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Short communication

ELECTROCARDIOGRAPHIC RESPONSE TO EXERCISE IN RACE HORSES DURING THE TRAINING SEASON

S. P. SABEV, D. T. KANAKOV & P. I. PETKOV

Faculty of Veterinary Medicine, Trakia University, Stara Zagora, Bulgaria

Summary

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In the present study, electrocardiography was performed before and immediately after the end of exercise in five female Hanoverian horses during the training season. The apex/base lead I was used. The influence of exercise on the amplitude and duration of the ECG complexes was recorded. Some abnormalities of cardiac rhythm (second-degree AV block, ventricular premature complexes) during rest were noted, too. Deviation in the length of P, S, R waves and the PQ interval were established after physical exertion. It was found out that exercise had no significant effect upon ECG wave amplitudes.

Key words: electrocardiography, horses, parameters

Electrocardiography is an important clinical diagnostic method to investigate the cardiac function of sports horses. Beside the standard peripheral leads, similar to those used for humans and dogs, some modified systems have been introduced in practice to measure cardiac biopotentials (apex/base lead). According to Holmes (1990) and Bonagura & Reef (2004), this lead is particularly suitable for tracking the heart rhythm of horses. The applicability of the modified method was also confirmed by the studies of Gabriel & Lekeux (1986), Reef (1989), and Gattland & Holmes (1990), regarding the incidence and diagnostics of supraventricular and ventricular arrhythmias in race horses.

The orientation, amplitude, and length of ECG elements depend on the animal's age (Tovar *et al.*, 1989), the lead system, the heart cavities volume, the respiration phase (Miller & Holmes, 1984; Grauerholz & Jaeschke, 1990) and the extent of the horses' training (Grauerholz, 1990). Detweiler *et al.* (1972) and Fregin (1982) have proposed reference values for the different ECG elements for different lead systems, with regard to the animals' age. The changes in the electrocardiogrammes of sports horses have been studied for different extents of physical load through standard bipolar leads (Gainutdinov & Karmanugov, 1981). In published references, no data could be found regarding the influence of physical exercise on the ECG with the modified lead system. According to a number of authors that had worked on the cardiology of horses (Reef, 1989, 1999; Raekallio, 1991; Scheffer *et al.*, 1995) bipolar thoracic leads are applicable to determine deviations in the work of the heart, such as arrhythmias, atrioventricular blocks, fibrillations, and preliminary depolarisation.

The aim of the current research was to determine the influence of physical load on the duration and amplitude of the different ECG elements in horses, as well as some deviations in the normal cardiac rhythm.

The study was performed at the Horse Breeding facilities of Trakia University with 5 female Hanoverian horses, aged 5–8 years. The horses were not pregnant and had been trained for 60 days. Just before the study, the heart and respiratory rates of animals were established by auscultation. The electrocardiography was performed using a Cardipia 400 (Trismed Co., South Korea) device. The needle electrodes were attached along the projection of the heart axis (base-apex lead), with the positive electrode fixed right behind the elbow, and the negative – in front of the rim of the scapula. The recording was done in tri-channel format, manual mode, rate of 25 mm/sec, sensitivity of 10 mm/1 mV, with enabled drift, muscle and AC filtres. Each animal was tested twice: before and immediately after training. No sedatives were used. The physical load was achieved through initial trotting for 15 min, followed by jumping over obstacles (1–1.5 m in height) for 20 min. The results on ECG waves' amplitudes interval lengths were statistically processed by means of ANOVA with limit of significance P<0.05.

In lead I, accepted as standard for horses, the P wave was well-expressed, positive, and predominantly biphasic. The Q wave was clearly distinguished and also positive. The R wave (part of the ventricular QRS complex) was clearly distinguished by its negative orientation and high amplitude. The S wave was on the isoelectric axis and in most cases, hardly apparent on ECG graphs. The highest variability was established for the T wave. Its amplitude varied from 0.5 to 1.2 mV. The biphasic shape was the most commonly observed, but there were also waves with sharp-summit and bifid shapes (Fig. 1). In most ECG records in lead I, the T wave was negative. There were no statistically significant changes in amplitudes of waves before and after training (Table 1).

The ECG performed immediately after training indicated a change in the lengths of the intervals (Table 2). A shortage in the duration times of waves P and T, the

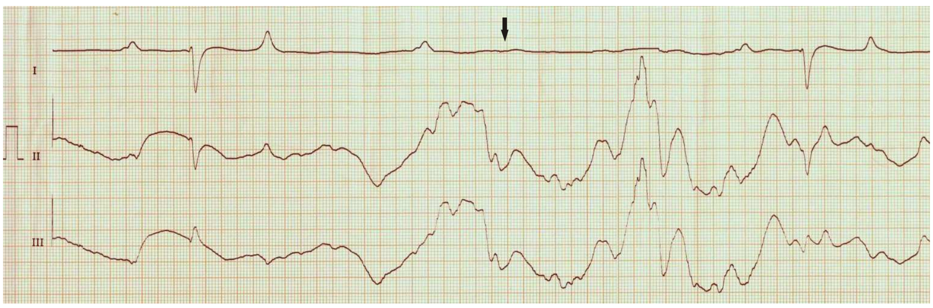

Fig. 1. Second-degree atrioventricular block (Mobitz I type). The arrow shows the site of the lacking ventricular complex.

atrial PQ complex , and the S wave was established. The duration of R waves was prolonged by 0.01–0.05 s. The described changes were statistically significant (P<0.01).

Table 1. Heart rate (min^{-1}) and wave amplitudes (mV) before and after physical exercise in Hanoverian mares. Values are presented as mean± SD, n=5)

Parameter	Before exercise	After exercise
Heart rate	37.20±6.45	66.20±1.11*
P wave	0.46±0.20	0.42±0.19
Q wave	0.24±0.11	0.22±0.08
R wave	1.72±0.41	1.96±0.34
S wave	0.18±0.08	0.18±0.04
T wave	0.78±0.31	0.92±0.16

* P<0.01 between periods before and after exercise.

Table 2. ECG interval durations (s) before and after physical exercise in Hanoverian mares. Values are presented as mean± SD, n=5)

Parameter	Before exercise	After exercise
P wave	0.138±0.010	0.112±0.010*
PQ interval	0.316±0.020	0.266±0.010*
QRS complex	0.152±0.010	0.146±0.005
R wave	0.072±0.010	0.100±0.010*
S wave	0.156±0.020	0.080±0.007*
T wave	0.124±0.005	0.114±0.020
QT interval	0.476±0.050	0.488±0.010

* P<0.01 between periods before and after exercise.

During the initial ECG testing of one 6-year old mare, the presence of a second-degree atrioventricular block was established, manifested by gradual elongation of PQ intervals, preceding the omission of a ventricular complex (type Mobitz I, Fig. 1). This condition was not accompanied by other cardiac deviations, and because of that the horse was still included in the study. During the second testing, after the physical exercise session, the block was not re-diagnosed. For another horse, a rhythmic disturbance appeared in the ECG, expressed as a preliminary ventricular complex (Fig. 2). After the training session and the second ECG testing, the arrhythmia was not found.

The lack of significant changes in wave amplitudes, before and after physical exercise, could be explained with the high extent of training and the relatively light physical effort that the horses endured. On the other hand, there is a theory that some peculiarities in the innervation of the equine heart, exhibited by the deeper penetration of the Purkinje's myocardial fibres and the instant and simultaneous transmission of impulses, do not lead to the appearance of changes in the wave heights on the ECG, even in cases of hypertrophied and dilated atria and ventricles (Anonymous, 2006).

Our results regarding the deviations in the cardiac rhythm confirm the data reported by other authors (Physick-Sheard, 1999; Bonagura & Reef, 2004; Anonymous, 2006). According to our studies, the base-apex lead can be successfully applied for the diagnostics of this type of abnormalities.

The differences in the P wave shape are not considered pathological in horses (Illera *et al.*, 1987; Kriz, 1999; Marlin & Nankervis, 2002). Unlike other animal species and humans, polymorphisms in atrial complexes are a frequent finding in healthy horses. Our results regarding their length and shape correspond with the data reported by the abovementioned authors. The shortening of the P wave after physical exercise, established in our study, is related to changes in the tonus of the vagus nerve. It confirms the changes in the

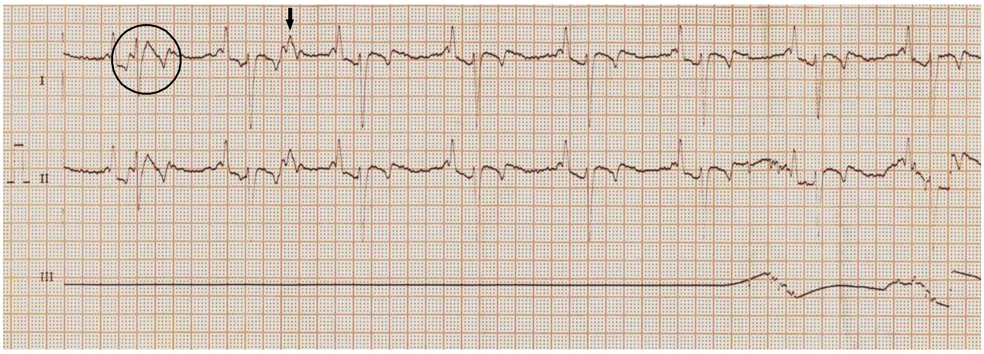

Fig. 2. Premature ventricular complex, differing by both shape and duration from others. The next T-wave is positive and bifid (arrow). The other T-waves are single-peak and negative.

duration times of the atrial systole in horses, as described by others (Bonagura & Reef, 2004).

The high amplitude of the peak R (1.72 mV, 1.96 mV), reflecting the depolarisation of the ventricles, is due to their higher mass, respectively higher number of active cells, as compared to the atria. Our results regarding the R wave amplitude are different from those of Detweiler & Patterson (1972) and Fregin (1982), produced in different lead systems. The negative direction can be explained with the fact that this wave reflects the movement of the electric impulse through the ventricular septum, which is in the direction from the apex to the base of the heart, i. e. opposite to the primary vector. The low amplitude of the S wave can be explained with the specific location of the electrodes on the horse body. The changes found out in the T wave before and after physical exercise cannot be considered as indicators of pathological deviations in the work of the heart, and are due to physiological, not organic changes of the cardiac muscle. Similar variations have been described by other authors (Matsui & Sugano, 1987). The graphical expression of ventricular repolarization is in accordance with other studies, regarding its variability (King *et al.*, 1994; Kostov, 1995; Kriz, 1999; Munoz *et al.*, 2005). Physical activity, stress, and limb position have a direct relation to the shape, amplitude, and length of the T segment. The shortening in the duration of P and S waves, as well as of the atrial PQ complex, is due to increased sympathetic activity and the subsequent tachycardia.

In conclusion, normal-intensity physical exercise of horses (jumping over obstacles) was not related to changes in the amplitudes of cardiac complexes. They resulted in shortened times of the atrial systole (PQ complex) and the S wave, and are accompanied by elongated R wave. Rhythmic deviations in the heart's work during the resting period did not reduce the physical tolerance during exercise.

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Correspondence:

Dr. S. Sabev
Department of Internal
Non-Infectious Diseases,
Faculty of Veterinary Medicine,
Trakia University,
6000 Stara Zagora, Bulgaria