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SYSTOLIC BLOOD PRESSURE ASSESSMENT OF MANGALARGA MARCHADOR HORSES AFTER PHYSICAL EXERCISE

AVALIAÇÃO DA PRESSÃO ARTERIAL SISTÓLICA EM EQUINOS DA RAÇA MANGALARGA MARCHADOR APÓS EXERCÍCIO FÍSICO

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SUMMARY

Blood pressure (BP) can be defined as blood pressure per surface unit of vascular wall, reflecting the interaction between cardiac output and peripheral vascular resistance. Systolic arterial pressure is the highest value on arteries, being associated with cardiac ventricular systole. Indirect blood pressure measurement is infrequently carried out in horses, but abnormal variations have been reported when colic, laminitis and epistaxis conditions occurs. A number of methods for indirectly measuring arterial blood pressure have been reported including invasive and non-invasive (oscillometric and ultrasonic-Doppler) techniques. The aim of this study was to evaluate the influence of physical exercise (gait) on values of systolic arterial pressure in horses. The study included ten adult Mangalarga Marchador horses (four males and six females) with mean weight of 426.60 ± 32.44 Kg and mean age of 6.7 ± 2.95 years old. Indirect measurements were obtained by oscillometric method in two different moments: rest (T0) and 5 minutes (T1) after the exercise. Comparisons between the different times were made using t-test at $p<0.05$ significance level. Uncorrected Coccygeal Values (CUCV) were 147±7 mmHg and 169±9 mmHg, respectively, at T0 and T1. The results showed that gait lead to significant increase of systolic arterial pressure ($p<0.0001$) and this occurred due to an increase of cardiac output during exercise. This clinical parameter could be used as a cardiac index for the evaluation of athletic horses.

KEY-WORDS: Arterial pressure. Equine. Exercise.Marcha gait.

RESUMO

A pressão arterial (PA) é definida pela força exercida pelo sangue por unidade de superfície da parede vascular, refletindo a interação do débito cardíaco com a resistência periférica sistêmica. A pressão sistólica representa a mais alta pressão nas artérias, sendo associada com a sístole ventricular cardíaca. A aferição indireta da pressão arterial ainda é subutilizada na medicina equina, mas oscilações já foram descritas em casos de cólica, laminite e epistaxe. São diversas as formas de aferição usadas, destacando-se as técnicas invasivas e não invasivas (oscilométrica e guiada pelo uso do Doppler). O presente trabalho teve como objetivo avaliar a influência do exercício físico (marcha) sobre os valores registrados para pressão arterial sistólica em equinos. Foram avaliados 10 equinos da raça Mangalarga Marchador, com idade de 6,7 ± 2,95 anos e peso médio de 426,60 ± 32,44 Kg, sendo quatro machos e seis fêmeas. Procedeu-se avaliação indireta da PA por método oscilométrico em dois diferentes momentos: repouso (T0) e com 5 minutos (T1) após o término do exercício, representado por 40 minutos de marcha. Os resultados foram analisados através da comparação entre médias (teste-t), considerando o nível de significância de 5%. Foram registrados valores CUCV (valores coccígeos não corrigidos) de 147±7 mmHg e 169±9 mmHg, respectivamente nos momentos T0 e T1. A análise dos resultados demonstrou que a marcha influenciou de forma significativa os valores registrados para pressão arterial sistólica ($p<0,0001$) e esse aumento pode ser justificado pela elevação do débito cardíaco em função da intensidade do exercício. Tal variável poderia ser um índice cardíaco utilizado para avaliar a condição física cavalos.

PALAVRAS-CHAVE: Equino. Exercício. Marcha. Pressão Arterial.

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INTRODUCTION

The natural and characteristic physical exercise of the genuinely Brazilian Mangalarga Marchador breed is gait (marcha), which spends a great deal of energy (REZENDE, 2006). During gait, the animal performs symmetric four-stroke swing, alternating side and diagonal biped support, always interspersed with moments of triple support. In competitions, the animal performs 40 consecutive minutes of exercise at a constant speed (09-12 km/h) in circular path, divided into two 20-minute gaits, clockwise and anti-clockwise (ABCCMM 2013).

The assessment of horse athletic performance depends on the physiological changes that occur during the physical exercise performed at either training or competition (MARQUES et al., 2002). The evaluation of the cardiovascular system during exercise includes measuring the heart rate (PRATES et al., 2009), blood pressure (BP) (BAYLY et al., 1983), as well as performing electrocardiogram (ALBERNAZ et al., 2011) and echocardiogram (BERTONE et al., 1987; DURANDO et al., 2002; MICHIMA et al., 2004), and measurements of pulmonary artery pressure, cardiac output and right ventricular pressure (ERICKSON et al., 1990; MANOHAR, 1993; DURANDO et al., 2002; HACKETT et al., 2003; GEHLEN et al., 2004; DIAS et al., 2013).

Blood pressure (BP) is defined as the force exerted by the blood per unit area of the vascular wall, reflecting the interaction of cardiac output and systemic peripheral resistance (MAGDESIAN, 2004). Systolic blood pressure (SBP) is determined by stroke volume and arterial wall elasticity, whereas diastolic blood pressure (DBP) represents the moment when the heart muscles dilate and fill the ventricles (COLLEN, 1996). There are two methods to measure BP: direct or invasive by arterial catheterization and, the indirect, held through different non-invasive techniques such as auscultatory, oscillometric, ultrasound with Doppler colorimetric and Photoplethysmography (BROWN & HENIK, 2002; MAGDESIAN, 2004).

Preferably, indirect BP measurement in horses is held in the coccygeal artery, located at the base of the tail (ROBINSON, 2008). At this point, the values are usually recorded as coccygeal uncorrected values (CUCV) for BP, SBP and DBP. The values can be corrected for heart level (height of the scapular-humeral joint), adding to the recorded CUCV, the height difference, in centimeters, between the joint and the pressure measurement point multiplied by 0.77 (PARRY, 1986).

BP is the main indirect tool to evaluate the inotropic response of the heart in relation to the effort, and it is associated with exercise tolerance (DURANDO et al., 2002). In humans, the pressure response of the artery is dependent on fitness, as well as individual age and sex (BECKER et al., 2007). Furthermore, it is known that SBP rises during exercise while DBP is either maintained or reduced (BECKER et al., 2007; SIEIRA et al., 2010). Similar BP behavior has been described for horses during exercise with differente levels (DIAS et al., 2013) tests.

Johnson et al. (1976) worked with 456 healthy Thoroughbred breed horses, and reported values ranging from 70-170 mmHg SBP. Parry et al. (1980) found values between 137.2 ± 4.1 mmHg CUCV for SBP of 18 horses of several breeds, including Thoroughbred. A study with 296 horses of various breeds, considered 98-125 mmHg SBP as normal (PARRY et al., 1984). Subsequently in 1986, Parry reported that equine normal systolic pressure ranges from 80 to 140 mmHg. Robinson (2008) describes SBP values between 98 and 125 mmHg for adult horses.

In 1977, Hörnicke et al. evaluated the effects of galloping (550 m/min) on systemic arterial pressure and heart rate of horses and recorded SBP values of 115 ± 15 mmHg before and 205 ± 23 mmHg after the exercise. Bayly et al. (1983) reported differences in mean blood pressure (MBP) only when Standardbred horses exercising on a treadmill reached a maximum speed of 154 m/min. These same authors found no influence of training on blood pressure.

This study evaluates the influence of physical exercise (gait) on the SBP of Mangalarga Marchador horses after performing physical activity.

MATERIAL AND METHODS

This research was approved by Council on Bioethics CEUA - UVV being under protocol number 177/2011. Ten Mangalarga Marchador horses, of which six females and four males were used, weighing 418 ± 31 kg average and aged between 3 and 11 years (mean 6.5 ± 2.9 years old). The animals were considered clinically healthy according to clinical examination performed before the start of the experiment. The horses used in the study belong to the same Mangalarga Marchador Haras, located in Guarapari - ES, Brazil, and underwent the same type of food and health management.

The animals' diet consisted of coast-cross hay *(Cynodon dactylon* x *Cynodon nlemfluensis)* supplied freely, and commercial concentrate (DoEqui topquality) containing 12% crude protein supplied at 1% of body weight, divided into three times daily (RALSTON, 1988). The mineral salt and water were provided *ad libitum.*

The selected horses were at the same training stage, started a year ago, and belonged to the same category according to the Brazilian Association of Mangalarga Marchador Horse Breeders (Associação Brasileira dos Criadores de Cavalos da raça Mangalarga Marchador – ABCCMM). The weekly training consisted of exercise while pulled by the halter for a period of 60 minutes twice a week, alternating three days including mounted exercises, gait (9-12 km/h) for 30 to 40 minutes. On weekends, the mounted animals gaited for 20 minutes a day at a speed of 9-12 km/h. In the summer months, training was complemented with swimming activity for 10 minutes attached to the halter, twice a week, alternating with days that they were walked.

The physical activity performed to determine SBP consisted of mounted lilting gait, during two 20-

minute sessions, clockwise and counter-clockwise, at average speed of 9-12 km/h, mimicking a competition exercise performed by ABCCMM. All tests were performed in the morning (between 6:00 and 11:00 am), when track characteristics such as average temperature and relative humidity were also recorded. All horses were exercised on the same day and for that, four horsemen with similar body weight were used.

Blood pressure was measured with the animal at rest, right before (T0) and within a maximum period of five minutes after the exercise (T1). For each time, T0 and T1, the following parameters SBP (mmHg), heart (bpm) and respiratory (mpm) rates, and body temperature (°C) were measured while the color of mucous membranes and capillary refill time (seconds) were also recorded. About 30 minutes after the completion of the physical activity, the horses underwent a new physical examination, which included measuring the same variables again, except for SBP.

For the measurements at T0 and T1, the horses were restrained in the trunk, in standing position, with the limbs parallel to each other and perpendicular to the body axis. The animal head was kept aligned to the trunk. The environment during the measurements was calm and quiet, and it was not necessary to tranquilize the animals as suggested by Robinson (2008). SBP was measured indirectly by oscillometry, in the coccygeal artery. We used an 8-cm cuff (40% of the horse tail circumference, following the methodology described by Parry, 1986) placed at the base of the horse tail. The cuff was connected to the Bic aneroid sphygmomanometer (BARAKAT et al., 2000). At the given times, final SBP was the mean of three consecutive readings, and it was usually recorded as CUCV (uncorrected coccygeal).

The analysis of the records was performed using the statistical GraphPad InStat software (version 3.0). Data were subjected to one-way analysis of variance and mean values were compared by t-test, at 5% significance level. Physical activity was considered to have influence on the following parameters SBP, heart and respiratory rates, and body temperature.

RESULTS AND DISCUSSION

During the clinical examinations performed to select the horses for the trial, the recorded parameter values were: mean heart and respiratory rate 45 ± 7 bpm and 29 ± 9 mpm, respectively, pinkish mucous, CRT 2 seconds and rectal temperature 37.8 ± 0.16°C. All values were within the normal range, according to Robinson (2008).

The local climate characteristics are typical of tropical regions with high temperatures (29°C) and high relative humidity (89%). The sand track was moist.

Table 1 shows mean values and standard deviations for the parameters heart (HR) and respiratory (RR) rate range values, body temperature (BT) and systolic blood pressure (SBP) measured at T0 and T1, as well as p values obtained in the t-test.

The oscillometric method principle is to analyze the oscillations of the arterial wall (JAFFE, 2006). Oscillations start when the cuff pressure is equal to systolic blood pressure, maximize when it is the same as the mean blood pressure and disappear when the pressure equals the diastolic blood pressure (CARVALHO, 2009). The oscillations can be detected by observing the needle oscillations on the gauge as the cuff deflates (BARAKAT et al., 2000; LATSHAW et al., 1979), or automated when using digital equipment (LATSHAW et al., 1979; PADDLEFORD, 1992; SILVA, 2010). In this study, SBP was measured by the mechanic oscillometric method, similar to that described by Barakat (2000). Although the chosen methodology is subjected to errors, all measurements were performed by the same veterinarian trained for such activity.

Table 1 - Mean values and standard deviation for the intervals of heart rate (HR), respiratory rate (RR), body temperature (BT) and systolic blood pressure (SBP) in Mangalarga Marchador horses that performed physical exercise, at rest, before (T0) and after a maximum of 5 minutes (T1) after the physical activity.

	HR (bpm)	FR (mpm)	BT (°C)	SBP (mmHg CUCV)
T0	7 ± 45 [a] (36-54)	29 ± 9 [a] (16-40)	37.8 ± 0.16 [a] (37.6 to 38.1)	7 ± 147 [a] (137-158)
T1	91 ± 15 [b] (72-104)	55 ± 17 [b] (32-80)	39.5 ± 0.72 [b] (39.0 to 40.4)	169 ± 9 [b] (156-179)
p	<0.0001	0.0005	<0.0001	<0.0001

* Values followed by different lowercase letters in the same column are significantly different ($p<0.05$) as determined by t-test.

According to Latshaw et al. (1979), the direct (or invasive) method of blood pressure measurement consists of intra-arterial catheterization. Although considered the "gold standard", the animal should preferably be sedated or under general anesthesia (SILVA, 2010; DIAS et al., 2012). Therefore, it is not applicable in clinical routine (HABERMAN et al., 2006), especially to evaluate horse athletes in the field. More recent study (DIAS et al., 2012) concluded that the implementation of facial catheter in horses is convenient and appropriate to evaluate animals exercising on a treadmill, unlike the present experiment that was performed in the field.

The indirect (or non-invasive) ways include the techniques auscultatory, oscillometric, ultrasound guided by Doppler and photoplethysmography (JEPSON et al., 2005; FEITOSA, 2008). Thus, although less accurate than the arterial cannulation, these are preferably used in clinical situations due to greater convenience and the possibility of repeating at short time intervals (JEPSON et al., 2005), as in the present study.

Unlike Caroli & Belli (2009), who measured SBP using the Doppler technique in horses with abdominal colic, the attempts to measure SBP using the Doppler ultrasound in the coccygeal artery were fruitless due to intense agitation of horses, especially after performing gait. According to Jepson et al. (2005), the comparison of the results obtained by the Doppler and oscillometric techniques were not significantly different for the mean SBP readings in horses. Although the mean blood pressures obtained are comparable, the oscillometric device resulted in data points with higher variation. A similar comparison was made by Haberman et al. (2006) in dogs, in which the authors concluded that both techniques produce similar values. Giguère et al. (2005) compared the results recorded in two oscillometric monitors used to measure blood pressure in foals and demonstrated that the measurement made using this methodology either in the coccygeal or dorsal metatarsal artery is acceptable to determine the mean arterial pressure in these animals. According to Robinson (2008), the oscillometric method is the most widely used technique in horses.

In this study, SBP varied significantly between the times measured ($p<0.0001$). The values recorded at rest are close to the limits reported by Johnson et al. (1976) and Parry et al. (1980), but higher than those reported by Hörnicke et al. (1977) and Parry et al. (1984). These authors worked with different breeds, but especially with the Thoroughbred. Therefore, it is possible to suggest that the discrepancies observed between these authors and the present study are related to methodology, noting that these authors used the Doppler methodology, as well as horse breeds, reflecting differences of the type of physical activity. Although for both breeds, the aerobic metabolism predominates due to the type of exercise performed, the exercise imposed on the Mangalarga Marchador was considerably longer, at a lower speed, compared with the physical activity performed by the Thoroughbred.

Measurement site was chosen based on the descriptions of Ellis (1975) and Robinson (2008), which cited the coccygeal artery as a good choice for indirect blood pressure measurement in horses, despite its small size and peripheral location.

During blood pressure measurements, the head of the horse was positioned and maintained at the same height of the tail. According to Parry et al. (1980) and Magdesian (2004), horse head height influences the results obtained during indirect pressure measurement, with the animal in station. Blood pressure values decrease when lowering the head and increase when lifting it up, possibly because a greater ejection force is required for the blood to reach the central nervous system.

SBP increased significantly after gait, and the recorded values were higher than all citations described previously in the literature (JOHNSON et al., 1976; PARRY et al., 1980, PARRY et al., 1984). This SBP increase after physical activity is expected. According to Boffi (2007), physical exercise leads to increased tonus of the sympathetic nervous system while the cardiovascular response to exercise involves increasing chronotropism, inotropism, batmotropism and dromotropism, leading to increased blood pressure and blood flow.

Brum et al. (2004) described a similar condition in humans. Dynamic exercises (muscle contractility followed by articular movement) activate the sympathetic nervous system leading to increasing cardiac output, heart rate and blood volume. There is the formation of muscle metabolites, which lead to vasodilation and hence reduction of vascular resistance and may increase SBP and even reduce diastolic blood pressure. According to Evans (1985), the BP increase in horses is more discreet than the increases in frequency and cardiac output due to decreased vascular and systemic resistance.

Even in human medicine, according to Monteiro & Sobral (2004), there are three physiological effects of physical exercise due to changes in the metabolic demand of the body, namely: immediate acute, delayed and chronic acute. The acute effects or responses occur in direct association with the workout. The immediate acute effect, during which the current research was conducted, occurs in the peri- and post-immediate physical exercise, leading to increased SBP proportional to the increase in cardiac output due to the need for increased blood flow. The late acute effects occur after 24 to 48 hours (sometimes up to three days) of physical activity and are identified by a slight reduction in blood pressure levels with improved endothelial function, important in hypertensive individuals. Finally, the chronic effects or adaptations that result from exposure to frequent and regular exercise sessions. The latter differentiates a physically trained individual from the sedentary one.

According to Polito & Farinatti (2003), the increase of systolic blood pressure response is directly related to the intensity of the exercise performed. According to Becker et al. (2007), the SBP change in humans during exercise, measured on the arm of individuals with an aneroid sphygmomanometer can be influenced by physical conditioning, as well as by age and sex. In their study, the SBP change in human athletes with good physical conditioning was 30.1 ± 17.3 mmHg for males and 20.3 ± 13.9 mmHg for females, representing, respectively, increases of 26.26 ± 15.09% and 18.57 ± 12.71% compared to baseline. This result was slightly higher than the increase percentage recorded in this study, where the average SBP increase of 21 ± 11.4 mmHg (14.55 ± 8.33%) was recorded immediately after exercise (T1) compared to values at rest (T0).

The mean values recorded after 30 minutes were: 45 bpm heart rate, 23 mpm respiratory rate, intestinal motility present at auscultation, pinkish mucosa and rectal temperature of 38.7°C. All values were within normal range according to Robinson (2008), suggesting that the tested horses are suitable for the type of physical activity imposed, which is also suggested by the SBP recorded immediately after the gait.

There are no reports in the literature assessing the blood pressure of Mangalarga Marchador horses; therefore, more research is needed on the subject in order to establish a standard for this breed.

CONCLUSION

The results of this study allow us to conclude that the physical activity performed, the gait test, changed significantly SBP values. It was also concluded that the tested horses were conditioned and able to perform the level of exercise imposed since they did not show clinical signs of fatigue.

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