

Assessing the cardiac valves conditions in athletic horses with poor performance

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Abstract

Heart murmurs and valvular regurgitation are common in horses and often have no effect on their performance. However, when structural changes occur in the heart size, they can affect performance adversely. This study aimed to examine the correlation between cardiac valves disease and poor performance in athletic horses. A total of 300 athletic Thoroughbred and mixed-breed horses including 164 mares and 136 stallions, with a history of poor performance, were selected. Horses with cardiac murmurs were identified and further cardiac examination including precise auscultation, base-apex electrocardiogram for possible dysrhythmias at rest and after exercise, echocardiographic and hematological tests were conducted in two stages. The first was at admission time and the second examination was done four to six months later to evaluate the outcome of the possible disorders. Respiratory system and musculoskeletal diseases were diagnosed respectively in 93 and 149 out of 300 examined horses and 36 horses showed heart murmur without any other complications. Echocardiography was performed in horses with heart murmur and 25 of them showed regurgitation of the cardiac valve. During the first examination, 7 horses were diagnosed with regurgitation and changes in the size of cardiac chambers, whereas this number increased to 25 during the second examination. There was no significant relationship between degree of murmur and severity of regurgitant jet in horses. The valvular regurgitation can affect the performance when causing changes in the size of the cardiac chambers which can consequently jeopardize the athletic future of the horse.

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Introduction

Horses are an extraordinary sports creature used in various fields including running, jumping, and exhibition. Poor performance in horses is the inability of an individual to perform at a level that can be reasonably expected based on the physical characteristics, level of training, and/or previous performance. Any decrease in performance may be critical to the equine athlete.¹ Even the slightest changes in the physical health of the horse can significantly affect their athletic performance. These abnormalities can hardly be detected as many of them emerge only during moderate or severe exercise and also the horses with poor performance may have concomitant problems.² Poor performance can have various reasons including musculoskeletal problems, respiratory diseases, cardiovascular disorders, and neurological diseases.^{2,3}

Cardiovascular insufficiencies have adverse effects on horse's performance by reducing the blood flow and incomplete oxygen transfer to the muscles. Detection of the negative effect of cardiovascular insufficiencies on horse's performance is difficult. A veterinarian should inspect the effect of any cardiovascular abnormality on the current performance of horses in comparison with the future, as well as the health situation. Also, any long-term effect on the physical status and horse longevity considered.^{4,5} Heart murmur and arrhythmia are often identified in horses that are active in all races. Most murmurs in horses can be associated with cardiac valve disease, and cause poor performance by creating changes in the size of cardiac cavities (ventricles and atria) or hemodynamic changes. These cases can be investigated and reflect heart pathology, which may cause not only poor performance but also jeopardize the life of the horse.^{6,7}

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The problems in the mitral, tricuspid, aorta and pulmonary valves have been reported in horses and can affect the performance according to the severity of the damage and the extent of valve regurgitation. Most managerial decisions about the race's future of horses are based on specific assessments alongside performance history, clinical findings and the jockey's athletic expectations of the horse. Through this approach, most heart disorders can be graded as mild, moderate and severe. The prognosis of cardiovascular disease depends on the type, site, severity of the current disorder, type of activity and physical status of the horse.

This study aimed to assess the cardiac valves disease in athletic horses with poor performance which could not benefit from their maximum race potential.

Materials and Methods

Animals. A total of 300 athletic Thoroughbred and mix-breeds horses including 164 mares and 136 stallions aged between 3-12 years old with a history of poor performance were examined. This study was conducted in some modern equestrian clubs in the Alborz and Isfahan provinces of Iran. The horses were active mostly in track and jumping competitions.

General examinations. The history of each horse includes age, type, feed content, type of exercise, the keeping conditions, the extent and length of poor performance, the applied treatments and the appearance of the horse (body condition score and the extent of weight loss) were evaluated. The general examination of horses included rectal temperature, respiratory rate, peripheral pulse, heart rate, mucus membrane status, CRT and jugular vein status.

Specific examination. It included the examination of the musculoskeletal systems such as lameness examination, serology test for identification of subclinical myopathy and radiography (if necessary), respiratory system such as auscultation, upper airway endoscopy, central nervous system (CNS) and cardiovascular system. Eventually, poorly performed horses with musculoskeletal, respiratory and CNS disorders were excluded from the project.

Cardiac examination. The cardiovascular examination included precise auscultation, investigating the rate, rhythm, murmur, edema and base-apex electrocardiogram for possible dysrhythmias at rest and after exercise.

Echocardiography. After confirmation of murmurs, echocardiography (2D, M-mode, Color Doppler, Pulse wave and Continued wave Doppler) was performed for diagnosing the possible cardiac disease. All echocardiographic examinations and measurements at two stages with an interval of four to six-months were performed by an echocardiography specialist and according to the standard protocol.⁸ During the examination, all horses were located in a quiet place and had been harnessed

physically without administrating any sedative drug. All measurements were performed at the time of examination and were absolutely according to the pre-determined measurement protocol that would be used during the data collection.^{9,10} Echocardiography examination was performed using an echocardiography device (MicroMaxx; Fujifilm Sonosite Inc., Bothell, USA) via phased array transducer 3.50 MHz with a maximum depth of 30.00 cm and using B mode, M mode, and Doppler methods. In this study, the stages of echocardiography were as follows: (1) investigating the morphological lesions, (2) motion abnormalities, (3) observation of heart cavities (4) investigation of heart valves performance (5) blood flow disorders (6) ventricular systolic and diastolic performance. The comprehensive assessment was done using supplementary methods of 2D mode, M-mode, and Doppler. All images were recorded using a video recorder. Mild regurgitation was defined by the presence of small and short jets occupying less than one-third of the right ventricular outflow tract (RVOT) in long axis right parasternal view of RVOT with the reverse diastolic flow in the pulmonary artery. Moderate regurgitation was defined as jets occupying more than one-third and less than two-thirds of RVOT. Regurgitations more than two-third of RVOT were considered severe.⁷

Blood testing. Blood samples were collected for hematology including fibrinogen, red blood cells (RBC), white blood cells (WBC) and biochemical (K, Ca, Mg levels and creatine kinase) examination. Blood cell count was measured with automated cell counters (Sysmex KX-21, Semex Co., Ontario, Canada) and fibrinogen level was assessed by coagulation method (Claus method) and biochemical tests were done using spectrophotometry (DR-5000, HACH Co., Loveland Colorado, USA) with Pars Azmoon kit (Pars Azmoon Co., Tehran, Iran).

Statistical analysis. The data were analyzed by SPSS (version 16.0; IBM Corp., Armonk, USA) for all comparisons and $p < 0.05$ was considered to be statistically significant.

Results

In this study, out of 300 athletic horses with a history of poor performance, 125 horses were Thoroughbred (68 stallions and 57 mares) and 175 mix-breed (68 stallions and 107 mares). 159 horses were in racing sports, 98 in the jumping show, and 43 in endurance riding.

Clinical results. Out of 300 studied horses, 93 horses were demonstrated with respiratory problems, 149 horses with musculoskeletal disease and 36 showed heart murmur without any other complications. In addition, 69.00% of horses were diagnosed with more than one disorder leading to poor performance. Out of 36 horses with murmur, the heart rate for seven horses was in the range of 54 to 65 beats per minute (bpm) and the range

for others was 26 to 40 bpm. The respiratory rate and rectal temperature were in a normal range.

Electrocardiography. In the first examination, only sinus arrhythmia at rest was observed in four horses, but in the second examination, one horse (No. 8) showed atrial fibrillation (AF) and the other (No. 2) suffered from congestive heart failure (CHF) with clinical finding including fore-limb edema, abdominal edema, jugular vein dilatation, tachycardia, tachypnea and cough. The AF electrocardiograph of horse No. 8 is shown in Figure 1.

Echocardiography. All 36 horses with heart murmur were examined through echocardiography. Valvular regurgitation was detected in 25 horses. As demonstrated in Table 1; 7 (28.00%), 16 (64.00%) and 1 (4.00%) horse, had aortic, mitral, and tricuspid regurgitation respectively.

In 2D echocardiography, some changes in the cusp of the involved valves were observed. Also, the results obtained from changes in the cardiac chambers (ventricles and atria) measured in the standard mode have also been provided. In the primary echocardiography assessment, left atrial or ventricular size increased slightly in 7 horses, while in the second assessment, atrial and ventricular size increased in all 25 horses. In addition, congestive heart failure and atrial fibrillation emerged in two horses with no clinical signs at the initial examination, but in second echocardiography, cardiac chambers size were much bigger than the first. The Mitral regurgitation echocardiography in horse No. 8, is shown in Figure 2. The murmurs and valves regurgitation in terms of the severity and site of involvement are demonstrated in Table 2.

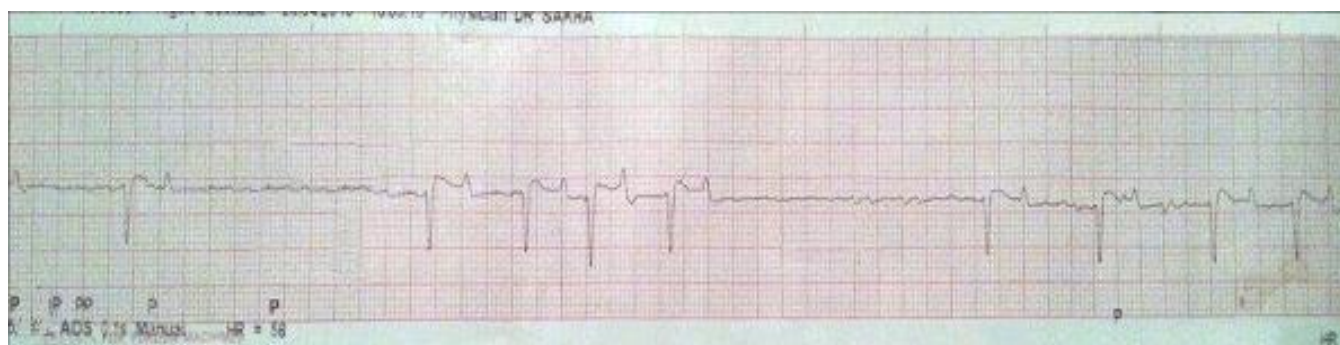


Fig. 1. Electrocardiograph shows atrial fibrillation in a horse with (moderate) mitral regurgitation.

Table 1. Echocardiography results of horses with valves regurgitation.

Horse No.	Valve	Cardiac chambers	
		1 st echocardiography	2 nd echocardiography (6 months later)
1	TR	-	Mild RV-RA (I.S)
2	MR	Mild LV (I.S)	Mod. LV (I.S) with CHF
3	AR	-	Mild LV (I.S)
4	MR	Mild LV-LA (I.S)	Mild LV-LA (I.S)
5	MR	-	Mild LV (I.S)
6	MR	-	Mild LV (I.S)
7	AR	Mild LV (I.S)	Mild LV (I.S)
8	MR	Mild LA (I.S)	Mod. LA (I.S) with AF
9	MR	-	Mild LV (I.S)
10	MR	-	Mild LV (I.S)
11	MR	Mild LV (I.S)	Mild LV (I.S)
12	MR	-	Mild LV-LA (I.S)
13	AR	-	Mild LV (I.S)
14	AR	-	Mild LV (I.S)
15	MR	Mild LV-LA (I.S)	Mild LV-LA (I.S)
16	MR	-	Mild LA (I.S)
17	AR	-	Mild LV (I.S)
18	MR	-	Mild LV (I.S)
19	MR	-	Mild LV (I.S)
20	MR	-	Mild LV (I.S)
21	MR	-	Mild LV-LA (I.S)
22	MR	-	Mild LV (I.S)
23	AR	-	Mild LV-LA (I.S)
24	AR	Mild LV-LA (I.S)	Mild LV-LA (I.S)
25	MR	-	Mild LV-LA (I.S)

AR: Aortic Regurgitation, MR: Mitral Regurgitation, TR: Tricuspid Regurgitation, LV: Left Ventricle, LA: Left Atrium, RV: Right Ventricle, RA: Right Atrium, I.S: Increased size, CHF: Cardiac Heart Failure, AF: Atrial fibrillation.

Table 2. Investigating the number of murmurs and regurgitations per the type of valve and severity of involvement.

Parameter	No. horses		Age	Echocardiography findings		
	1 st echocardiography	2 nd echocardiography		Prolapse	Vegetative lesion	Thickened
All Murmur		36		-	-	-
Murmur > 3/6		28	8 (4-12)	-	-	-
All regurgitations		25		4	4	6
Mitral valve						
All Murmur		26		-	-	-
All regurgitation		17		2	2	5
Mild regurgitation	9	5	8 (4-12)	-	-	-
Moderate regurgitation	8	10		-	-	-
Severe regurgitation	0	2		-	-	-
Aortic valve						
All Murmur		11		-	-	-
All regurgitations		7		1	2	1
Mild regurgitation	4	2	8 (5-10)	-	-	-
Moderate regurgitation	3	5		-	-	-
Tricuspid valve						
All Murmur		4		-	-	-
All regurgitation		1		1	0	0
Mild regurgitation	1	0	12	-	-	-
Moderate regurgitation	0	1		-	-	-

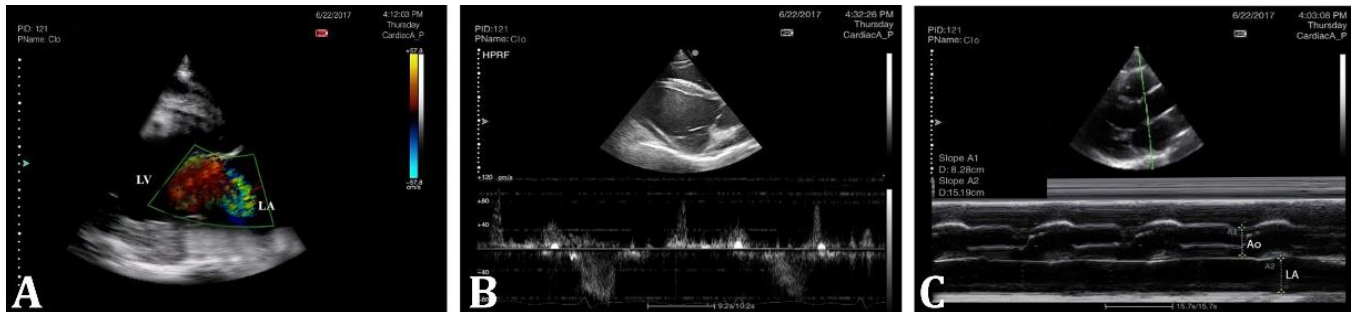


Fig. 2. **A)** Right parasternal long-axis color flow Doppler echocardiogram of the left ventricle (LV) and left atrium (LA) obtained from the fifth intercostal space. This shows abnormal forward flow in systole representing Mitral regurgitation. **B)** The Continue Wave Doppler spectral display showing moderate mitral regurgitation. **C)** M-mode echocardiograms of the left atrium (LA) and Aortic root (AO) in horse with moderate mitral insufficiency. This horse had a left atrium diameter of 15.19 cm.

Blood tests. In the initial stage of blood tests, all parameters were normal. The hematology and biochemical tests result of 25 horses with a heart murmur and valvular regurgitation in the second stage are shown in Table 3. There were no significant changes in the blood tests result, except for fibrinogen, WBC and leukocyte parameters with slight enhancement in four horses.

Discussion

Heart murmur is often diagnosed in athletic horses due to their poor performance. These murmurs can be physiological or associated with valve insufficiency or other structural abnormalities.^{4,11} According to previous studies, heart murmurs were found in most Thoroughbred horses undergoing exercise. However, despite the frequent presence of murmurs in horses, it did not necessarily cause poor performance.¹²⁻¹⁴ This is due to the fact that

many of these murmurs are physiological and have no association with cardiovascular disease. Physiological murmurs related to ventricular depletion and ventricular filling can be auscultated up to 50 and 15.00% of horses, respectively.⁵ In addition to the high prevalence of physiological murmurs, no pathological regurgitations of the mitral and tricuspid valves have also been developed in response to the exercise in Standardbred and Thoroughbred horses.^{6,7,15} Cardiac valves disease such as stenosis or insufficiency can produce limitations on cardiac output and may increase cardiac workload. Valvular stenosis disorders in horses are typically congenital and rare. Nevertheless, acquired valvular regurgitation (also known as valvular insufficiency) is common.^{16,17} Most valvular diseases in horses regarding their nature are degenerative or associated with heavy exercise. Infectious endocarditis, rupture of chorda tendinea, and inflammation of the valves leaflets are rare causes of valvular disease.^{16,17}

Table 3. Blood tests results of the horses with valves regurgitation and their reference values (RVs).

No.	RBC ($\times 10^6 \mu\text{L}^{-1}$)	WBC ($\times 10^3 \mu\text{L}^{-1}$)	PCV (%)	Fib (mg dL ⁻¹)	TP (g L ⁻¹)	K (mEq L ⁻¹)	Ca (mg dL ⁻¹)	Mg (mg dL ⁻¹)	CK (UL ⁻¹)
1	7.00	7.30	41.00	400.00	73.00	3.10	11.80	2.30	220.00
2	10.70	17.30	50.00	580.00	92.00	3.80	12.20	2.40	255.00
3	7.10	6.90	38.00	220.00	75.00	3.40	12.80	2.50	345.00
4	7.50	7.00	38.00	340.00	76.00	4.30	13.50	2.30	190.00
5	8.50	9.80	39.00	350.00	63.00	4.90	12.80	2.40	165.00
6	8.50	8.10	40.00	280.00	77.00	5.00	11.20	2.60	220.00
7	9.70	10.20	40.00	390.00	73.00	3.40	11.30	2.30	345.00
8	7.00	20.10	45.00	620.00	89.00	4.30	13.10	2.80	295.00
9	9.20	8.60	39.00	370.00	69.00	4.20	12.60	2.60	335.00
10	5.80	10.70	38.00	270.00	63.00	4.60	12.50	2.20	260.00
11	8.50	12.80	41.00	390.00	62.00	4.10	11.90	2.50	225.00
12	7.50	7.90	38.00	380.00	72.00	4.80	13.40	2.80	175.00
13	6.50	15.60	46.00	490.00	88.00	3.20	12.70	2.60	150.00
14	8.30	11.60	40.00	370.00	69.00	3.50	11.80	2.50	330.00
15	10.30	7.10	39.00	310.00	72.00	4.80	12.60	2.60	370.00
16	8.90	9.30	41.00	280.00	73.00	3.40	11.60	2.70	165.00
17	9.80	13.10	39.00	210.00	72.00	4.90	13.30	2.20	375.00
18	11.90	9.30	41.00	280.00	73.00	3.70	12.50	2.40	385.00
19	7.90	12.20	40.00	380.00	63.00	4.20	13.40	2.30	255.00
20	9.00	10.20	42.00	410.00	64.00	4.50	13.80	2.20	215.00
21	6.90	16.80	52.00	540.00	78.00	3.70	11.40	2.60	155.00
22	11.20	7.60	37.00	300.00	66.00	3.70	11.20	2.50	280.00
23	6.80	13.90	38.00	300.00	71.00	4.10	12.60	2.70	340.00
24	12.40	7.10	39.00	310.00	72.00	4.20	12.40	2.50	155.00
25	11.00	11.80	46.00	280.00	66.00	3.40	11.80	2.80	370.00
RVs	6.80-12.90	5.40-14.30	32.00-53.00	200.00-400.00	60.00-77.00	3.00-5.00	11.20-13.60	2.20-2.80	145.00-380.00

RBC: Red blood cells, WBC: White blood cells, PCV: Packed cell volume, Fib: Fibrinogen, TP: Total protein, K: Potassium, Ca: Calcium, Mg: Magnesium, and CK: Creatine kinase.

Determining the causes of poor performance in horses without a history of evident clinical disease is challenging.¹⁸ In this study, the precise cause of poor performance was found easily in 32.00% of thoroughbred and mixed breeds at the initial examination. But in the rest of the cases (68.00%), the cause was detected after specific examinations and use of special instruments. Moreover, 69.00% of horses had more than one disorder leading to decreased performance. In addition, the heart murmur was identified in 36 horses at different degrees. These murmurs were auscultated in 21, 3, and 12 cases in mitral, tricuspid, and aorta valves respectively. In a study by Martin, *et al.*, out of 348 horses with a history of poor performance, in 73.50% of them, a definite diagnosis was made after precise examination, associated with poor performance in both racing and exhibition horses.² Sometimes, mild disorders may be sufficient for decreased performance, which becomes most evident during exercise. Also, several diseases may occur simultaneously in some horses.^{3,19} In a study by Morris and Seeherman on 275 racing horses with a history of decreased performance in races, 84.00% of the horses showed more than one disorder.²⁰ Thus determining the real clinical significance of any special problem may be difficult.

In this study, regurgitation of cardiac valves was observed in 25 horses, with 17 (68.00%) being observed in the mitral valve, which was also the most common

regurgitation disorder. Based on the results obtained, no significant relationship was found between the level of performance and the degree of valvular regurgitation. Regarding the effect of cardiac murmurs and valvular regurgitation as well as exercise, there is limited information. Kriz *et al.* in a study that attempted to assess the effect of heart murmurs on performance, investigated 846 horses but there was no effect of murmurs on performance.²¹ In another study by Martin, *et al.*, out of the 348 horses investigated, 102 had valvular regurgitation, with mitral regurgitation being the most common.² In Rostami *et al.* study on determining the clinical significance of heart murmur through echocardiography, overall, 450 racing horses were investigated in terms of cardiac and respiratory function. In addition, 18 horses (eight with pulmonary murmurs degrees 3-4 and 10 normal horses) were investigated. Echocardiography was performed in two groups and findings were compared. No significant relationship was found between the degree of murmurs and the intensity of the regurgitated jets.²² In the study by Young *et al.* on Thoroughbred horses, no relationship was found between the degree of murmur or the degree of valvular regurgitation and performance.⁷ Moreover, in a study by Young and Wood examining the effect of age and training on the sufficiency of cardiac valves in Thoroughbred horses, 58.00% of the National Hunt horses had mitral regurgitation.¹⁵

In this study, in some horses, enlargement of cardiac chambers was observed. The size and shape of the left atrium and left ventricle lead to the severity of mitral regurgitation, though in acute cases, there may be no sufficient time to create considerable changes in the size of these two cavities. If the regurgitation of the mitral valve is only mild-to-moderate, this may not be important for the horse's performance. However, if the degree of regurgitation is more severe, the left atrium suffers increased pressure and volume. At this time, mitral valve regurgitation can affect performance due to the arrhythmia caused by atrial enlargement. Atrial arrhythmia especially AF can occur secondarily in an enlarged LA and may be the cause of poor performance.²³ Aortic valve regurgitation is usually due to age-related degenerative changes or valve prolapse. Congenital and infection changes are less common but may occur. Through echocardiography, degenerative changes in the aortic valve can be easily detected as thickening or prolapse.^{24,25} Mild aortic regurgitation is associated with a normal life with almost normal performance. However, relatively severe or severe aortic valve regurgitation is associated with poor performance and longevity.²⁶ If the aortic valve regurgitation of a horse is diagnosed in less than 10 years, the probability of poor performance and longevity increases.¹⁷ More severe insufficiencies of aortic valve regurgitation most probably result in LV enlargement, which can be associated with ventricular arrhythmia.²⁷ When the left ventricle enlarges, stretching the annulus of the mitral valve can cause secondary mitral regurgitation. If it progresses, congestive heart failure can develop. Tricuspid valve regurgitation (TR) is common in athletic horses especially in National Hunt horses in England and Standardbreds. Without a negative impact on the performance, horses can usually tolerate mild to moderate tricuspid regurgitation. However, in case of more severity and if it leads to enlargement of the right atrium, the risk of AF would be serious.²⁸ Reef performed echocardiography on 43 horses with severe mitral regurgitation and CHF. The affected horses had a significant increase in the mean values of the left ventricular and left atrial size. The mean values for EF showed no significant difference compared to normal horses.¹⁸ Zucca *et al.* demonstrated the prevalence of heart murmur among the Standardbred race with a history of poor performance, 752 Standardbred horses with poor performance underwent precise diagnostic protocol.

In the same study, in 157 out of 233 horses with a heart murmur, echocardiography was performed. Tricuspid regurgitation murmur was identified in 185 horses, while MR, AR, and PR murmurs were observed in 23, 9, and three horses respectively. Findings of this study suggested that heart murmur is a common finding in Standardbreds with poor performance.²⁹

In conclusion, there was no significant relationship between the severity of murmur or valvular insufficiency and poor performance. This study showed that innocent murmurs and mild insufficiency, in general, do not appear to have a negative impact on athletic performance in racehorses, although pathological murmurs and moderate to severe insufficiency can affect performance. These data also showed that the pathological changes in the size of the cardiac chambers (enlargement of the ventricles and atria, decrease in the diameter of the septum and the free wall of the ventricles) are associated with poor performance. Pathological enlargement of cardiac chambers may not occur in the primary stage of the disease but may develop over time, or sometimes affect the performance even in the early stages of the disease. Overall, cardiac valves disease is one of the complications that needs to be monitored regularly to determine future race performance of the horse.

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Conflict of interest

The authors declare no financial or conflict of interest regarding this study that could inappropriately influence the work.

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