

Nitrogenous metabolism in Thoroughbred and Arabian foals from birth to five months of age

[*Metabolismo do nitrogênio em potros PSI e Árabe do nascimento aos cinco meses de idade*]

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ABSTRACT

The maturation of nitrogen metabolism was studied in six Thoroughbred and six Arabian foals. Rectal temperature, heart and respiratory rates and serum concentration of several hematochemical parameters (total protein, urea, uric acid, creatinine, and albumine) were monitored from birth to 5 months of age. In both breeds, all the parameters except albumine showed significant differences over time ($P < 0.05$). The two breeds did not differ from each other at any time point. Statistically significant decreases in urea and creatinine concentrations were related to the growth needs of foals during this critical period of development.

Keywords: foal, nitrogenous metabolism, physiological parameters, growth

RESUMO

A maturação do metabolismo do nitrogênio foi estudada em seis potros da raça Puro-Sangue Inglês e seis da raça Árabe. A temperatura retal, batimento cardíaco e concentração sérica de várias características hematoquímicas (proteína total, uréia, ácido úrico, creatinina e albumina) foram investigadas do nascimento aos cinco meses de idade. Em ambas as raças, todas as características, exceto a albumina, mostraram diferenças significativas ao longo da maturação ($P < 0,05$). As duas raças não diferiram uma da outra durante os períodos de vida equivalentes. Reduções significativas das concentrações de uréia e creatinina mostraram as necessidades de crescimento dos potros durante esse período crítico de desenvolvimento.

Palavras-chave: potro, metabolismo do nitrogênio, características fisiológicas, crescimento

INTRODUCTION

Several studies on the assessment of functional abilities of the athlete horse using metabolic and hematological investigations have been carried out on adult subjects (Judson et al., 1983; Caola, 1986; Caola and Balbo, 1987; Greppi and Serrantoni, 1993; Aguera et al., 1995; Evans et al., 2002).

Normal values for adult horses are usually reported on veterinary medicine text books. Regarding foals, with the exception of some studies on metabolic profile (Sato et al., 1978) and blood parameters (Jeffcott et al., 1982; Bauer et al., 1984; Harvey et al., 1984), data from literature are scarce and not univocal.

Muscular development occurs during the first year of life in the horse (Martin-Rosset et al., 1983). Muscular growing is the basis of athletic performance in the adult horse and it would be useful to determine serum levels of some metabolites mainly involved in muscular activity. Time from birth to 150th day of life is a very critical period for foals, because of the significant changes which occur in growing organism. So, this study is aimed at understanding the metabolic processes which characterize the foal growth, in particular from birth to the fifth month of life, by examining the pattern of some physiological and hematological parameters, in order to obtain standard values for nitrogenous metabolism (total protein, urea, uric acid, creatinine, albumine) and some physiological parameters (rectal temperature, heart and respiratory rates).

MATERIALS AND METHODS

Six Thoroughbred and six Arabian clinically healthy female foals were used for this study. Foals from these two breeds are naturally inclined to physical activity. Foals were fed a commercial creep food, fortified with vitamins and minerals, which ensure the recommended percentage of total protein (18%), calcium (0.9%) and phosphorus (0.6%). At 08.00 AM, rectal temperature, heart and respiratory rates were recorded from all foals. Blood samples were collected through jugular venipuncture, using vacutainer tubes¹ with no additive. Recordings and collections were done on the day after birth and every 30 days until the fifth month of life, with a simultaneous monitoring system². Blood samples were clotted at room temperature for 1h and centrifuged at 2,000rpm for 20min; sera were then stored at -20°C. By means of a spectrophotometer³ serum concentrations of the following hematochemical parameters were analyzed as nitrogenous metabolism index: total proteins, with a biuret (end-point) colorimetric method (Code 90009051)⁴; urea, with an UV

kinetic (fixed time) enzymatic method (Code 90005027)⁴; uric acid, with an enzymatic (end-point) colorimetric method (Code 90001005)⁴; creatinine, with a kinetic (fixed time) colorimetric method (Code 90006021)⁴ and albumine, with a BCG (end-point) colorimetric method (Code 90003401)⁴. To compare overall parameters studied on the different breeds at different times, two-way repeated measures analysis of variance (ANOVA) was used, being $P \leq 0.05$ considered statistically significant. The Bonferroni significant difference test was applied for posthoc comparison.

RESULTS AND DISCUSSION

Tables 1 and 2 show average values of the haematochemical and physiological parameters, expressed in their conventional units of measurement with the related standard deviations and statistical significance observed in different experimental conditions in six Thoroughbred and Arabian foals.

By applying a two-way repeated measures analysis of variance, the following results were obtained: total protein (breed: $F_{(1,50)}=0.64$, $P=0.44$; time: $F_{(5,50)}=31.54$, $P<0.0001$; interaction: $F_{(5,50)}=0.45$, $P=0.80$); urea (breed: $F_{(1,50)}=0.97$, $P=0.34$; time: $F_{(5,50)}=312.02$, $P<0.0001$; interaction: $F_{(5,50)}=2.43$, $P=0.04$); uric acid (breed: $F_{(1,50)}=0.02$, $P=0.87$; time: $F_{(5,50)}=8.69$, $P<0.0001$; interaction: $F_{(5,50)}=0.17$, $P=0.97$); creatinine (breed: $F_{(1,50)}=0.001$, $P=0.92$; time: $F_{(5,50)}=59.44$, $P<0.0001$; interaction: $F_{(5,50)}=2.03$, $P=0.09$); albumine (breed: $F_{(1,50)}=1.43$, $P=0.25$, time: $F_{(5,50)}=1.75$, $P=0.14$; interaction: $F_{(5,50)}=0.25$, $P=0.93$); rectal temperature (breed: $F_{(1,50)}=0.80$, $P=0.39$; time: $F_{(5,50)}=34.13$, $P<0.0001$; interaction: $F_{(5,50)}=0.39$, $P=0.85$); heart rate (breed: $F_{(1,50)}=0.51$, $P=0.49$; time: $F_{(5,50)}=25.59$, $P<0.0001$; interaction: $F_{(5,50)}=1.05$, $P=0.40$); respiratory rate (breed: $F_{(1,50)}=1.95$, $P=0.19$; time: $F_{(5,50)}=114.91$, $P<0.0001$; interaction: $F_{(5,50)}=0.54$, $P=0.74$).

¹ Terumo Corporation, Japan.

² Argus TM-7, Schiller, Barr, Switzerland.

³ Model DU-40, Beckman Instruments, Fullerton, CA.

⁴ SEAC, Florence, Italy.

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Table 1. Average values of the haematochemical and physiological parameters, expressed in their conventional units of measurement with the related standard deviations and statistical significance observed in different experimental conditions in six Thoroughbred foals

Parameters	Experimental conditions					
	1 st day	30 th day	60 th day	90 th day	120 th day	150 th day
Total protein (g/dl)	5.47±0.31	6.25±0.19*	6.12±0.29	6.25±0.19*	6.72±0.23 [◊]	6.17±0.19 [▲]
Urea (mg/dl)	18.72±0.45	15.10±0.62*	9.47±0.59*	12.98±0.70* [■]	16.70±0.66 [◊]	19.42±1.29* [▲]
Uric acid (mmol/l)	0.46±0.08	0.58±0.06*	0.50±0.06*	0.51±0.05*	0.49±0.06*	0.50±0.03*
Creatinine (mg/dl)	2.80±0.25	1.48±0.32*	1.68±0.23*	1.77±0.21*	1.50±0.26*	1.53±0.17*
Albumine (g/dl)	2.97±0.22	2.88±0.28	2.83±0.20	3.03±0.22	3.08±0.22	2.83±0.19
Rectal temperature (°C)	38.70±0.12	38.48±0.12*	38.38±0.07*	38.30±0.06*	38.35±0.10*	38.32±0.07*
Heart rate (bpm)	87.50±4.98	77.00±4.00*	75.67±3.50*	75.67±3.67*	71.00±2.37*	74.17±4.62*
Respiratory rate (c/min)	46.83±4.92	28.67±2.94*	24.50±3.27*	22.67±2.87*	21.33±2.50*	20.83±2.14*

Significance (Bonferroni - P<0,05):

- * vs 1st day
- vs 30th day
- vs 60th day
- ◆ vs 90th day
- ▲ vs 120th day
- ◊ vs 1st, 30th, 60th, 90th days

Table 2. Average values of the haematochemical and physiological parameters, expressed in their conventional units of measurement together with the related standard deviations and statistical significance observed in different experimental conditions in six Arabian foals

Parameters	Experimental conditions					
	1 st day	30 th day	60 th day	90 th day	120 th day	150 th day
Total protein (g/dl)	5.42±0.39	6.33±0.22*	6.07±0.16	6.47±0.22 [■]	6.72±0.31 [■]	6.22±0.24 [▲]
Urea (mg/dl)	18.85±0.29	15.12±0.87*	9.62±0.63*	13.15±0.59* [■]	16.58±0.67* [■]	17.97±0.77* [■]
Uric acid (mmol/l)	0.46±0.06	0.57±0.06*	0.50±0.06*	0.52±0.06	0.50±0.06*	0.51±0.06
Creatinine (mg/dl)	2.72±0.35	1.30±0.18*	1.61±0.23*	1.62±0.23*	1.70±2.24*	1.77±0.22*
Albumine (g/dl)	3.03±0.26	2.97±0.22	2.93±0.32	3.13±0.26	3.08±0.29	3.03±0.22
Rectal temperature (°C)	38.77±0.14	38.52±0.15*	38.42±0.12*	38.35±0.08*	38.33±0.10*	38.33±0.10*
Heart rate (bpm)	87.33±2.94	79.17±2.32*	78.17±2.32*	72.67±3.56* [■]	73.67±4.63*	74.33±5.28*
Respiratory rate (c/min)	44.33±4.68	28.83±2.86*	22.33±2.73*	21.33±1.51*	21.50±2.17*	21.33±1.03*

Significance (Bonferroni P<0,05):

- * vs 1st day
- vs 30th day
- vs 60th day
- ◆ vs 90th day
- ▲ vs 120th day

Lack of data for foal led to assess the health status of neonatal foals by examining the pattern of some physiological and hematological parameters from birth to fifth month of life. Changes in these variables which occur during the observed period can be explained by growth and differentiation-related processes that are specific for young animals (Waelchli et al., 1992; Brommer et al., 2001). The low concentration of total protein on the day of birth is probably due to the low concentration of globulins at birth (Sato et al., 1978). Statistical significant increase on the 30th day of life, compared to the birth, could be due to the immunological adjustments of the organism. At birth, there are minimal quantities of immunoglobulins (Bauer et al.,

1989), which show a rapid increase after the ingestion of the colostrum (Bauer et al., 1985). As the maternal antibodies decline, due to normal turn-over, the foal rapidly gains immunocompetence and begins to synthesize its own immunoglobulins, reaching normal adult levels (Spensley et al., 1987; Kaneko, 1989). Statistical significant increase of total proteins is supported by previous studies, which show lower values in young animals compared to adults (Rumbaugh and Adamson, 1983; Gill et al., 1985; Bauer et al., 1985). Total proteins pattern is the same in both breeds: this parameter shows a mean value of 5.47g/dl and of 5.42g/dl, respectively, in Thoroughbred and Arabian foals on the first day of life and reaches 6.25g/dl in

Thoroughbred and 6.47g/dl in Arabian foals at the 30th day of life. The contemporary decrease of urea, which falls from the mean value of 18.7mg/dl in Thoroughbred and 18.8mg/dl in Arabian foals after birth to 12.98mg/dl in Thoroughbred and to 13.1mg/dl in Arabian foals on the 30th day of life, confirms the growth requirements of the foal, as suggested by the high protein retention/protein intake ratio observed during this period (Doreau et al., 1986). It could be associated with an increased demand for amino acids necessary for structural and enzymatic protein synthesis, according to previous studies (Bauer et al., 1984). The statistical significant decrease of total proteins from the 120th day to the 150th day of life in both breeds has to be related to the contemporary increase of urea, as the main residue of protein metabolism. Uric acid shows a mean value of 0.46mmol/l in both Thoroughbred and Arabian foals in the first month of life and reaches 0.50mmol/l in Thoroughbred and 0.51mmol/l in Arabian foals in the fifth month of life. Most of literature about serum creatinine involvement in muscular metabolism refers to adult horses. Data obtained from researches on foals are scarce and not univocal and can be explained with the metabolic adjustments which occur during growth in young animals. In this study, the same behavior was also observed for both breeds, with a statistical significant decrease ($P < 0.05$), which is in agreement with previous studies (Rose et al., 1979; Harvey et al., 1984; Edwards et al., 1990). It can be related to the rapid growth and muscular development of the foal during the first months of life. In relation to albumine dosage no statistical significant differences were observed in both breeds. The high value of rectal temperature at the birth is supported by literature (Ousey et al., 1991); this parameter follows, in both breeds, the circadian pattern reported for the foal (Piccione et al., 2002).

Heart and respiratory rates show high values in both breeds 1 day after the birth (87.5bpm and 46.8c/min in Thoroughbred foals and 87.3bpm and 44.3c/min in Arabian foals). This is probably due to an excited or active status of the foal. The foal heart rate immediately after birth is around 40-80bpm, and increases up to 130-150bpm because of the physical activity due to its first attempts to stand; during the following days, heart rate settles at 70-100bpm (Koterba, 1990). The heart rate pattern recorded on the foal's first

week of life depends on cardio-circulatory system modifications that occur within the first 12 hours of life: the foramen ovale and the arterial duct close and the right-left cardiac shunt that persists in approximately 18% of cases (Bucca, 2001) resolves spontaneously during the following weeks. In the newborn, the heart is forced to pump the blood through a vascular system that presents a strong elastic, peripheral resistance. Since the organism of the newborn is not yet able to vary cardiac output, it compensates the limited systolic volume by increasing the heart rate. This may explain the significant effect of time on the statistically significant decrease ($P \neq 0.05$) in heart rate observed in both breeds during the 30 days of life (Piccione et al., 2005).

A significant effect of time was also found in both groups for respiratory rate. It confirms the homeostatic physiological variability of this parameter during the neonatal period. It is known that in newborns there is a physiological respiratory immaturity due to an incomplete anatomical-functional development. Indeed, the physiological values of the respiratory rate are around 60-80 ram immediately after birth (Koterba, 1990), though it significantly drops within 15 minutes (Stewart et al., 1984). Twelve hours later this value is 30-50c/min and by the end of the first week of life, it ranges between 20 and 40c/min (Koterba, 1990).

CONCLUSIONS

It is concluded that hematochemical and physiological parameters of foals are to be considered in relation to age, particularly with differentiation-related processes which accompany the growth of young organisms and should be cautiously interpreted to allow for individual variations.

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