all recorded using a questionnaire designed for the study.

The base apex lead system of ECG was used to evaluate cardiac function (Rezhakani *et al*., 2009). The animals were grouped according to age and intensity of the exercise regimen. A Class 1, type CF electrocardiogram machine, Dr. Lee ECG-120 B (Dr. Lee, Korea) and ECG thermal paper were used. The horses were subjected to electrocardiogram using the base-apex lead system. No anesthetics, sedatives or tranquilizers were used. The animals were placed in their stall boxes and were given 5-10 min rest prior to ECG. The procedure was conducted on a resting animal prior to exercise. This was done in 3 replicates at 30 min to 1 hour interval. Alcohol was used to clean and disinfect the skin surface and allow proper surface contact. Alligator clips were used to attach the electrodes to specific points on the skin of the animal following the descriptions of Hallowell (2008). The left arm electrode (yellow) was placed over the cardiac apex while the right arm electrode (red) was placed over the heart base near the right jugular furrow (Figure 1). The ground cable (black) was attached to the neck. Lead I of the ECG was recorded and printed on a standard ECG thermal paper (50 m/m and 30 m length) and calibrated at 50 mm/sec and 1 mV/cm scale. Each recording was mounted on paper, interpreted and analyzed.

In interpreting the electrocardiogram, the heart rate of each animal was first computed. This was achieved by counting the number of small boxes between R-R intervals. The computed heart rate was then recorded in each data sheet provided. The direction of the T wave was reported either as upward (positive), downward (negative) or bidirectional (biphasic) based on the report of Colahan (2009). They were then recorded and tabulated based on age, gender, exercise frequency and best time record.

The data collected were analyzed using Chi square test of independence with level of significance at P<0.05. This test of independence was used to determine if age, gender, exercise frequency and best time record were associated with the T wave direction.

Figure 1. Base- apex ECG lead placement in a Thoroughbred racehorse.

RESULTS AND DISCUSSION

T wave directions for the 80 horses included in the study showed that 52.5% (42) of the sample population had T waves that were upward in appearance (Figure 2), 16.2% (13) exhibited a downward T wave vectorial direction (Figure 3) while 31.2% of the samples had bidirectional T wave vectorial direction (Figure 4).

Table 1 shows the frequency of T wave vectorial directions at different age groups. Of all the racehorses used, 55% are less than 5 years of age, 43% were 5-10 years old, and 1.2% were more than 11 years of age. Among the horses aged less than 5 years, 50% had upward T waves, 20% had downward and 29% had bidirectional T waves. For horses aged 5-10 years old, 57% have upward, 11% downward and 31% bidirectional T wave directions. One horse aged greater than 11 years old, showed 1 bidirectional T wave. Statistical analysis showed that the observed differences in T wave vectorial directions were not significantly different. The observed differences in terms of values among age groups may be more of

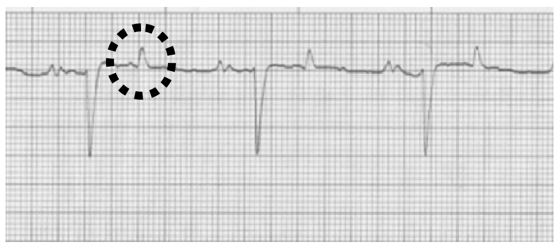

Figure 2. Upward T wave vectorial direction (dashed circle) in a Thoroughbred racehorse.

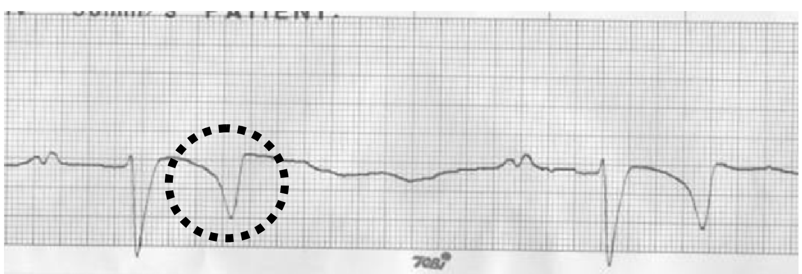

Figure 3. Downward T wave vectorial direction (dashed circle) in a Thoroughbred racehorse.

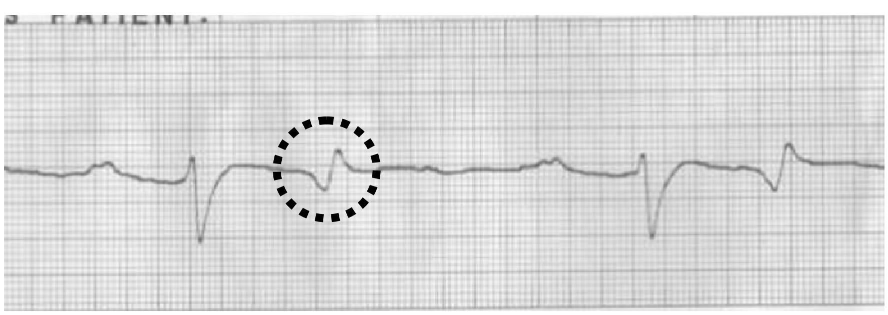

Figure 4. Bidirectional T wave vectorial direction (dashed circle) in a Thoroughbred racehorse.

individual responses to various factors rather than collective effects of age to T wave vectorial direction.

Racehorses are expected to reach their optimum performance within the 5-6 year old range. This is believed to be coupled with significant changes in their cardiovascular function as well as ECG waveform values (Gicana, 2010). But this study showed that alterations in T wave vectorial direction may not be solely dependent on the age of the animals. Like cardiovascular function, T wave vectorial directions may be influenced by interplay of several factors rather than by a single variable.

Table 1. Relationship between age and T wave vectorial direction in Thoroughbred racehorses.

Age	Upward	Downward	Bidirectional	Total
<5 years old	22	9	13	44
5-10 years old	20	4	11	35
>11 years old	0	0	1	1
Total	42	13	25	80

*No differences were observed among columns using the Chi square test ($P<0.05$).

Table 2 shows the frequency of the different T wave vectorial directions among male and female Philippine racehorses. The data showed that 66.6% (26/39) of the males and 39% (16/41) of females have an upward T wave vectorial direction. Downward T wave vectorial direction was encountered more frequently in females (24.4%) than in males (7.69%). Bidirectional T wave was seen in 36.6% of the female population and 25.6% in the male population. However, these differences were not statistically significant.

Table 2. Relationship between gender and T wave vectorial direction in Thoroughbred racehorses.

Sex	Upward	Downward	Bidirectional	Total
Male	26	3	10	39
Female	16	10	15	41
Total	42	13	25	80

*No differences were observed among columns using the Chi square test ($P<0.05$).

The observed differences in the directions of the T wave among male and female racehorse may be influenced by several factors. According to Khan (2008), the normal morphology of the T wave is upright. This is considered the positive deflection (Edwards, 1997). This means a normal repolarisation process occurred within the heart. On the contrary, downward or bidirectional or very tall (high upright)

T waves are considered abnormal as these abnormalities may denote pathological conditions such as electrolyte imbalance, particularly hyperkalemia (Muñoz *et al*., 2003) .

A downward or bidirectional T wave is attributable to differences in the normal repolarisation pathway of the heart (Khan, 2008). A normal upward (positive) deflection is seen when the electrical potentials alongside the ventricular walls start repolarising. This means they are more or less uniform in reaching relaxation phase. However, a possible scenario of scattered electrical impulses that may be due to dilatation, hypertrophy, regurgitation or valvular insufficiencies may cause differences in the direction of the T wave.

Elevated T waves may be part of the early repolarisation syndrome that may be secondary to increased ventricular mass (Turpeinen *et al*., 1996). As stated by Colahan (1999), T wave differences may be related to the ventricular mass of the animal (Colahan *et al*., 1999). Among gender, a study made by Buhl (2008) pointed out that the differences in the ventricular mass between male and female horses may be due to the increased anabolic hormones circulating in the horse's body, particularly in males. These hormones contribute to the increase of skeletal and myocardial mass of male horses. In addition, certain pathological conditions may influence the travel of electrical potentials along the ventricular walls leading to changes in the wave form directions (Muñoz *et al*., 2003). These conditions include atrio-ventricular blocks, atrial fibrillation, electrolyte imbalances or structural deformities.

The observed differences among gender were not statistically significant. Thus, gender alone does not have an influence in the T wave vectorial direction. Furthermore, gender cannot be used to evaluate performance of the horse nor predict its winning chances. This observation is consistent with the findings of Gicana (2010) stating that gender alone does not impose inherent differences in various ECG waveforms.

Table 3 compares the T wave vectorial direction at different frequencies of exercise. Overall, 71% of the racehorses showed an upward T wave vectorial direction while only 3% of the racehorses showed a downward T wave vectorial direction. Bidirectional T waves were seen in 26% of the racehorses. For horses that engaged in exercise training six-times-a-week, 68% upward, 2% downward and 30% bidirectional T waves were observed. On the other hand, horses that received seven times a week training showed 75% upward, 3% downward and 22% bidriectional T waves.

Table 3. Relationship between exercise frequency and T wave vectorial direction in Thoroughbred racehorses.

Exercise frequency	Upward	Downward	Bidirectional	Total
6 times a week	30	1	13	44
7 times a week	27	1	8	36
Total	57	2	21	80

*No differences were observed among columns using the Chi square test (P<0.05).

The data revealed that in both six and seven times a week training, upward T wave is most commonly observed. It also showed that majority of the trainers and their horses are still engaged in a six-times-a-week training. The relationship between the frequency of exercise and T wave vectorial directions was not statistically significant. This means that although exercise plays a big role in the development of good cardiovascular performance, there are still other factors that need to be considered in conditioning the animals. These factors include exercise gaits, nutrition, genetic advantage and even body weight (Gicana, 2010). Changes in the normal T wave morphology may denote that abnormal ventricular repolarisation is present (Kasumoto, 2009). The presence of an abnormal ventricular repolarisation may affect the cardiac filling time causing changes in the cardiac output as well as the stroke volume of the heart leading to a decreased efficiency in circulation and ultimately poor performance of the horse (Hinchcliff, 2008).

The best time records of each of the samples were compared with the different T wave vectorial directions (Table 4). Horses were divided into three groups with different best time records (BTR): <1.35 min, 1.35-1.40 min and >1.40 min. The majority of the T wave vectorial alterations occurred mainly in horses whose BTR was 1.35-1.40 min (80%). Within this group, upward T wave vectorial direction was seen in 34 out of the 64 (53%) horses. Downward and bidirectional T waves were seen in 16% and 31% horses, respectively. Horses with BTR <1.35 min showed upward T wave vectorial direction in 5 out of 10 (50%). Only 1 horse presented a downward T wave vectorial direction whose BTR was <1.35 min while 4 horses presented a bidirectional T wave vectorial direction. Although there were observed differences among groups of animal, values were not statistically significant.

Table 4. Relationship between best time record and T wave vectorial direction in Thoroughbred racehorses.

Best time record	Upward	Downward	Bidirectional	Total
<1.35 min	5	1	4	10
1.35-1.40 min	34	10	20	64
>1.40 min	3	2	1	6
Total	42	13	25	80

No differences were observed among columns using the Chi square test ($p<0.05$).

The BTR is a direct measurement of the performance level of the horse. It is believed that heart rates can influence this performance. Gicana (2010) stated that age, sex, body weight exercise and abnormal ECGs can affect the BTR and ultimately the performance of the animal. In this study, there was no relationship between BTR and T wave vectorial directions. Thus, despite the presence of varying T wave vectorial directions, an animal can still win. Furthermore, this study cannot conclude if presence of T wave vectorial variations can really alter future performance of the horse.

The significance of this study highlights the need for close monitoring of horses undergoing training to prevent cardiovascular function alteration that may have a future impact in their overall performance. This will prevent sudden deaths, poor performance and irreversible cardiac damages to the horse athletes. Trainers and veterinarians may use different diagnostic tools, like ECG, in monitoring the effectiveness of their training regimens in their quest to develop a superior racing animal.

In this study, it was found out that racehorses have three T wave vectorial directions – upward, downward and bidirectional. Majority of the racehorses in the Philippines showed upward T waves at 53% followed by bidrectional at 31% and lastly, downward at 16%. There was no single factor evaluated that showed significant influence on T wave vectorial direction. This study only considered T wave vectorial direction and its relationship to various factors. However, relationship of the presence of T wave vectorial directions to concrete clinical abnormalities like hyperkalemia and other disorders were not considered. Also, the presence of cardiovascular disorders was not evaluated using complementary diagnostic tools like echocardiography and radiography. This will be a good future research direction in the field of electrocardiography in horses as well as their cardiopulmonary functions.

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