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Original article

Short-term and long-term PQ, QT and R-R intervals' variability at the resting condition and after exercise testing in healthy Anglo-Arabian horses

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Abstract

The duration of electrocardiographic (ECG) parameters: PQ, QT and R-R intervals change during long-term and short-term observation as the consequence of the fluctuations in autonomic nervous system activity among others dependent on the exercise and resting. There is no data of horse breed influence on these parameters.

The aim of the study was to assess the duration and the variability of the PQ, QT and R-R intervals in the resting conditions and after exercise testing in Anglo-Arabian horses.

Material and Methods: 27 healthy Anglo-Arabian horses aged 3.4 ± 1.0 years (15 male, 12 female) had ECG examination in the standing position using Einthoven system of leads. The longest and the shortest PQ, QT and R-R intervals were measured after night rest and after exercise testing and the means were calculated.

Conclusions: 1) In Anglo-Arabian horses the difference between the longest and the shortest PQ interval at rest vs. after exercise is 0.06 ± 0.05 vs. 0.03 ± 0.02, QT interval is 0.04 ± 0.03 vs. 0.04 ± 0.04, R-R interval 0.19 ± 0.15 vs. 0.08 ± 0.11. 2) The PQ and R-R intervals reveal high short-term variability either at the resting conditions or after exercise testing. 3) After exercise testing PQ, QT and R-R intervals are shorter than at the resting conditions. The delta PQ and R-R are 2 times smaller in contrast to delta QT which is constant. 4) The PQ and R-R interval variability was greater at the baseline condition than after exercise testing. The QT variability was similar at baseline condition to that after exercise testing.

Key words: Anglo-Arabian horses, R-R variability, ECG, heart

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Introduction

PQ, QT and R-R interval duration changes with the fluctuations in autonomic nervous system activity. The physical exertion and psychological distress are the most common factors related to autonomic tone changes (Pueyo et al. 2003, Mirvis and Goldberger 2004). Therefore, the conditions in which the electrocardiographic study is performed should be taken into account in assessing its results (Rajendra 2006).

Heart rate variability reflects the autonomic modulation of the normal sinus rhythm and it has been proven that even 10-second ECG recordings are valuable for the assessment of the risk of a cardiovascular event. The QT interval changes slowly and depends on the changes in heart rate occurring in the preceding 140 seconds and its increased variability is correlated with higher risk of cardiac death. The PQ interval duration is also related with autonomic tone and heart size.

The assessment of the variability of electrocardiographic parameters at the resting condition and immediately after exercise may increase the diagnostic yielding of the electrocardiogram.

There may be species or even breed differences concerning the duration and variability of PQ, QT and R-R intervals. In Anglo-Arabian horses, the analysis of short-term and long-term variability of PQ, QT and R-R intervals has not been done so far.

The aim of the study was to assess the duration and variability of PQ, QT and R-R intervals at the resting conditions and immediately after exercise testing in healthy Anglo-Arabian horses.

Materials and Methods

The study group consisted of 27 Anglo-Arabian horses aged 3.4 ± 1.0 years (15 male, 12 female). All the horses were used for leisure time activity. Only healthy horses were included in the study. In the medical history obtained from their carers and in the clinical examination there were no significant abnormalities. In all the animals the electrocardiogram was performed using the portable electrocardiograph Schiller AT-1 in the standing position with an equal load on each leg. The forelimbs were kept parallel to each other and perpendicular to the long axis of the body. Neither means of physical coercion nor tranquilizers were used. The standard bipolar limb leads according to Einthoven were used. The alligator clips fixed to the electrocardiographic leads were attached directly to the skin previously degreased with the methyalated spirit. The electrodes were placed on the caudal aspect of the forelimb 15 cm below the level of the olecranon and on the hind limbs, distal or lateral to the stifle join (Rajendra et al. 1985). The electrocardiogram lasting 30 seconds was recorded during paper speed of 50 mm/second and deflection of 10 mm/1mV. The PQ, QT and R-R interval measurements were performed manually in the lead II. Heart rate was calculated as the average heart rate of the recorded electrocardiogram at the resting and post-exercise conditions. In resting electrocardiograms, atrioventricular block 2:1 (AVB) with one non-conducted P wave were recorded in four horses (3 female and 1 male). AVB occurrence resulted in a substantial R-R interval prolongation caused in fact by the block itself but not by the variability of the sinus rhythm and therefore that interval was not included in the further R-R interval variability analysis. The electrocardiograms were performed twice: in the morning after a night's rest (resting conditions) and within one minute after the exercise testing performed using a lunge line (after the exercise testing). The exercise testing consisted of three periods: 10 minutes of walk, 15 minutes trot and 10 minutes of canter. All the PQ, QT and R-R intervals were measured and either the longest or the shortest one was noted at the resting conditions as well as after exercise testing.

The means of the shortest and the longest parameters were obtained. The variability of studied parameters was presented as the difference between the longest and the shortest interval.

The statistical analysis

The obtained data were presented as means and their standard deviations. The statistical significance of the differences between parameters related to the short-term variability was studied with the use of the t-Student's test or Wilcoxon test depending on their distribution. P value < 0.05 was considered statistically significant.

Results

Obtained values of the duration of studied parameters at the resting conditions and after the exercise testing were presented in Table 1.

In three horses, a second degree atrioventricular block with one non-conducted P wave in the electrocardiogram recorded in the resting condition were present. In each case of the event, the PQ and QT interval after a non-conducted P wave were neither the longest nor the shortest among all the studied intervals in the analyzed electrocardiographic recordings.

Table 1. Duration of minimal and maximal PQ, QT and R-R intervals after night rest conditions and after the exercise testing.

	At rest	After exercise	P
HR	46 ± 12.2	64 ± 14	<0.001
PQ min (s)	0.28 ± 0.05	0.24 ± 0.04	<0.005
PQ max (s)	0.33 ± 0.08	0.28 ± 0.05	<0.001
Delta PQ (s)	0.06 ± 0.05	0.03 ± 0.02	<0.03
QT min (s)	0.44 ± 0.05	0.39 ± 0.05	<0.001
QT max (s)	0.48 ± 0.05	0.43 ± 0.05	<0.001
Delta QT (s)	0.04 ± 0.03	0.04 ± 0.03	NS
R-R min (s)	1.27 ± 0.31	0.93 ± 0.26	<0.001
R-R max (s)	1.47 ± 0.30	1.02 ± 0.25	<0.001
Delta R-R (s)	0.19 ± 0.15	0.08 ± 0.11	<0.002

PQ min – the shortest PQ interval
PQ max – the longest PQ interval
delta PQ – the difference between the longest and the shortest PQ interval: PQ max and PQ min
QT min – the shortest QT interval
QT max – the longest QT interval
delta QT – the difference between the longest and the shortest QT interval: QT max i QT min
R-R min – the shortest R-R interval
R-R max – the longest R-R interval
delta R-R – the difference between the longest and the shortest R-R interval: R-R max i R-R min

All the parameters were significantly shorter after exercise testing than at the resting condition.

Comparing the variability of the studied parameters both at resting conditions and after exercise testing it was shown that the variability of the PQ and R-R intervals was higher at resting conditions than after exercise testing, whereas the QT interval variability in both studies did not differ. At the resting conditions, the 2:1 atrioventricular block occurred in 3 horses whereas after exercise testing no horse had conduction disturbances.

Discussion

The main result of our study was the assessment of the duration of PP, PQ and R-R intervals at the baseline conditions and after the exercise testing as the range of the observed values in healthy adult Anglo-Arabian horses. Such data could be regarded as physiological range and are expected to be useful for either clinical practice or scientific research.

The PQ interval is a measure of time needed to conduct the electrical impulse from the sinoatrial node to the ventricular muscle (Mirvis and Goldberger 2004). In physiological conditions, the PQ interval depends mainly on the velocity of the electrical impulse conduction through the atrial muscle what is relatively stable in any given individual and the conduction time through the atrioventricular junction which is modulated by the autonomic tone. The sympathetic activation accelerates and parasympathetic activation decelerates the velocity of the conduction through the atrioventricular junction and respectively shortens and lengthens the PQ interval (Arai et al. 1989, Mirvis and Goldberger 2004). The duration of PQ interval depends on the lead used for the electrocardiogram recording (Muñoz 1995).

In our study the duration of PQ interval ranged from 0.2 to 0.52 s and remained in the same range in the horses which had AVB. The obtained data show that PQ interval in Anglo-Arabian horses is usually longer than in humans in whom the reference value is below 0.20 s, and only elderly people could have prolonged PQ intervals to 0.22 s (Mirvis 2004). The cause of the longer PQ interval could be slower heart rate and larger heart related to the body dimensions and weight. The PQ interval in Anglo-Arabian horses is also longer than in other breeds of horses including Andalusian and Turkmene horses. In the former, the mean PQ interval lasts from 0.219 ± 0.04 s to 0.245 ± 0.07 s in the dependence of used lead (Muñoz et al. 1995) and in the latter, the PQ interval duration lasts 0.294 ± 0.004 s with the range from 0.21 to 0.44 s (Alidali et al. 2002). The direct comparison of the PQ intervals' duration among the horses of other breeds on the basis of the literature data is difficult because usually only the means and their standard deviations are known as well as the measurements are performed using another lead system. It seems that interbreed differences may exist what should be proved in further studies.

The reference value of the PQ intervals in horses shown in the literature is less than 0.5 s. (Menzies-Gow 2001). This value is much higher than in our study in which the longest PQ interval duration in resting conditions exceeded 0.5 s only in one case and in the other cases did not exceed 0.45 s whereas the shortest PQ intervals at the resting conditions did not exceed 0.36 s. Another author also reported much shorter upper range of the references value for the PQ interval in horses (Alidadi et al. 2002). The presence of differences cannot be explained by the processes related to aging because all the studied animals were young and adult. The obtained results cannot be transferred to older individuals.

The QT interval is a parameter related to the duration of depolarization and repolarization of the working myocardium (Mirvis and Goldberger 2004). Its duration depends on the heart rate as well present and during period lasting 2-3 min preceding measured

QT interval (Pueyo et al. 2003). The increased QT variability is a pathological phenomenon due to the increased susceptibility to cardiac death (Berger 2003, Zareba and Bayes de Luna 2005). The reference value of the QT interval in horses in the literature is less than 0.6 s (Fazio et al. 2003). In Turkish and Andalusian horses, the mean QT interval was above 0.5 s whereas in our study the longest QT interval was at least 0.5 s in one third of the studied animals at the resting conditions whereas the shortest QT interval only in one horse was 0.44 s. This observation indicates the possibility of the interbreed differences regarding duration of the QT interval. Similarly to the PQ interval duration, the interbreed differences may concern QT interval as well.

The variability of the R-R intervals during sinus rhythm may be physiological and their cyclic changes are related to the respiratory phases and parasympathetic activity. Chaotic changes of R-R intervals in humans may be a manifestation of damage to the sinoatrial node called sick sinus syndrome (Sosnowski and Petelezn 1993, Stein et al. 2005).

The mean R-R interval of the recording lasting 30 s in our study group at the resting conditions varied from 0.64 s to 2.00 s what is equivalent to the heart rate between 30/min to 90/min. Mean heart rate in the study group was 46/min at resting conditions. It was significantly higher than the values obtained in studies of mean heart rate in other breeds of horses. Other authors accept lower heart rate values in horses – between 28/min and 44/min. (Potter 19850). The heart rate range in the Turkmene horse was between 20/min and 49/min (Alidadi et al. 2002). The horses which had AVB did not have slower heart rate than the others. The presence of AVB did not influence heart rate significantly during 30-s recording because it was the only one non-conducted P wave during that period.

The second result of our study was showing the decrease in PQ and RR intervals duration after exercise testing. The delta PQ and R-R are 2 times lower in contrast to delta QT which was constant.

The duration of the PQ, QT and R-R intervals both the shortest and the longest in the recordings at the baseline conditions were significantly longer than after exercise testing recordings in all studied horses. These results are partially concordant with the results of Fazio and coworkers study that showed the shortening of the PQ and QT intervals and the increase in the heart rate in horses following a sprint running 1200 m and 1600 m distance. Similar relations were not reported following running 7000 m distance (Fazio et al. 2003). In our study the exercise testing was not so heavy but on the other hand the studied horses were not trained for equestrian sports so their reaction to quite small loads could be more pronounced.

The third result of our study was showing the decrease in the variability of the PQ and R-R intervals after the exercise testing whereas the QT interval variability did not differ significantly.

The observed long-term variability of the PQ, QT and R-R intervals is related to the persistent activation of the sympathetic nervous system and inhibition of the parasympathetic system after exercise testing (Arai et al. 1989, Gajek et al. 2003, Goldberger et al. 2006). During intensive physical exercise, releasing catecholamines as neuromediators of the sympathetic activation having short half-life time and other neurotransmitters like neuropeptide Y whose half life time is much longer and the parasympathetic inhibition could persist for longer period (Potter 1985). Studies of the sympathetic nervous system activity revealed that the return to the baseline values after exercise testing related to the sympathetic activation may occur even 30 min after exercise (Gajek et al. 2003).

The short-term variability of the PQ and R-R intervals in the after exercise period was lesser than at the baseline conditions what could be related to the inhibition of the parasympathetic system. The lack of AVBs after exercise testing confirms the inhibition of the parasympathetic and the activation of sympathetic nervous system what favors better conduction through the AV junction. The AVB is considered benign in horses if it disappears in response to exercise, excitement or administration of anti-cholinergic agents such as atropine, all of which decrease vagal influence on the heart (Robertson 1990, King 1994).

In the study group we have not revealed significant differences between short-term and long-term variability of QT intervals. The myocardium has mainly sympathetic innervation and parasympathetic innervation if present does not play any significant role in the regulation of the process of the depolarization.

The adaptation of heart rate to the respiratory phase allow maximal adaptation of the flow through vascular pulmonary bed to the amount of the oxygen in the pulmonary alveoli. During inspiration the amount of the oxygen in the lung and heart rate increase and during expiration the amount of oxygen in pulmonary alveoli decreases and concomitant decrease in heart rate and blood flow occurs (Hayano and Yasuma 2003, Ito et al. 2006). Physiological respiratory variability of heart rate is observed in horses (Menzies-Gow 20010). The results of our study indicate the variability of the duration of PQ interval nevertheless the respiratory phases were not recorded what is a shortcoming of our study which make interpretation of the results more difficult. However that shortcoming was not relevant to the obtained results in the aspect of the assessment of the duration and variability of the studied electrocardiographic parameters at rest and after exercise testing in healthy horses what was the aim of our study.

Conclusions

1. In Anglo-Arabian horses the difference between the longest and the shortest PQ interval at rest vs. after exercise is 0.06 ± 0.05 vs. 0.03 ± 0.02, QT interval at rest is 0.04 ± 0.03 vs. 0.04 ± 0.04 after exercise, and R-R interval at rest 0.19 ± 0.15 vs. 0.08 ± 0.11 after exercise.

2. The PQ and R-R intervals reveal high short-term variability either at the resting conditions or after exercise testing what indicates that their reference values should be presented as the range of means of the shortest and the longest intervals.

3. After exercise testing PQ, QT and R-R intervals are shorter than at the resting conditions. The delta PQ and R-R are 2 times smaller in contrast to delta QT which was constant.

4. In Anglo-Arabian horses, the PQ and R-R interval variability was greater at the baseline condition than after exercise testing. The QT variability was similar at baseline condition and after exercise testing.

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