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Physical and electrocardiographic evaluation of horses used for wagon traction

[*Avaliação física e eletrocardiográfica de cavalos utilizados para tração de carroças*]

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ABSTRACT

The objective of this research was to evaluate the electrocardiogram (ECG) of horses used for wagon traction and to compare the results with the parameters obtained from inactive horses or horses submitted to a training routine. Fifty-six 3-15-year-old healthy horses (22 females and 34 males) were divided into three groups: control (without a work routine; N=21), wagon traction (N=25) and athlete (N=10) and submitted to physical examination and ECG (at rest). The rhythm, heart rate (HR), amplitude and duration of ECG waveforms and intervals were obtained from the frontal plane and base-apex leads. Heart score (HS) was calculated using the arithmetic mean of QRS duration in LI, LII and LIII. Measurements of ECG waves were smaller in control group, in comparison with wagon traction and athlete groups, suggesting that exercise can change ECG. Similar results were observed in the wagon traction and athlete groups, but the electrophysiological adjustments to exercise were not the same for these groups.

Keywords: ECG, equine, cart horses, cardiovascular system, heart score

RESUMO

O objetivo deste trabalho foi avaliar o eletrocardiograma (ECG) de cavalos que tracionavam carroças (carroceiros; N=25), comparando os resultados com os parâmetros de cavalos que não realizavam essa atividade (controles; N=21), ou que apresentavam uma rotina de treinamento (atletas; N=10). O ECG foi precedido pelo exame físico do animal e, a partir das derivações no plano frontal e na base-ápice, determinou-se o ritmo, a frequência cardíaca, a amplitude e a duração das ondas e dos intervalos, em repouso. O escore cardíaco foi calculado pela média aritmética da duração do complexo QRS em DI, DII e DIII. O grupo controle apresentou menores valores de amplitude e duração das ondas do ECG, em comparação aos grupos carroceiro e atleta, sugerindo que o exercício pode alterar o ECG. Resultados semelhantes foram observados nos grupos carroceiro e atleta; contudo, os ajustes eletrofisiológicos ao exercício não foram os mesmos para esses dois grupos.

Palavras-chave: ECG, equinos, tração de carroças, sistema cardiovascular, escore cardíaco

INTRODUCTION

The use of horse force represents a major social and economic activity at inner cities of Sao Paulo state. Horses used for wagon traction undergo intense activity and prolonged work. That exhaustive routine is not preceded with a conditioning period and veterinary assistance. Most of these animals will never go through cardiovascular evaluation. According to literature, horses used for wagon traction are usually 2-20-year-old crossbred animals from both genders (Andrade *et al.*, 2009; Alves *et al.*, 2010).

Equine cardiovascular evaluation includes direct inspection of mucosa and veins, palpation of cardiac shock (in precordial region) and arterial pulse (head and limbs), cardiac auscultation (in all valve areas) and indirect inspection by complementary exams such as electrocardiogram (ECG). ECG records electrical impulses from

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heart in waveforms (P wave – QRS complex – T wave) to determine the heart rate, and observes normal and pathological rhythm and electric conduction disorders (Fernandes *et al.*, 2004).

Base-apex and the bipolar standard are ECG leads commonly used in horses. Some authors consider the base-apex lead more suitable for heart rhythm evaluation, since the electrodes are not placed on the limbs. Thereby, ECG can be better tolerated diminishing animal excitement and artifacts during the evaluation (Bonagura *et al.*, 2010). However, the bipolar leads are widely used for the study of electric vector direction in the heart (Radostits *et al.*, 2002).

According to Steel and Stewart (1974), the duration of the QRS complex is influenced by heart size. Therefore, these authors established the heart score to estimate the heart size, correlating it with animal performance. Athletic horses (with good physical conditioning) present heart score values close to or greater than 100 ms (Bello *et al.*, 2012). We found no literature about heart score in wagon traction horses.

Exercise intolerance associated with cardiac disorders are common in horses (Melchert *et al.*, 2012; Schwarzwald, 2013); even so, there are few data about heart compromising in pulling wagon horses, even though these animals are often subjected to intense and prolonged exercise.

The objective of this study was to evaluate the cardiovascular system of horses used for wagon traction, through clinical examination, ECG (at rest) and heart score, also to compare the results with values obtained for athletic and idle horses (animals that do not perform routine physical activity).

MATERIALS AND METHODS

In this study, fifty-six 3-15-year-old healthy horses were evaluated. The animals were divided into three groups: control - composed of 21 crossbred horses (7 males and 14 females) not subjected to physical effort; wagon traction - with 25 crossbred horses (17 males and 8 females), who pulled the wagon, routinely, with loads and people; athlete - with 10 Arabian Purebred horses (male) trained on the circular exerciser three times per week. The type and frequency of physical activity were investigated during the anamnesis. The experimental protocol (number 13.1.2366.74.0) was approved by the Research Ethics Committee (CEP-FZEA).

Physical examination established animal health condition based on mucosa inspection (ocular and conjunctiva), capillary refill time, cardiac shock (in precordial region), arterial pulse (carotid and coccygeal) and cardiac auscultation. Thoracic tape weighing estimated horse weight.

ECG at rest was obtained with Cardiocare 2000 electrocardiograph (Bionet®) used to register: bipolar (LI, LII, LIII), unipolar augmented (aVR, aVL and aVF) and base-apex leads, at speed 25mm/s and sensibility 1cm=1mV. The electrodes were placed according to the techniques described by Fernandes *et al.* (2004) and Lessa *et al.* (2012), respectively.

Electric axis was determined by QRS polarity in the bipolar and unipolar augmented leads. In LII and base-apex, the rhythm, heart rate (HR), P-R/QT intervals, amplitude and duration of waves and QRS complex were obtained. The heart score (HS) was calculated by arithmetic mean of the QRS complex duration at LI, LII and LIII, using the formula: HS = QRS (ms) LI + QRS (ms) LII + QRS (ms) LIII/ 3 (Bello *et al.*, 2012).

Results were submitted to descriptive statistics and variance analysis (by *Feisher Snedecor* hypothesis test for 1% and 5% probability levels). Multiple comparisons were performed by *Bonferroni* test ($P<0.05$) and correlations were presumed by *Pearson* coefficient.

RESULTS

The average age and weight of control and athlete groups were 6.90±3.25 years and 420.95±97.77kg, 5.00±0.81 years and 476.50±28.22kg, respectively. Wagon traction group presented higher mean age (10.56±3.47 years) ($p=0.0352$) and lower mean weight (350.80±70.82kg) ($p=0.0001$), in comparison to control and athlete groups.

No horse presented alteration in the color of mucosa, capillary refill time, cardiac shock intensity and arterial pulse. Splitting of the first and/or second heart sounds were observed in horses of control (43%), wagon traction (44%) and athlete (10%) groups. Cardiac murmurs were not auscultated.

Electrocardiographic parameters are shown in Table 1 (electric axis and LII) and Table 2 (base-apex). Sinus rhythm was the most frequent in all three groups (LII and base-apex). In LII, P-wave amplitude was higher in the wagon traction and athlete groups, in comparison to control group. The athlete group presented longer P-wave and P-R interval duration when compared to control and wagon traction groups. In athlete group, there was a negative correlation between HR and P-R interval (Pearson correlation = -0.726), indicating that PR duration decreased with increasing HR. Positive T wave (T +) amplitude was higher in the wagon traction group. HR, electrical axis, amplitude of positive R (R +) and negative T (T -) waves and duration of QRS complex and Q-T interval were not different between groups (Table 1).

HS mean value for the athlete group (97.33±12.15ms) (P<0.0001) was higher than control (58.60±17.74ms) and wagon traction groups (66.81±18.84 ms) (Figure 1).

Table 1. Electrocardiographic parameters (mean ± standard deviation) from control, wagon traction and athlete groups. All measurements were made with the bipolar lead II, except for the electric axis, assessed with the bipolar and unipolar leads

Parameters	Control N=21	Wagon traction N=25	Athletic N=10	P value
Electric axis (°)	16.90±61.67a	29.80±73.77a	66.00±37.77a	0.1474
HR (bpm)	44.33±6.65a	43.76±6.55a	46.70±16.99a	0.6939
Rhythm	Sinus (71%)	Sinus (80%)	Sinus (60%)	---
	Sinus arrhythmia (19%)	Sinus arrhythmia (8%)	Sinus arrhythmia (20%)	
	Sinus tachycardia (10%)	Sinus tachycardia (12%)	Sinus tachycardia (20%)	
P amplitude (mV)	0.19±0.09a	0.26±0.06b	0.27±0.05b	0.0056
P duration (s)	0.08±0.03a	0.09±0.02a	0.12±0.03b	0.0012
P-R interval (s)	0.25±0.03a	0.27±0.06a	0.33±0.05b	<0.0001
R (+) amplitude (mV)	0.55±0.49a	0.60±0.36a	0.92±0.53a	0.0929
QRS duration (s)	0.10±0.12a	0.09±0.07a	0.11±0.02a	0.8169
Q-T interval (s)	0.46±0.06a	0.46±0.05a	0.43±0.07a	0.3640
T (+) amplitude (mV)	0.19±0.093a	0.38±0.251b	0.17±0.051a	0.0395
T (-) amplitude (mV)	0.39±0.151a	0.33±0.183a	0.53±0.224a	0.0530

HR – heart rate; bpm – beats per minute; s - seconds; mV - milivolts; ° – degree.
Different letters on same line represents difference between mean values.

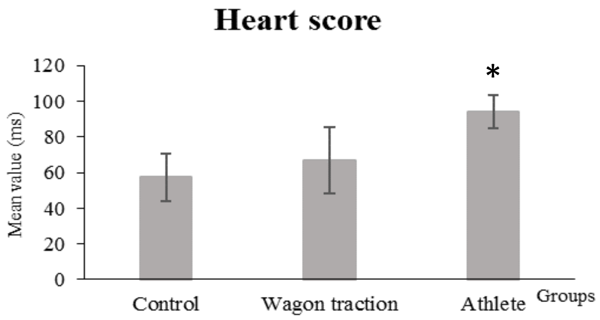

Figure 1. Graphical representation of mean values of the cardiac score of horses from control, wagon traction and athlete groups. *P<0.0001 *versus* control and wagon traction group.

Observations from base-apex demonstrated higher P wave amplitude and QRS complex duration in wagon traction and athlete groups, when compared to control group. In athlete group, there was a negative correlation between HR and P-R interval (Pearson correlation = -0.529). Negative S wave (S -) amplitude was higher in wagon traction group than in control and athlete groups. HR, duration of P wave and P-R/Q-T intervals and amplitude of T wave (T - and T +) were not different between groups for base-apex (Table 2). No correlation was observed between weight and ECG measures, including HS (*Person* correlation <+0.3).

Table 2. Electrocardiographic parameters (mean ± standard deviation) from control, athlete and wagon traction groups. Measurements were made with the base-apex lead

Parameters	Control N=21	Wagon traction N=25	Athletic N=10	P value
HR (bpm)	46.59±10.11a	45.55±6.61a	47.41±10.75a	0.8401
Rhythm	Sinus (53%)	Sinus (57%)	Sinus (40%)	---
	Sinus arrhythmia (21%)	Sinus arrhythmia (22%)	Sinus arrhythmia (40%)	
	Sinus tachycardia (16%)	Sinus tachycardia (17%)	Sinus tachycardia (20%)	
	Sinus tachyarrhythmia (10%)	Sinus tachyarrhythmia (4%)	---	
P amplitude (mV)	0.16±0.06a	0.23±0.10b	0.22±0.04b	0.0352
P duration (s)	0.15±0.18a	0.13±0.10a	0.11±0.02a	0.7943
P-R interval (s)	0.27±0.04a	0.29±0.05a	0.31±0.06a	0.1038
S (-) amplitude (mV)	0.86±0.25a	1.18±0.41b	0.85±0.13a	0.0017
QRS duration (s)	0.09±0.02a	0.11±0.02b	0.11±0.01b	0.0038
Q-T interval (s)	0.44±0.05a	0.46±0.06a	0.44±0.04a	0.4085
T (+) amplitude (mV)	0.24±0.113a	0.40±0.584a	0.29±0.105a	0.6733
T (-) amplitude (mV)	0.51±0.256a	0.52±0.487a	0.37±0.189a	0.6512

HR – heart rate; bpm – beats per minute; s - seconds; mV – millivolts.
Different letters on same line represents difference between mean values.

DISCUSSION

In the wagon traction group, the higher age can be justified due to the common practice of using adult horses for pulling wagons. During physical examination, all horses were considered healthy, so the lower average body weight in wagon traction group could be associated with crossbreeding and preference for smaller horses for this activity. Similar results were described by Alves *et al.* (2010). In the control group, idleness contributed to weight gain.

Splitting of the first and/or second heart sounds could be auscultated, predominantly, in control and wagon traction groups. The first heart sound (S1) occurs at the beginning of ventricular systole and is synchronized with the atrioventricular valves closure. Variations in the intensity and quality of S1 are uncommon in horses (Marr e Reimer, 2006; Schwarzwald, 2013). Possible causes of the S1 split are the prolonged diastolic period and arrhythmias (not observed in this study) and structural lesions in atrioventricular valves (evaluated only by echocardiography). Nevertheless, cardiac abnormality diagnosis cannot be established exclusively by the observation of S1 variations (Bonagura *et al.*, 2010). Splitting of second cardiac sound (S2) is a result of asynchronous closure of semilunar valves and is considered common and physiological in healthy horses, occurring after variations in the HR and respiration (Radostits *et al.*, 2002; Schwarzwald, 2013).

HR values did not differ between leads and rhythm observations were similar (Table 1 and 2). The base-apex is generally well tolerated and recorded for a longer period (60 s), which allows for a better assessment of the cardiac rhythm. Perhaps for this reason, sinus tachyarrhythmia has been detected only in the base-apex (Table 2). The information generated by the LII (in the frontal plane) and base-apex were complementary and could be used as a reference for other studies.

Normal sinus was the predominant cardiac rhythm in all groups, followed by sinus arrhythmia, sinus tachycardia and sinus tachyarrhythmia (Table 1 and 2), as described by Melchert *et al.* (2012) and Schwarzwald *et al.* (2012). Sinus arrhythmia and sinus tachycardia may be observed in healthy horses and be consequence of the increase in vagal tone and animal manipulation, respectively (Radostits *et al.*, 2002; Fernandes *et al.*, 2004; Mantovani *et al.*, 2013). On the other hand, sinus tachyarrhythmia, noted in control (10%) and wagon traction (4%) groups (Table 2), has not been described as a normal rhythm for horses and could be related to the cardiovascular conditions of these animals.

According to Schwarzwald *et al.* (2012), HR at rest can decrease in response to physical activity (training), but the HR average values in wagon traction and athlete groups did not differ from the control group (Table 1 and 2). Possibly, this parameter was influenced by sympathetic stimulation, caused by handling of the horses during the physical exam.

The mean electrical axis of all three groups was positive, similar to values described by Fernandes *et al.* (2004) for non-athletic horses. Those results differed from studies performed by Dumont *et al.* (2010), which reported negative values for athletic horses. In 81% of the control group, the axis ranged from 0° to +75°. In the wagon traction and athlete groups this variation was between 0° and +12° (76%) and +45° to +130° (90%), respectively, indicating a tendency to right axis deviation. According to Dumont *et al.* (2010), right or left axis deviation may suggest cardiac hypertrophy in horses, consistent with exercise.

The ECG parameters for the wagon traction group were consistent with the references presented by Bonagura *et al.* (2010) and Lessa *et al.* (2012); despite scarcity of information about ECG particularities in horses that pull wagon (an exhausting and constant activity) in scientific literature. For this reason, wagon traction horses' ECGs were compared to the results from idle crossbred horses, from the same locality (control group). Results showed that P wave amplitude (in LII and base-apex) and QRS duration (in base-apex) were higher in the wagon traction group. Nevertheless, this initial comparison does not completely support the hypothesis that these peculiarities are related to pulling wagon activities. Therefore, data from the wagon traction group were compared to ECG parameters from athletic horses in exercise. Both athlete and wagon traction groups presented the same differences when compared to the control group: higher P wave amplitude (in both LII and base-apex) and higher QRS complex duration (in base apex). In the athlete group, there was also higher P wave duration, tendency to increase the amplitude of R (+) ($p=0.0929$) and T (-) ($p=0.0530$) waves and longer P-R interval (in LII), when compared to control group. Differences observed between wagon traction and athlete groups were higher amplitude of T (+) (in LII) and S (-) (in base-apex) waves in wagon traction group. T wave amplitude increase was described in healthy horses undergoing physical exercise (Piccione *et al.*, 2003; Pedersen *et al.*, 2013) or as a consequence of HR increase (Bonagura *et al.*, 2010). Dumont *et al.* (2010) reported that higher S (-) amplitude, after prolonged exercise, was probably related to a right ventricular hypertrophy.

The present results suggest that the increase in amplitude and duration of ECG waves (at rest) is related to regular exercises. This assumption is based on the fact that similar results were observed in the wagon traction and athlete groups. ECG measurements (in LII and base-apex leads) for the control group were similar or lower than the values obtained for wagon traction and athlete groups. To our knowledge, this is the first study to evaluate the cardiovascular system of wagon traction horses (using physical exam and ECG) and draw a comparison with horses in extreme routine situations (idleness and regular exercise). Moreover, few authors have described the routine exercise effects on resting ECG.

The athlete group presented a higher PR interval (LII) (Tab. 1) and negative correlation between this interval and FC (LII and base-apex), which can be explained by a physiological cardiovascular adjustment, represented by the vagal tone, due to exercise (Bonagura *et al.*, 2010). This condition was not verified in the wagon traction group.

HS from the athlete group was close to 100 ms, indicating that depolarization period, heart size and exercise were probably related to each other (Bello *et al.*, 2012). Nonetheless, wagon traction group HS was low and close to values obtained for the control group, suggesting that there could be poor adaptation of the cardiovascular system for traction work.

CONCLUSION

Exercise can induce ECG changes; however, wagon traction horses did not present all electrophysiological adjustments to exercise as are observed in athletic horses. According to some parameters evaluated, those animals were more like horses in idleness condition, thus indicating that wagon traction horses present inadequate cardiovascular adaptation to this activity.

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