QUANTITATIVE ECHOCARDIOGRAPHY OF ATHLETIC QUARTER HORSES

ECOCARDIOGRAFIA QUANTITATIVA DE EQUINOS ATLETAS DA RAÇA QUARTO DE MILHA

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SUMMARY

Equine echocardiographic examination is a useful and safe method to evaluate cardiac structure, function and flow. Echocardiographic reference values for each breed and its correlation with physical activity can help both to follow equine athletes and diagnose any changes that may occur. Fifty athletic Quarter Horses were submitted to echocardiographic examination. The parameter values were analyzed and compared with other breeds of athletic horses. Increased heart chambers and thickness of heart muscle, as well as lower heart rate were observed. It was also possible to observe that males had higher values of the ventricular septum and ventricular stroke volume when compared with females. Reference values are established for cardiac evaluation at rest of athletic horses of the Quarter Horse breed. Those values correspond to the type of activity that these animals practice, and are adequate for their performance.

KEY-WORDS: Echocardiography. Equine. Quarter Horse. Exercise.

RESUMO

O exame ecocardiográfico de equinos representa um método útil e seguro para avaliação de estrutura, função e fluxo cardíacos. Valores de referência ecocardiográficos para cada raça e a correlação com a atividade física desempenhada por este podem auxiliar tanto no acompanhamento de equinos atletas como no diagnóstico de alterações que possam se manifestar. Realizou-se um exame ecocardiográfico em cinquenta equinos atletas da raça Quarto de Milha em repouso. Os valores foram comparados e analisados com equinos de outras raças e participantes de outras modalidades esportivas. Verificou-se aumento de câmaras cardíacas e de espessura da musculatura cardíaca, além de menor frequência cardíaca em repouso. Foi possível também observar que os machos apresentaram maiores valores de septo ventricular e volume de ejeção ventricular quando comparados com as fêmeas. Ficam estabelecidos valores de referência para avaliação ecocardiográfica em repouso de equinos atletas da raça Quarto de Milha. Os valores encontrados correspondem com o tipo de atividade que estes animais praticam, sendo suficientes para o desempenho adequado de sua função.

PALAVRAS-CHAVE: Ecocardiografia. Equinos. Quarto de Milha. Exercício.

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INTRODUCTION

The quantification of cardiac variables assessed by echocardiographic examination is of great importance to better evaluate equine heart during clinical and experimental studies, as well as a tool for monitoring the training of these animals (MICHIMA, 2003).

Echocardiography is a noninvasive and safe method to evaluate cardiac function, flow, structure and indexes important for animal athletic performance, identifying heart injuries, disorders or structural abnormalities that may impair performance, and providing important information to determine animal fitness as well (POOLE & ERICKSON, 2004).

The activity performed by horses that participate in barrel racing and pole bending events be classified according to duration and type of exercise. These aerobic events that last less than a minute, lead mainly to an increase of myocardial mass and size of heart chambers, according to Mcardle et al, 1998, who classified horse activity based on human physical activity. Other changes reported by these authors are: mild cardiac hypertrophy characterized by increased left ventricular cavity and moderate thickening of their walls, increased plasma volume, decreased resting heart rate and increased ejection volume both at rest and during exercise, either by the increase of ventricular volume or an improvement of ventricular contractility.

The reproducibility of cardiac measurements by M-mode echocardiography has been researched for a long time (LONG, 1992, SAMPSON, 1999). Therefore, as long as the techniques used are standardized, the variation among the measured parameters are small enough to warrant the use of echocardiography in clinical and experimental studies (KRIZ, 2002).

In this study, we used the quantitative echocardiography standard technique to establish reference values for cardiac evaluation of Quarter Horses at rest, aiming to evaluate the influence of the horses' athletic performance on their cardiac function after barrel and pole bending events that they participated in.

MATERIAL AND METHODS

Fifty male and female Quarter Horses, aged 3 years old or more, that participated in Barrel and Pole bending events in São Paulo state were evaluated. First, physical examination was performed and the following parameters were evaluated: heart rate (beats per minute- bpm), respiratory rate (breaths per minute-bpm), weight (kg), capillary filling time (s), rectal temperature (ºC), frequency of caecal movements (movements per minute), degree of hydration and color of mucous membranes (mouth and eyes).

Both B and M-modes echocardiography were performed. During the examination, the horses were calm, restrained by the halter only, in a quiet low light, as suggested by Vöros, 1990. The area between the 3rd and 5th intercostal spaces of the right cardiac window was well cleaned, with water and soap when necessary. Further, a sufficient amount of contact ultrasound gel was applied for proper visualization of cardiac structures, avoiding the presence of air between hair and transducer (LONG, 1992; REEF, 1998). Considering that the horses were competing, the region was not shaved for esthetic reasons; therefore a small amount of ethyl alcohol was applied in the area before the contact gel to avoid air between hair and transducer. To facilitate the examination on the right cardiac window, the right forelimb was positioned slightly ahead of the contralateral limb, as suggested by Long, 1992 and Reef, 1998.

The horses were evaluated at rest, that is, no physical activity was performed during two hours prior to examination. The ultrasound equipment used was a Sonoheart 180 Plus 1.9, Sonosite®, that worked in both M and B-modes and Doppler as well, equipped with 2 to 4 MHz micro-convex multi-frequency C15 transducer (Sonosite®). The examination was carried out on the right cardiac window, between the 3rd and 5th intercostal space, above the olecranon and caudal to the triceps muscle (REEF, 1998). The transducer was adjusted to scan up to 25 cm in depth and 2 MHz frequency. The technique used has been described by Reef, 1998. The following parameters were evaluated during B and M-mode echocardiography: interventricular septum thickness (IVS), left ventricular free wall (LVFW) and left ventricular internal diameter (LVID), during the end of diastole and peak systole; the aortic diameter at the end of diastole (Ao) and left atrium in systole (LAs), LA:Ao ratio, distance from point E (greater opening of the mitral valve) to interventricular septum (E-S), ventricular ejection time – from the opening to the closing of the aortic valve leaflets (VET), ejection fraction of the left ventricle (EF), stroke volume (SV) and cardiac output (CO).

A descriptive analysis of the quantitative variables was performed and the results are presented as mean values, with minimum and maximum values and standard deviation as well.

The horses were divided in two groups according to sex, with 29 males and 21 females in each group. The comparative analysis was performed by the unpaired T test, at significance level of 5% ($p = 0.05$).

RESULTS

None of the horses had abnormal physical examination. The mean age was 7.28 years old and average heart rate was 31.56 bpm.

Tables 1 and 2 show statistical analysis results.

Figures 1, 2 and 3 show few images used during the echocardiographic examination of these horses.

DISCUSSION

The echocardiographic examination technique used was adequate for the evaluation of the horses, except for animals with more dense hair. Because the area

Table 1 - Values of the heart parameters obtained from the echocardiographic examination of athletic Quarter Horses.

	M	SD
Weight (kg)	442.76	34.40
IVSd (cm)	2.88	0.36
IVSs (cm)	4.19	0.44
LVIDd (cm)	10.16	0.92
LVIDs (cm)	6.17	0.81
LVFWd (cm)	3.13	0.83
LVFWs (cm)	4.55	0.91
Ao (cm)	6.71	0.70
LAs (cm)	10.08	0.83
LA:Ao	1.50	0.16
E-S (cm)	1.40	0.38
VET (s)	0.63	0.11
FS (%)	39.50	6.33
EF (%)	66.66	7.20
SV (ml)	394.10	85.10
CO (l/min)	12.42	3.91

M: mean, SD: standard deviation, d: diastole, s: systole, IVS: interventricular septum, LVID: left ventricle internal diameter, LVFW: left ventricle free wall, Ao: aortic diameter , LA: left atrium diameter, E-S: distance from point E to the interventricular septum, VET: ventricular ejection time, FS: fraction shortening, EF: ejection fraction, SV: stroke volume, CO: cardiac output.

Table 2 - Values of the heart parameters obtained from the echocardiographic examination of athletic Quarter Horses according to gender.

	Females	Males
Weight (kg)	439.10	445.17
IVSd (cm)	2.82	2.93
IVSs (cm)	4.00^{b}	4.34^{a}
LVIDd (cm)	9.96	10.30
LVIDs (cm)	6.28	6.09
LVFWd (cm)	3.33	3.00
LVFWs (cm)	4.61	4.50
Ao (cm)	6.73	6.70
LAs (cm)	10.21	10.00
LA:Ao	1.53	1.48
E-S (cm)	9.58	1.37
VET (s)	0.64	0.63
FS (%)	37.77	40.83
EF (%)	64.10^{b}	68.52^{a}
SV (ml)	362.70^{b}	416.90^{a}
CO (l/min)	11.61	13.01

Different letters in the same row are significantly different ($p<0.05$). d: diastole, s: systole, IVS: interventricular septum, LVID: left ventricle internal diameter, LVFW: left ventricle free wall, Ao: aortic diameter , LA: left atrium diameter, E-S: distance from point E to the interventricular septum, VET: ventricular ejection time, FS: fraction shortening, EF: ejection fraction, SV: stroke volume, CO: cardiac output.

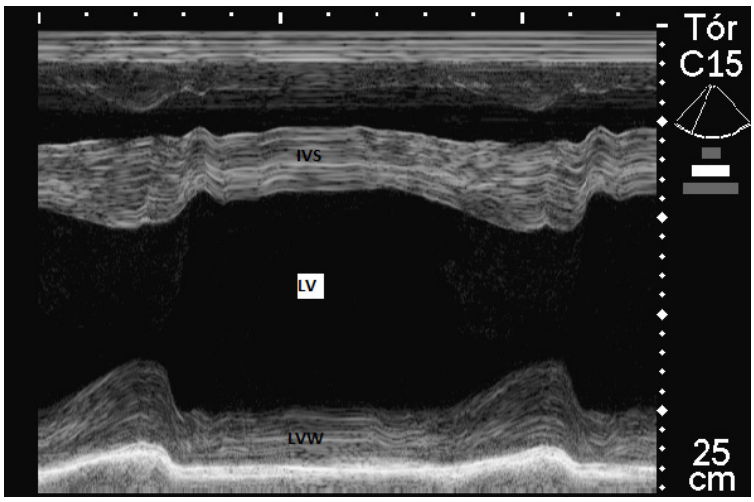

Figure 1 – Echocardiographic M- mode image showing the minor axis of left ventricle of Quarter Horses, obtained from the parasternal right window. *IVS: interventricular septum; LV: left ventricle. LVW: left ventricular wall*. Depth 25 cm.

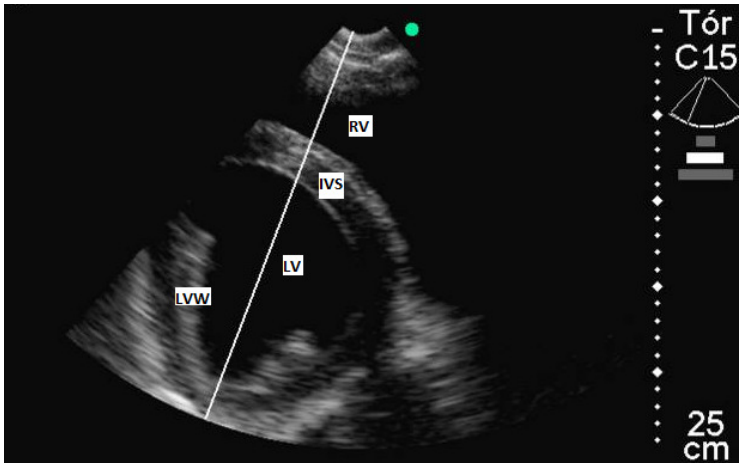

Figure 2 - Echocardiographic B- mode image showing the minor axis of left ventricle of Quarter Horses, obtained from the parasternal right window. Note the guide line M-mode dividing the left ventricle at its bisector. *IVS: interventricular septum; RV: right ventricle; LV: left ventricle; LVW: left ventricular wall*. Depth 25 cm.

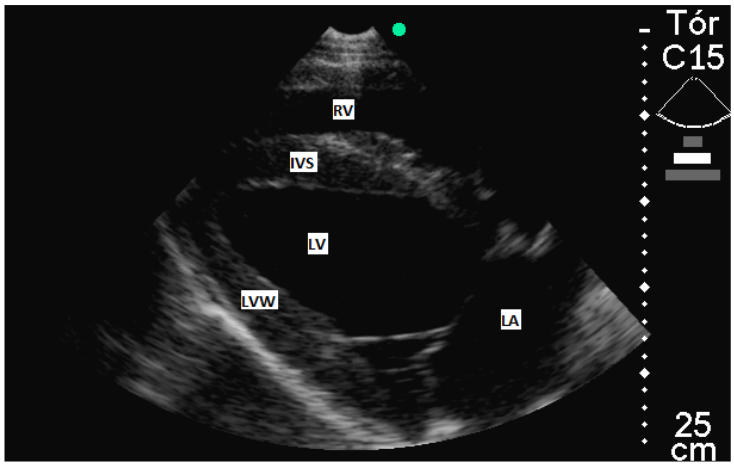

Figure 3 - Echocardiographic B- mode image showing the major axis of the four chambers of Quarter Horses, obtained from the parasternal right window. *LA: left atrium; IVS: interventricular septum; RV: right ventricle; LV: left ventricle. LVW: left ventricular wall*. Depth 25 cm.

was not shaved, there was more air between the transducer and the skin, and the resulting image was less sharp with lower quality

B-mode echocardiography to evaluate heart anatomy and movement was effective as mentioned by Long, 1992, whereas M-mode was adequate when the transducer was correctly placed, that is, as perpendicular as possible to the structures to be analyzed (REEF, 1998).

The values found for interventricular septum thickness and left ventricular internal diameter in both systole and diastole, were higher than the values reported by Michima, 2003 for Thoroughbred Arabian endurance horses, and lower than the values observed by Long, 1992 for Thoroughbred English racing horses. The mean values measured for the left ventricular free wall were higher than the values reported by Michima, 2003. However, this parameter can not be safely correlated with other studies due to lack of data, since because of different heart sizes, the technique does not always allow to visualize the entire thickness of the wall (the larger the heart, the lesser this structure can be visualized).

The fraction and stroke volume were higher than those observed by Michima, 2003, and lower compared to the value found by Lightowler, 2002, who studied horses weighing between 330 and 550 kg, and again, the type of physical activity performed by each of these animals may explain the results, and possibly the weight did not play a big role since animals' average weight was within the same range.

The results are consistent with those reported by Mcardle, 1998, since it is expected an increase of the diameter of heart chambers and thickening of the heart muscle during anaerobic physical activity. Thus, justifying the different values found for horses that compete in aerobic events compared to endurance events.

No significant statistical differences were found for several of the studied parameters between males and females, with the exception of interventricular septum thickness in systole (IVSs), stroke volume (SV) and ejection fraction (EF), where males had higher mean values. These results corroborate Latorre, 2005, who also found significant difference in the stroke volume and ejection fraction between male and female horses, possibly in this case, because male horses had higher mean weight than the females, which would require a greater functional capacity of the heart to meet the physiological need during exercise.

The ejection fraction (EF) was lower than that reported by Long, 1992 and higher compared to the results of Michima, 2003. However, the values were within the standard range, 32 to 55% (REEF, 1998), which characterizes a normal ventricular function. These differences may be related to the greater contraction force required during a highly intense exercise such as barrel racing and pole bending, the heart must in this case, contracts exerting more force and intensity to compensate for the rapid demand compared to endurance events. Therefore, when compared to race horses, this difference can be explained by the fact that these animals have larger hearts, thus requiring greater contraction force to meet the demand of the exercise performed by the horses.

The difference found in the E-S distance compared to the results of other cited authors may be explained by the increased ventricular septum thickness that diminishes the distance from the septum leaflet of the mitral valve to the interventricular septum. The aortic diameter in diastole, as well as the diameter of the left atrium in systole were lower than the values found by Lightowler, 2002; Long, 1992 and Michima, 2003, suggesting possible hypertension of these animals, which should be studied further, including during physical activity. On the other hand, the ratio AE:Ao was higher compared to the values reported by Michima, 2003, and also differs from Reef, 1998, who reported values lower than 1.

The other variables analyzed during the physical examination were not significantly different. During physical examination, cardiac arrhythmia was observed in 13 animals (26%). It was not possible to characterize the type of arrhythmia without performing an electrocardiography, but it is known that bradyarrhythmias are most commonly found in athlete horses and are associated with the parasympathetic tone. These arrhythmias are usually present at rest and should disappear with increased sympathetic tone and decreased parasympathetic tone, which occurs during animal excitement or during exercise (REEF, 1999).

CONCLUSIONS

The mean values of the analyzed heart parameters are, therefore, established. The horse gender influenced the following parameters: interventricular septum in systole, stroke volume and left ventricular ejection fraction, whose values were higher for males compared to females. This study also showed the influence that the type of physical activity performed by Quarter Horses had on the heart anatomy and function, with the slight enlargement of the heart chambers and hypertrophy of the heart muscle.

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REFERENCES

KRIZ, N. G.; ROSE, R. J. **Repeatability of standard transthoracic echocardiographic measurements in horses**. Australian Veterinary Journal, v.80, n.6, p.362-370, 2002.

LATORRE, S. M. **Padronização ecocardiográfica das dimensões e índices cardíacos em eqüinos da raça Mangalarga Marchador.** São Paulo: Universidade de São Paulo, 2005. 100p. Dissertação

(Mestrado em Medicina Veterinária) – Faculdade de Medicina Veterinária e Zootecnia, 2005.

LIGHTOWLER, C. H.; PIDAL, G.; CATTÁNEO, M.; GARCIA LIÑEIRO, J. **Diâmetros y volúmenes del ventrículo izquierdo del caballo determinados por ecocardiografia**. Archivos de Medicina Veterinária, v.34, n.1, p.135-146, 2002.

LONG, K. J. **Two-dimensional and M-mode echocardiography.** Equine Veterinary Education, v.4, n.6, p.303-310, 1992.

MCARDLE, W. D.; KATCH, F. I.; KATCH, V. L. **Treinamento para potência anaeróbica e aeróbica**. In: MCARDLE, W. D.; KATCH, F. I.; KATCH, V. L. Fisiologia do exercício: energia, nutrição e desempenho humano, 4ed, Guanabara Koogan, 1988, p.373-393.

MICHIMA, L. E. S. **Avaliação de dimensões e índices cardíacos obtidos por ecocardiografia de equinos de enduro criados no Estado de São Paulo.** São Paulo: Universidade de São Paulo, 2003. 71p. Dissertação (Mestrado em Medicina Veterinária) – Faculdade de Medicina Veterinária e Zootecnia, 2003.

POOLE, D. C.; ERICKSON, H. H. **Heart and vessels: function during exercise and response to training.** In: HINCHCLIFF, K. W.; KANEPS, A. J.; GEOR, R. J. Equine Sports Medicine and Surgery. Ed. Saunders. 2004, p.699-727.

REEF, V. B. **Cardiovascular ultrasonography**. In: REEF, V. B. Equine Diagnostic Ultrasound. Philadelphia: W. B. Saunders. 1998, p.215-72.

REEF, V. B. **Electrocardiography and echocardiography in the exercising horse.** In: MARR, C. Cardiology of the horse. Ed. W.B. Saunders, 1999, p.150-160.

VÖROS, K.; HOLMES, J. R.; GIBBS, C. **Anatomical validation of two-dimensional echocardiography in the horse**. Equine Veterinary Journal, v.22, n.6, p.392-397, 1990.