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THIRTY-DAY RHYTHMICITY IN ELECTROCARDIOGRAPHIC AND ELECTROLYTIC PARAMETERS IN THE ATHLETIC HORSE

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ABSTRACT

This paper describes circatrigintan progress of some electrocardiographic parameters and of the serum electrolytes in the jumper horse during a period of pre-competitive training performed in order to define the temporal organization of some parameters employed to evaluate the athletic performance of the horse. Five Sella Italiana horses, clinically healthy and specifically trained have been utilized for the study. All the subjects have undergone electrocardiographic recordings and blood sample takings by means of jugular venopuncture, at rest and always at the same hour, every five days for a period of one month. The following electrocardiographic parameters have been measured on individual ECG-recordings: P wave duration and amplitude, P-Q interval duration, QRS complex duration, R wave amplitude, T wave duration, S-T segment duration, Q-T interval duration, the longest and shortest R-R intervals; besides, mean R-R interval and D R-R, the highest, lowest and mean heart rate, have been calculated. The concentrations of magnesium, calcium, phosphorus and chlorine and of sodium and potassium have been determined on the blood samples, respectively by UV spectrophotometry and by flaming. The application of a statistic trigonometric model has permitted to point out the circatrigintan periodicity of the following electrocardiographic parameters: P wave duration, T wave duration, R wave amplitude, mean R-R interval and mean heart rate, and of the following serum electrolytes: sodium and magnesium. Based on these results, it is hypothesized that the cardiovascular system follows a "deterministic" progress with a "linear" variability systematically predictable within the temporal period considered.

Key words*:* Biorhythm, electrocardiographic parameters, horse, physical exercise, serum electrolytes.

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INTRODUCTION

Chronophysiological investigation techniques have long been used, in both man and laboratory animals, to individuate periodicity of cardiovascular parameters at various frequencies [6,10,11,29]. The literature includes research aimed at verifying a physiological temporal pattern in arterial pressure [5,14,27], heart rate and some electrocardiographic parameters [1,2], which help to define ultradian and circadian temporal rhythms in some cardiovascular diseases [12,13]. The lack of data regarding cardiovascular chronophysiology in domestic species led us to carry out a study on chronocardiology in the horse, using an analytic method [8]. This method has been used for the study of the haematochemical, haematological temporal pattern of some enzymatic activities and of rectal temperature in domestic animals [4,7,16-19,21, 22] and has also recently been employed for chronophysiological study of some electrocardiographic, haemogasanalytic and arterial pressure parameters [16,17,20,21,23,24]. Greater knowledge of chronophysiological aspects and the study of the mechanisms involved are of particular importance when considering the various physiological responses during athletic performance. In the human species, chronophysiological studies applied to athletic practice have been instrumental in identification of intervals of variance in performance, over different periods (day, month, year), which reflect a diversity of training programs and allow for the necessary planning of training and competitive activity. The study of chronophysiological responses to physical activity in the athlete is very complex, since it involves the whole organism; evaluation of performance levels in the athlete is equally complex, but can be simplified by using individual functionality indicators [3,15]. Individuation of the temporal organization of the parameters used to evaluate performance would enable us to define a clear temporal range, during which the organism appears to perform best and, consequently, give a starting-point for planning different types of training. In the analysis of time series of biologic functions obtained over several months, rhythmicity is found with a period of about 30 days. Biological variations or rhythms with a frequency of 1 cycle in 30±5 days are called circatrigintan [9]. On this basis and in order to define the temporal organization of the parameters involved in the evaluation of the athletic performance of the horse we set up a study into the circatrigintan progress of some electrocardiographic and electrolyte parameters in the jumpers, during a period of pre-competition training. Greater understanding of circartrigintan rhythms in the horse can be used in the improvement of training programs for athletic horses.

MATERIALS AND METHODS

It was used 5 clinically healthy Sella Italiana geldings, average age 16±2 years. For 30 days before the study, the animals followed the same pattern of daily activity, they were kept in naturally lit individual boxes and fed on hay and commercial pellets at 06.30 a.m., at 01.00 p.m. and at 07.00 p.m.. During the whole of July, every 5 days and at the same time electrocardiographic recordings were made on all the animals at rest, using a digital multichannel electrocardiograph[1], with a deflection of 10 mm/mV and chart speed of 25 mm/sec. Immediately after each electrocardiographic recording blood samples were taken by jugular venipuncture. Spectrophotometry in UV was used to establish the concentration in each sample of the following serum electrolytes: magnesium, calcium, phosphorus, chlorine, while flame spectrophotometry was used to calculate sodium and potassium concentrations. The electrocardiographic recordings were measured with a standard bipolar DII lead. On each recording the following electrocardiographic parameters were measured: P wave duration, P wave amplitude, P-Q interval duration, QRS complex duration, R wave amplitude, T wave duration, S-T segment duration, Q-T interval duration, the longest and shortest R-R intervals. The following parameters were also calculated: the average R-R interval and the difference between the longest and shortest R-R intervals (DR-R), the maximum, minimum and average heart rate.

Statistical analysis

Statistical elaboration of the data was based on the average values obtained at the various time-points (5 days equidistant), since the intragroup variance was not significant. For each parameter, we applied a trigonometrical statistical model to the average values of each temporal series to describe the periodic phenomenon analitically, by identifying its main characterizing parameters: Mesor (Midline estimating statistic of rhythm), expressed in the conventional unit of the respective parameter, with the fiducial limits at 95%, Amplitude (A), expressed in the same unit of the respective Mesor, and the acrophases (f), calculated using the single cosinor method and indicated by date, with the confidence interval at 95%. The procedures to be described use the cosine function:

$$f(t) = M + A \cos (ùt + f)$$

as a model for biologic rhythms, with f(t) the value at time t of the function defined by parameters M (mesor = value about which oscillation occurs), A (amplitude = half the difference between the highest and lowest values), ù (angular frequency =degrees/ unit time, with 360° representing a complete cycle) and f (acrophase = timing of high point, in degrees).

The acrophase is a measure of timing of a rhythm in relation to a defined reference timepoint selected by the investigator. It is used for data which can be described by the fitting of a mathematical model, e.g., a cosine curve, and represents the crest time of the cosine curve best fitting to the data; it may be expressed in (negative) degrees as the lag from the acrophase reference (360°C=1 period) or in calendar time units (days for the circatrigintan rhythm).

RESULTS

Table 1 shows, for each of the 5 horses, the average values of the electrocardiographic parameters studied, expressed in their conventional units of measurement, together with the standard deviations, observed at the various time points (5 days equidistant). Table 2 shows, again for each of the 5 horses, the average values of the serum electrolytes examined, expressed in their conventional units of measurement, together with the standard deviations, observed at the different time points (5 days equidistant). The application of the periodic statistical model enabled us to define the circatrigintan progress of the following electrocardiographic parameters for each of the 5 horses:

Table 1 . Average values of electrocardiographic parameters studied, expressed in their conventional units, together with standard deviations, measured at different time points (5 days equidistant)

PARAMETER	RECORDINGS (DAYS)					
	5	10	15	20	25	30
P wave duration (sec)	0.13±0.01	0.13±0.02	0.14±0.02	0.14±0.01	0.14±0.02	0.13±0.02
P wave amplitude (mm)	2.62±1.00	2.76±1.08	2.90±1.06	3.12±1.16	2.87±1.49	3.74±1.43
P-Q interval duration (sec)	0.33±0.11	0.37±0.03	0.37±0.02	0.37±0.04	0.39±0.04	0.38±0.03
QRS complex duration (sec)	0.11±0.02	0.10±0.02	0.10±0.02	0.11±0.02	0.10±0.03	0.11±0.02
R wave amplitude (mm)	12.40±1.29	11.30±2.33	9.70±4.15	9.90±3.86	9.40±3.90	11.92±7.74
T wave duration (sec)	0.17±0.01	0.16±0.03	0.15±0.01	0.14±0.03	0.14±0.02	0.16±0.01
S-T segment duration (sec)	0.27±0.05	0.26±0.04	0.27±0.05	0.26±0.02	0.29±0.04	0.27±0.02
Q-T interval duration (sec)	0.55±0.06	0.52±0.04	0.53±0.04	0.51±0.03	0.54±0.03	0.53±0.01
Shortest R-R interval (msec)	1692±127.55	1412±139.36	1526±142.06	1482±148.73	1627±166.01	1635±122.76
Longest R-R interval (msec)	1946±166.22	1634±123.81	1674±163.19	1685±135.54	1917±195.17	1878±60.58
Average R-R interval (msec)	1809±142.76	1523±119.51	1596±146.43	1610±139.49	1820±172.63	1840±40.86
ΔR-R	274±74.03	222±11.22	148±74.63	203±56.12	290±110.00	243±175.50
H.R. max (beats/min)	36.03±2.55	42.81±4.15	39.61±3.93	40.50±3.95	36.88±3.88	36.70±3.62
H.R. min (beats/min)	31.01±2.67	36.90±3.01	36.14±3.84	35.60±2.99	31.30±3.69	31.95±1.66
Average H.R. (beats/min)	33.33±2.57	39.59±3.25	37.86±3.77	37.26±3.02	32.97±3.61	32.60±0.89

Table 2 – Average values of serum electrolytes studied, expressed in their conventional units, together with standard deviations, measured at different time points (5 days equidistant)

PARAMETER	SAMPLE TAKINGS TIME (DAYS)					
	5	10	15	20	25	30
Sodium (mmol/l)	145.40±1.52	147.80±1.79	151.60±2.30	147.60±3.42	145.20±3.11	144.10±0.84
Potassium (mmol/l)	3.78±0.36	4.90±0.19	4.28±0.36	4.48±0.22	4.35±0.21	3.70±0.66
Magnesium (mg/dl)	1.88±0.13	1.78±0.14	1.69±0.12	1.76±0.21	1.78±0.17	1.86±0.11
Phosphorus (mg/dl)	3.67±1.11	2.57±0.43	2.96±0.72	2.30±0.97	3.82±0.97	2.03±0.47
Chlorine (mmol/l)	114.14±5.73	109.24±6.22	110.04±7.88	106.54±3.77	114.10±7.42	110.36±4.63
Calcium (mmol/l)	3.29±0.18	3.52±0.22	3.48±0.31	3.57±0.26	3.33±0.17	3.30±0.21

P wave duration, T wave duration, R wave amplitude, average R-R interval and average heart rate.

The acrophases, which were calculated using the single cosinor method and are indicated by date, with the relative fiducial limits at 95%, were as follows: on 21st July (16th-26th July) for P wave duration, on 7th July (5th-9th July) for T wave duration, on 6th July (1st-11th July) for R wave amplitude, on 30th July (23rd July-7th August) for average R-R interval and on 15th July (7th-25th July) for average heart rate. Regarding the electrolytes, sodium and magnesium showed a circatrigintan periodicity. The acrophases, which were calculated using the single cosinor method, were as follows: on 16th July (12th-20th July) for sodium and on 3rd July (27th June-9th July) for magnesium. Table 3 shows the Mesor, with the fiducial limits at 95%, the amplitude and the acrophases (indicated by date) with the confidence interval at 95%, for the above mentioned parameters.

DISCUSSION

Rhythmic progress of some parameters which describe heart's electric activity - recorded on body surface and expressed by conventional ECG parameters - was shown in our horses by applying rigorous statistical methods. Circatrigintan rhythmicity in the following electrocardiographic parameters was shown: P wave duration, T wave duration, R wave amplitude, average R-R interval and average heart rate. Previous research on the athletic horse has demonstrated a circadian periodicity, with diurnal acrophases, for the P-Q interval duration, the QRS complex duration and the T wave amplitude [24]. English Thoroughbred horses have also shown a circasemidian rhythm of heart rate and the R-R interval, the latter synchronized by age and training [28]. Among the serum electrolytes studied, only sodium and magnesium showed circatrigintan periodicity, with the acrophases, how-

Table 3 – Mesor, with fiducial limits (F. L.) at 95%, Amplitude (A) and Acrophase (f), indicated by date, with confidence interval (C. I.) at 95%, of electrocardiographic parameters and serum electrolytes resulted periodic

PARAMETER	M	F.L. (95%)	A	f	C.I. (95%)
P wave duration (sec)	0.13	(0.12-0.14)	0.0006	21st July	(16th-26th July)
T wave duration (sec)	0.15	(0.14-0.16)	0.001	7th July	(5th-9th July)
R wave amplitude (mm)	10.77	(10.14-11.40)	1.52	6th July	(1st-11th July)
Average R-R interval (msec)	1699.77	(1630.54-1768.99)	166.42	30th July	(23rd Jul-7th Aug)
Average H.R. (beats/min)	35.60	(34.10-37.09)	3.59	15th July	(7th-25th July)
Sodium (mmol/l)	146.95	(145.79-148.10)	3.30	16th July	(12nd-20th July)
Magnesium (mg/dl)	1.79	(1.76-1.83)	0.08	3rd July	(27th June-9th July)

ever, not coinciding with those of the periodical electrocardiographic parameters; so we could hypothesize that the electrocardiographic parameters and the electrolytes, which are closely connected from an electrophysiological point of view, could be synchronized by various factors. Many studies have been made on humans concerning the periodicity of the variables connected with cardiocirculatory activity, in particular arterial pressure, heart rate, stroke volume and cardiac output; these parameters have been observed as important synchronizers of electric heart activity and show a periodic rhythm with diurnal acrophases. The application of chronophysiological methods to the parameters commonly used for evaluating athletic performance, enabled us to usefully examine the rhythmic variations of the parameters studied and to establish reference standards in order to monitor and plan training sessions in the human athlete.

CONCLUSION

Based on these results, it is hypothesized that the cardiovascular system follows a "deterministic" pattern, with a "linear" variability that is systematically foreseeable over a given temporal period. Moreover, the significant correlation already observed in the human species between rhythmic events related to the cardiovascular system, serum electrolytes, energetic metabolism and body temperature [15], encourages the continuation of this research with further electrocardiographic recordings, at different times, in order to understand the temporal organization of the heart's electric activity and to individuate the exogenous and endogenous variables which may synchronize this process. This would make it possible to define, in the athletic horse, a complete temporal chronogram of the functional parameters involved in athletic performance.

SOURCE AND MANUFACTURER

[1]P80 Digital Multichannel Eletrocardiograph. Esaote Biomedica, Genoa, Italy.

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