INDIAN KATHIAWARI HORSE’S EXERCISE PHYSIOLOGY: PRELIMINARY STUDIES ON ECHOCARDIOGRAPHIC INDICES AND CARDIAC BIOMARKERS

GIRIDHARAN SRINIVASAN¹, pothiappan P ¹, N.R. SENTHIL¹, S. KAVITHA¹, and P. SELVARAJ¹

¹Madras Veterinary College

November 21, 2023

Abstract

Background: Indian Kathiawari horses are well-known as an endurance breed in the Indian subcontinent, yet not much research has been undertaken on their exercise physiology. An evaluation of the exercise physiology of Kathiawari horses could significantly contribute to the further development of the breed and for the improvement of its healthcare.

Objectives: This study aimed to investigate the changes in cardiac biomarkers and echocardiographic indices before and after exercise in Indian Kathiawari horses.

Methods: Eighteen working Kathiawari horses age ranging from 2 years to 12 years, consisting of 8 mares and 10 stallions were selected for this study. Horses were subjected to exercise for a period of ± 40 mins. Serum samples were collected before and after exercise for evaluation of changes in cardiac biomarkers concentration. Electrocardiographic and echocardiographic evaluations were also done for same horses before and after exercise.

Results: CTnI, CTnT, CK-MB and NT-proBNP after exercise showed highly significant increase when compared to before exercise. Significant increase in left ventricular dimensions and systolic function such as LVIDd, LVIDs, EDV, ESV, SV, Ao, LA, EF and FS after exercise when compared to before exercise. Post exercise doppler echocardiographic showed increase in number of aortic regurgitation compared to pre exercise. Significant changes were seen in P and T wave morphology and significant decrease in the duration of P wave, P-Q interval, QT interval and R-R intervals immediately after the exercise. Significant elevation was noticed in P wave amplitude immediately after the exercise.

Conclusion: In Indian Kathiawari horses the concentration of cardiac biomarkers are increased after 3 hour of exercise. Increased left ventricular dimensions and systolic function was observed in horses after exercise. This study contributes to establishing the reference ranges of cardiac biomarkers in Kathiawari horses after exercise.
Summary

Background: Indian Kathiawari horses are well-known as an endurance breed in the Indian subcontinent, yet not much research has been undertaken on their exercise physiology. An evaluation of the exercise physiology of Kathiawari horses could significantly contribute to the further development of the breed and for the improvement of its healthcare.

Objectives: This study aimed to investigate the changes in cardiac biomarkers and echocardiographic indices before and after exercise in Indian Kathiawari horses.

Methods: Eighteen working Kathiawari horses age ranging from 2 years to 12 years, consisting of 8 mares and 10 stallions were selected for this study. Horses were subjected to exercise for a period of ± 40 mins. Serum samples were collected before and after exercise for evaluation of changes in cardiac biomarkers concentration. Electrocardiographic and echocardiographic evaluations were also done for same horses before and after exercise.

Results: CThI, CThT, CK-MB and NT-proBNP after exercise showed highly significant increase when compared to before exercise. Significant increase in left ventricular dimensions and systolic function such as LVIDd, LVIDs, EDV, ESV, SV, Ao, LA, EF and FS after exercise when compared to before exercise. Post exercise doppler echocardiographic showed increase in number of aortic regurgitation compared to pre exercise. Significant changes were seen in P and T wave morphology and significant decrease in the duration of P wave, P-Q interval, QT interval and R-R intervals immediately after the exercise. Significant elevation was noticed in P wave amplitude immediately after the exercise.

Conclusion: In Indian Kathiawari horses the concentration of cardiac biomarkers are increased after 3 hour of exercise. Increased left ventricular dimensions and systolic function was observed in horses after exercise. This study contributes to establishing the reference ranges of cardiac biomarkers in Kathiawari horses after exercise.

Key words: cThI, cThT, CK-MB, NT-proBNP, Kathiawari

Introduction

India has few unique horse breeds, which survived in its harshest environment for and has a history of usage over several thousand years as pack animals, war, local transport, agriculture and religious ceremonies. Kathiawari horses are culturally important animals in India and has a very rich heritage and is one of the breed with excellent endurance capabilities. In general, the cardiovascular problems in horses can cause poor performance and sudden death during high-intensity exercises. Thorough cardiac examination is more important for assessing the performance of heart and diagnosing cardiovascular dysfunctions in horses (Chanda and Petchdee, 2022). Cardiac troponin I (cThI) and cardiac troponin T (cThT) are the specific cardiac biomarkers for diagnosing the cardiac injuries in horses. These biomarkers are more effective in identifying cardiac injuries due to various conditions such as infection, trauma, ischemia, toxicity, inflammation, or autoimmune disorders thus paving the way to extend their clinical use in equine cardiology (Lippi and Plebani, 2019). Use of these biomarkers shall be seen as a new revolution in the diagnosis of heart diseases especially when assayed with the novel high-sensitivity immunoassays, which enables the detection of even trace amounts of both cThI and cThT in the vast majority of healthy individuals (van der Linden et al ., 2017).

The exercise induced increases in cThI is mild and not comparable to the concentrations found in the horses with signs of cardiac disease. The increased concentrations of cThI along with the clinical symptoms and findings on ECG, echocardiography and necropsy indicate that the assay is used to detect horses with cardiac disease. Pronounced elevation in cardiac troponin I (cThI) concentration could be a robust indicator of myocardial injury (Nostell and Häggström, 2008).
Echocardiography is very useful for investigation of cardiac structures and determination of the chamber size provides valuable information about the cardiac function. Echocardiographic examination is a fundamental tool for identifying and interpreting abnormal findings in healthy horses. Normal reference ranges for several echocardiographic measurements have been reported for Thoroughbreds, Standardbreds, Warmbloods and Arabian Thoroughbreds. Up to now, no echocardiographic reference values have been reported for Indian breeds like Kathiawari and Marwari horses. Based on this aim the study was undertaken in Indian Kathiawari horses.

Materials and Methods

Study design

The healthy horses that were brought for periodical health checkups to the Large Animal Medicine Out-patient Unit of Madras Veterinary College Teaching Hospital were subjected to this clinical study. Indian Kathiawari horses regardless of sex, breed and age were selected for the study and subjected to thorough physical examination (Allaam et al., 2014), electrocardiography and echocardiography (two-dimensional, M mode and color Doppler) to confirm the health condition of horses. Eighteen working Kathiawari horses of average age 6.19 ± 0.75 ranging from 2 years to 12 years and body weight 332.28 ± 15.41 ranging from (195 Kg to 430 Kg) and consisting of 8 mares and 10 stallions were selected. Their hemato-biochemical assessments were carried out. Consent for exercise was obtained from all horse owners. Horses were subjected to exercise for a period of ± 40 mins (Rossi et al., 2019). 2 mL of Serum samples were collected before and after exercise for evaluation of changes in cardiac biomarkers concentration. Electrocardiographic and echocardiographic evaluations were also done for same horses before and after exercise.

Electrocardiography

Electrocardiogram was taken in all horses just before and immediately after exercise as per standard base-apex lead system described by Verheyen et al. (2010) by using the four lead electrocardiogram (Contec ECG300G Vet). The following parameters in Lead II were recorded. P wave amplitude and duration, QRS duration, T wave amplitude and duration, PQ interval, QT interval and RR interval. Electrocardiograms were recorded at the speed 25mm/s with an amplitude voltage of 10mm/mV.

Echocardiographic examination

Echocardiographic examinations were performed using an Aeroscan CD 25 ultrasound system with a phased-array sector transducer working at frequencies between 3.6 - 4.5 MHz with a maximum depth of 24 to 26 cm, a frame rate of 13 to 31 frames/ s and the focus point at 10 to 15 cm to obtain 2-D, M-mode and Doppler images of the heart, as per the procedure reported by Schwarzwald (2019).

Echocardiography was performed in right parasternal short-axis view at the level of the chordae tendinae. Echocardiographic indices including left ventricular internal diameter during diastole and systole (LVIDd and LVIDs), left ventricular posterior wall thickness during diastole and systole (LVPWd and LVPWs), Interventricular septum thickness during diastole and systole (IVSd and IVSs), end diastole volume (EDV), end systole volume (ESV), ejection fraction (EF), fractional shortening (FS), stroke volume (SV), aortic diameter (Ao) and left atrium in three cardiac cycles and the average values were recorded and compared between before and after exercise. Color doppler echocardiography (Gunther-Harrington et al., 2018) was done before and after exercise to identify valvular regurgitation.

Cardiac biomarkers

Two mL blood was collected before and 3hours after exercise in a clot activator vacutainer and allowed to stand for some time until the clotting occurred and the serum samples was separated. Cardiac biomarkers such as Cardiac Troponin T, Cardiac Troponin I and NT-pro BNP were analyzed (Hammerer-Lercher, 2001) using fully automatic fluorescence based hormone analyzer (sandwich immunodetection method/ iCHROMA III).

Statistical analysis
Data analysis was performed with commercially available software (IBM SPSS version 20.0). Shapiro-Wilk test was used for normal distribution of data. The data were statistically analysed by paired T-test to compare the concentration of cardiac biomarkers, echocardiographic indices and electrocardiographic parameters in horses before and after exercise. The confidence interval percentage and the significance level were 95% and p<0.05 respectively.

**Results**

This present study describes pre and post exercise values for cardiac biomarker, electrocardiogram and echocardiography in working Kathiawari horses.

**Electrocardiogram**

The electrocardiogram parameters were presented in Table 1.

Heart rate and P wave amplitude were significantly increased after exercise when compared to before exercise. Duration of P wave, PQ interval, QT interval and RR interval were significantly shorter after exercise when compared to before exercise. There was no significant change in QRS complex duration, T wave amplitude and duration in before and after exercise.

In the present study, before exercise 16 horses had bifid P-wave and 2 horses had a single P-wave. After exercise, 7 horses had bifid p-wave and 11 horses had single P-wave. (Fig. 1)

In the present study, before exercise 12 horses had negative T-wave and 6 had positive T-wave. After exercise 13 horses had positive T waves and 5 had negative T waves. (Fig. 2) ST coving was noticed in two horses after exercise.

No arrhythmias were noted before exercise but after exercise two horses had sinus arrhythmia. One horse had sinus tachycardia (HR= 105 bpm) (Fig. 4) and another one had second degree AV block Mobitz type 1. (Fig. 3)

**Echocardiographic changes related to exercise**

The echocardiographic parameters were presented in Table 2.

Prior to exercise the values of LVIDd, LVIDs, EDV, SV and LA were 9.08 ± 0.34, 5.63 ± 0.26, 470.00 ± 37.41, 295.42 ± 24.20 and 7.59 ± 0.23 respectively. After exercise the values were 10.03 ± 0.24, 6.24 ± 0.19, 568.56 ± 28.70, 385.42 ± 23.77 and 8.43 ± 0.24 respectively. The values of echocardiographic parameters were increased after exercise when compared to before exercise. Highly significant increase in LVIDd, LVIDs, EDV, SV and LA were seen after exercise.

Prior to exercise the values of LVPWd, ESV, EF, FS, and Ao were 2.30 ± 0.14, 167.00 ± 15.13, 62.23 ± 1.40, 35.29 ± 1.02 and 6.24 ± 0.16 respectively. After exercise the values were 2.67 ± 0.20, 197.54 ± 14.16, 67.76 ± 2.30, 40.51 ± 1.90 and 6.70 ± 0.20 respectively. Significant increase in LVPWd, ESV, EF, FS, and Ao were seen after exercise.

Left atrial dimension and left ventricular internal diameter during diastole and systole, left ventricular posterior wall during diastole, aortic diameter, end diastole volume, end systole volume, stroke volume, ejection fraction and fractional shortening increased significantly after exercise when compared to pre-exercise values.

Mild aortic regurgitation was noted on three horses after exercise (Fig. 5). Prior to the exercise there was no identifiable aortic, mitral and tricuspid regurgitation in all horses.

**Cardiac biomarkers**

The cardiac biomarkers results were presented in Table 3.

The results showed that the highly significant increase in CTnI concentration after exercise (0.03 ± 0.01 ng/mL) than before exercise (0.01 ± 0.00 ng/mL). The concentration of CTnT after exercise (28.95 ± 4.52
pg/mL) showed a highly significant increase than before exercise (13.64 ± 0.71 pg/mL). Assessment of NT-proBNP concentration revealed highly significant increased concentration of this biomarker in horses after exercise (32.87 ± 3.92 pg/mL) than before exercise (14.78 ± 1.01 pg/mL). Concentration of CK-MB after exercise (151.56 ± 39.55 U/L) showed a highly significant increase than before exercise (91.06 ± 27.96 U/L).

Table 1: Mean ± S.E, values of electrocardiographic parameters in horses before and after exercise (n=18)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Before exercise</th>
<th>After exercise</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>P wave duration (ms)</td>
<td>115.56 ± 5.50</td>
<td>82.22 ± 5.08</td>
<td>0.000**</td>
</tr>
<tr>
<td>P wave amplitude (mv)</td>
<td>0.34 ± 0.01</td>
<td>0.46 ± 0.04</td>
<td>0.006**</td>
</tr>
<tr>
<td>QRS duration (ms)</td>
<td>75.56 ± 5.50</td>
<td>75.56 ± 5.50</td>
<td>1.000 NS</td>
</tr>
<tr>
<td>PQ interval (ms)</td>
<td>291.11 ± 20.14</td>
<td>205.56 ± 10.94</td>
<td>0.002**</td>
</tr>
<tr>
<td>T wave duration (ms)</td>
<td>93.33 ± 9.15</td>
<td>86.87 ± 9.29</td>
<td>0.059 NS</td>
</tr>
<tr>
<td>T wave amplitude (mv)</td>
<td>1.04 ± 0.11</td>
<td>1.59 ± 0.34</td>
<td>0.113 NS</td>
</tr>
<tr>
<td>QT interval (ms)</td>
<td>360.00 ± 9.15</td>
<td>273.33 ± 12.21</td>
<td>0.000**</td>
</tr>
<tr>
<td>RR (interval (ms)</td>
<td>1573.33 ± 61.27</td>
<td>904.44 ± 52.36</td>
<td>0.000**</td>
</tr>
<tr>
<td>HR (bpm)</td>
<td>38.89 ± 1.42</td>
<td>70.67 ± 4.62</td>
<td>0.000**</td>
</tr>
</tbody>
</table>

*Significantly different from the mean value compared to before exercise (p < 0.05). ** Highly significant difference from the mean value compared to before exercise (p < 0.01). NS Non-significant difference from the mean value compared to before exercise.

Table 2: Mean ± S.E, values of echocardiographic parameters in horses before and after exercise (n=18)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Before exercise</th>
<th>After exercise</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IVSd (cm)</td>
<td>2.25 ± 0.11</td>
<td>2.33 ± 0.12</td>
<td>0.159 NS</td>
</tr>
<tr>
<td>LVIDd (cm)</td>
<td>9.08 ± 0.34</td>
<td>10.03 ± 0.24</td>
<td>0.003**</td>
</tr>
<tr>
<td>LVPWd (cm)</td>
<td>2.30 ± 0.14</td>
<td>2.67 ± 0.20</td>
<td>0.045*</td>
</tr>
<tr>
<td>IVSs (cm)</td>
<td>3.63 ± 0.16</td>
<td>3.67 ± 0.16</td>
<td>0.703 NS</td>
</tr>
<tr>
<td>LVIDs (cm)</td>
<td>5.63 ± 0.26</td>
<td>6.24 ± 0.19</td>
<td>0.010*</td>
</tr>
<tr>
<td>LVPWs (cm)</td>
<td>3.76 ± 0.25</td>
<td>3.78 ± 0.19</td>
<td>0.936 NS</td>
</tr>
<tr>
<td>EDV (mL)</td>
<td>470.00 ± 37.41</td>
<td>568.56 ± 28.70</td>
<td>0.004**</td>
</tr>
<tr>
<td>ESV (mL)</td>
<td>167.00 ± 15.13</td>
<td>197.54 ± 14.16</td>
<td>0.048*</td>
</tr>
<tr>
<td>EF (%)</td>
<td>62.23 ± 1.40</td>
<td>67.76 ± 2.30</td>
<td>0.028*</td>
</tr>
<tr>
<td>SV (mL)</td>
<td>295.42 ± 24.20</td>
<td>385.42 ± 23.77</td>
<td>0.002**</td>
</tr>
<tr>
<td>FS (%)</td>
<td>35.29 ± 1.02</td>
<td>40.51 ± 1.90</td>
<td>0.011*</td>
</tr>
<tr>
<td>Ao (cm)</td>
<td>6.24 ± 0.16</td>
<td>6.70 ± 0.20</td>
<td>0.019*</td>
</tr>
<tr>
<td>LA (cm)</td>
<td>7.59 ± 0.23</td>
<td>8.43 ± 0.24</td>
<td>0.002**</td>
</tr>
<tr>
<td>LA/Ao</td>
<td>1.23 ± 0.04</td>
<td>1.26 ± 0.03</td>
<td>0.427 NS</td>
</tr>
</tbody>
</table>

Abbreviations: d and s, diastolic and systolic measurement respectively; IVS and LVPW, thickness of the interventricular septum and left ventricular posterior wall respectively; LVID, left ventricular internal diameter; LA and Ao, internal diameter of the left atrium and aorta respectively; EDV and ESV, end diastolic and end systolic left ventricular volume respectively; FS, fractional shortening of the left ventricle; EF, ejection fraction; SV, stroke volume.

Table 3: Mean ± S.E, values of cardiac biomarkers in horses before and after exercise (n=18)
### Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Before exercise</th>
<th>After exercise</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac Troponin I (ng/mL)</td>
<td>0.01 ± 0.00</td>
<td>0.03 ± 0.01</td>
<td>0.003**</td>
</tr>
<tr>
<td>Cardiac Troponin T (pg/mL)</td>
<td>13.64 ± 0.71</td>
<td>28.95 ± 4.52</td>
<td>0.001**</td>
</tr>
<tr>
<td>NT-proBNP (pg/mL)</td>
<td>14.78 ± 1.01</td>
<td>32.87 ± 3.92</td>
<td>0.000**</td>
</tr>
<tr>
<td>CK-MB (U/L)</td>
<td>91.06 ± 27.96</td>
<td>151.56 ± 39.55</td>
<td>0.006**</td>
</tr>
</tbody>
</table>

**Abbreviations:** NT-proBNP, N-Terminal pro Brain Natriuretic peptide; CK-Mb, Creatine kinase myocardial binding. *Significantly different from the mean value compared to before exercise (p < 0.05). **Highly significant difference from the mean value compared to before exercise (p < 0.01). NS Non-significant difference from the mean value compared to before exercise.

**Fig 1:** ECG recording showing bifid P-wave before exercise and changed to single P-wave immediately after exercise.
**Fig 2**: ECG recording showing negative T-wave before exercise and changed to positive T-wave immediately after exercise.

**Fig 3**: ECG recording showing second degree AV block Mobitz type I

**Fig 4**: ECG recording showing normal sinus rhythm before exercise and changed to sinus tachycardia immediately after exercise.
Discussion

India is known to have several unique breeds of equines since many centuries. Many of the native equine animals had gone either extinct or got mixed up with other breeds losing breed identity. More than 2500 year old Tamil Language Texts called “Sangam” Corpuses had documented about the ancient equines of Tamil Nadu, which is one of the ancient and still surviving civilization of the World. Kathiawari is one of the unique equine breeds of India and has home tracts in the Kathiawar peninsula in the modern day Gujarat, India. This horse has a historical role as a war horse, serving until the end of the First World War for the Indian army and also used as a cavalry mount. The Kathiawari horse breed has experienced a decline in its population over the years. The decline in the population of Kathiawari horses underscores the importance of immediate need for conservation measures to safeguard this unique Indian horse breed for future generations. This study is unique because it represents acquisition and assessment of the exercise physiology related values in routinely heavy working Kathiawari horses and not in the laboratory or post exercise on a treadmill.

Kathiawari horses are well known runners and covers long distances of running under desert climatic conditions of India and has phenomenal endurances. Their ECG studies were helpful and there was a significant decrease in the duration and increase in the amplitude of the P wave after the exercise compared to before exercise. Similar findings in other horse breeds were also reported by Piccione et al. (2003). An increase in the P-wave amplitude on an electrocardiogram (ECG) could indeed be related to an increase in sympathetic tone. When sympathetic tone is increased, it can lead to an increase in atrial contractility and, consequently, an increase in the amplitude of the P-wave on an ECG. It’s important to note that an increase in P-wave amplitude can also be associated with other factors, such as atrial enlargement or conditions that affect the conduction of electrical impulses within the atria.

A highly significant increase (p<0.01) in heart rate was observed after exercise when compared with before exercise. An increased heart rate in the present study is in concurrence with Hassan et al. (2015). The elevated heart rate following exercise may be attributed to the activation of the sympathetic nervous system.
and the subsequent rise in catecholamine levels. P wave changed their bifid positive form to single positive form which is due to the fusion of the P1 and P2 components of P wave, because of increased heart rate. Similar findings were also reported by Mathapati & Saini (2019) in Thoroughbred horses during exercise. Morphology of the P wave was influenced by alterations in the heart rate which is also observed by Schade et al. (2014).

Highly significant reduction of PQ, QT and RR interval after exercise was observed in the present study. PQ interval measures the time required for the electrical impulse to travel from the sinoatrial node to the ventricular muscle (Mirvis and Goldberger, 2004). In normal physiological conditions, PQ interval depends primarily on the velocity of the electrical impulse conduction through the atrial muscle. The duration of conduction through the atiroventricular junction is subjected to modulation by the autonomic nervous system. Mirvis and Goldberger (2004) found that sympathetic activation accelerates this conduction velocity, leading to a shorter PQ interval after exercise in horses which was in accordance with our study.

T wave morphology is the most variable component in ECG of the horse. Inversion of polarity and increase in T wave amplitude was the most common electrocardiographic abnormalities (Verheyen et al., 2010a) especially related to stress and to strenuous training.

QT interval represents the duration of depolarization and repolarization of the ventricular myocardium (Mirvis and Goldberger, 2004). Similar findings were also found by Pasławska et al. (2012) after exercise testing PQ, QT and R-R intervals were shorter than the resting conditions.

An irregular ST segment could suggest myocardial hypoxia or variations in potassium levels and blood pH (Babuscio & López, 2006). ST segment irregularities exceeding 0.3 mV may suggest conditions such as shock, endotoxicemia, abdominal pain, or electrolyte disorders (Diniz et al., 2011, Dumont et al., 2011).

There were no echocardiographic studies conducted in Kathiawari horses. In the present study of Kathiawari horses, among all echocardiographic parameters, LVID during diastole and systole, LVPWd, EDV, ESV, SV, Ao and LA were significantly increased after exercise. The present study was in accordance with Buhl and Ersboll (2012) reported in Standardbred horses. Left ventricular internal diameter in diastole (LVIDd), left ventricular mass (LVM), and mean wall thickness (MWT) were increased after physical training. These findings support the concept of athlete’s heart, wherein training induces cardiac hypertrophy. A similar finding of cardiac hypertrophy was also observed in our study.

Training-related increases in left ventricular (LV) dimensions have been consistently observed in various horse breeds, including Thoroughbred horses (Young, 1999), Standardbreds (Buhl et al., 2005; Buhl and Ersboll 2012), and elite Arabian horses (Sleeper et al., 2014). Additionally, Trachsel et al. (2016) reported that training serves as a potent stimulus for cardiac hypertrophy.

FS% and EF% were increased significantly after exercise in our study. Young et al. (2005) found that there was a positive association between left ventricular ejection fraction and left ventricular mass with race rating in older flat racehorses running over sprint and longer distances. Gunther-Harrington et al. (2018) also found that increased FS% after exercise. It may be secondary to sympathetic activation and its positive inotropic effect. Increased heart rate may also contribute to increase in systolic function as a result of Bowditch effect.

In the present study, the LV internal diameter and systolic function had the strongest relationship with exercise performance. Pluim et al. (2000) found that increases in both wall thickness and left ventricular internal diameter signify the presence of eccentric left ventricular hypertrophy in endurance-trained athletes.

While cardiac biomarkers are important tools, so far no studies were conducted to evaluate the cardiac biomarkers in Kathiawari horses. In our study there was a highly significant increase in cTnI, cTnT, CK-MB and NT-proBNP 3 hours after exercise in Kathiawari horses. Similar findings were reported in other breeds by Holbrook et al. (2006) and Pourmohammad et al. (2020) suggested that exercise induced a certain level of myocardial stress in Thoroughbred horses. Nostell and Häggström (2008) also suggested that horses typically exhibit low cardiac troponin I (cTnI) values at rest. However, intense, short-term exercise leads to a mild increase in cTnI concentrations, which can persist for up to 10-14 hours. Durando et al. (2006) found
that higher than normal values of cTnI even after 12 and 24 h after exercise. Walton (2014) reported that cTnI values of clinically healthy horses are less than 0.2 ng/mL and those with greater than 0.3 ng/mL are considered to be abnormal. Shields et al. (2018) suggested that the increased cTnT concentration after high intensity short term exercise may not have been solely due to cardiac muscle release but also possibly as a result of impaired renal function, exercise induced dehydration or skeletal muscle damage.

Exercise can lead to various physiological changes, including the release of catecholamines, which may induce transient myocardial ischemia. Additionally, increased heart rates and blood volume can cause mechanical stretching of cardiac myocytes, dehydration and acid-base imbalances may also contribute to cell damage (Weippert et al., 2016). These factors collectively result in short-lived elevations in circulating cardiac troponin (cTn) concentrations.

CK-MB is a less sensitive cardiac biomarker than cardiac troponin for evaluation myocardial injury (Sim et al., 2008). Serum CK-MB activity was a less specific cardiac biomarker in horses but was included in the study to support the cTnI concentration results (Fletha et al., 2016). BNP is expressed in the ventricular myocytes and in response to pressure or volume overload and mechanical stresses to ventricle walls, contribute to increase in BNP level after exercise (Alter et al., 2007 and Sadeghian Chaleshtori et al., 2022). These findings were in accordance with our study which showed elevation of CK-MB and NT-proBNP after exercise.

Conclusion
Kathiawari horses remaining one of the long surviving endurance horse breed, with its legendary roles in World Wars, their exercise performance assessment becomes important. Exercise physiology and cardiac evaluation is very much important and directly related to performance in horses. The cardiac biomarkers such as cTnI, cTnT, CK-MB and NT-proBNP showed a highly significant increase after exercise when compared to their levels before exercise. In the post exercise echocardiographic findings, significant increase in the left ventricular dimensions and systolic functions were observed. As normal reference values have not been reported in Kathiawari horses, this study established the normal reference ranges for future usages.

Conflict of interest
The authors confirm that they have no conflict of interest to declare.

Ethical approval
Written informed consent was obtained from horse owners.

REFERENCES


Fletha et al., 2016). BNP is expressed in the ventricular myocytes and in response to pressure or volume overload and mechanical stresses to ventricle walls, contribute to increase in BNP level after exercise (Alter et al., 2007 and Sadeghian Chaleshtori et al., 2022). These findings were in accordance with our study which showed elevation of CK-MB and NT-proBNP after exercise.

Conflict of interest
The authors confirm that they have no conflict of interest to declare.

Ethical approval
Written informed consent was obtained from horse owners.

REFERENCES


Fletha et al., 2016). BNP is expressed in the ventricular myocytes and in response to pressure or volume overload and mechanical stresses to ventricle walls, contribute to increase in BNP level after exercise (Alter et al., 2007 and Sadeghian Chaleshtori et al., 2022). These findings were in accordance with our study which showed elevation of CK-MB and NT-proBNP after exercise.

Conflict of interest
The authors confirm that they have no conflict of interest to declare.

Ethical approval
Written informed consent was obtained from horse owners.


