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Research article

# Field screening of murmurs and arrhythmias in performance Argentine polo ponies

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## Abstract

Polo is a high-intensity sport, and the horses who participate in it are known to receive a high workload on their hearts. Having cardiac disorders can impair their athletic performance or even increase the risk of collapsing during the game. In sport horses, murmurs and arrhythmias are commonly-found physiological conditions; nevertheless, many of them are related to heart diseases. Though numerous studies on murmurs and arrhythmias have been done among several kinds of horses, the information in polo horses is still limited. This study was done to investigate the prevalence of murmurs and arrhythmias in performance Argentine polo ponies by field screening with fast and convenient methods. A hundred and ninety-six performance Argentine polo ponies (162 mares and 34 geldings) with ages between 6 – 20 years old were included in this study. Cardiac auscultation with a simple stethoscope was done to detect and grade murmurs, and electrocardiography with an iPhone ECG (electrocardiogram) recorder was done at the same time to find if there were any arrhythmias. The results showed 98 ponies (50%) that probably had cardiac abnormalities, these could be divided into 61 ponies (31.1%) with only murmurs, 18 ponies (9.2%) with only arrhythmias, and 19 ponies (9.7%) with both murmurs and arrhythmias. In conclusion, murmurs and arrhythmias were found frequently by field screening of this study; cardiac examination should not be overlooked, and those ponies with murmurs and/or arrhythmias should be examined further to determine whether they were pathologic or not.

**Keywords:** Argentine polo pony, Arrhythmias, Field screening, Horse, Murmurs

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# INTRODUCTION

Due to cantering and galloping for almost an entire game (approximately 7 minutes), polo is considered to be a high-intensity sport for the horses. At these speeds, their heart can beat more than 200 beats per minute (Marlin and Nankervis, 2002). As polo horses undergo a high workload, having cardiac abnormalities may lead them to incapability of athletic performance or even unexpected situations such as collapsing, which is a life-threatening condition for the horses and can also cause an accident for their riders (Reef et al., 2014). For the reasons above, the cardiac examination should be considered to provide proper management for those who have cardiac abnormalities to avoid the occurrence of unexpected consequences.

In each polo club, there is a large number of horses, and completing a full cardiac examination takes a long time and requires a lot of equipment. However, murmurs and arrhythmias are conditions that can be easily identified by performing non-invasive simple methods including cardiac auscultation and electrocardiography.

The use of a stethoscope to perform cardiac auscultation is a low-cost and convenient standard heart examination method that is also practicable in the field. Placing a stethoscope on the thorax can provide information on heart rate, heart sound, and heart rhythm. In horses, heart rate and heart rhythm can be obtained from each side of the thorax, and performing cardiac auscultation on both sides of the thorax will provide more information about heart sounds and murmurs. By placing a stethoscope on the left thorax, 3 valves can be observed, including the pulmonic, aortic, and mitral valves. While placing a stethoscope on the right thorax, the sound that originated from the tricuspid valve will be more clearly audible. (Marr and Bowen, 2010; Reef et al., 2014)

Prevalence of murmurs in sport horses has been evaluated in a number of previous studies. Two studies that were done on horses used in racing sports (flat racing and national hunt racing) reported murmurs in high prevalence at 68% and 81.1% (Patteson and Cripps, 1993; Kriz et al., 2000). In the contrary, the prevalence of murmurs in Standardbreds was reported much lower at 31% by Zucca et al. in 2010. Same as in polo horses, which reported at 34.6% by Mokhber Dezfouli et al. in 2019.

The gold standard for identifying abnormal cardiac rhythm is electrocardiography. For ECG recording, twelve leads are used: three standard leads (lead I, lead II, and lead III), three augmented leads (aVR, aV, and aVF), and six chest leads (V1, V2, V3, V4, V5, and V6) (Costa et al., 2014). Though the three standard leads are frequently used without extra leads, this technique requires three electrodes that must be connected to a recording machine, requires many equipment, and is inconvenient to use in the field. Furthermore, only one bipolar lead is required to identify arrhythmias in horses. (Vezzosi et al., 2018; Kraus et al., 2019) In recent years, new ECG recording tools have been developed for easier and more convenient use. An iPhone heart monitor is one of those developing tools, it records and shows electrical activity from base to apex of the horse's heart, and is practical to use in field screening as it has been declared by previous studies that this tool is acceptable and can provide accurate arrhythmias detection in horses (Vezzosi et al., 2018; Kraus et al., 2019).

The prevalence of arrhythmias in horses was found to be 32% in 50 horses used in various sports (Fakur et al., 2010). According to Slack et al.,

2015, only 11.5 percent of Standardbreds developed arrhythmias. Another study in pre-race Thoroughbreds discovered arrhythmias in just 7.8% of the horses (Massie et al., 2021). A survey of arrhythmias in polo horses, on the other hand, had never been done previously.

Many previous studies have reported the prevalence of both murmurs and arrhythmias in a variety of numbers on various types of horses, but only a few studies have been done in the polo field. In addition, the Argentine polo pony is one of the famous breeds used in polo. However, no study on cardiac abnormalities in this breed has been conducted, and the prevalence of murmurs and arrhythmias in this breed is still under question. Therefore, this study aimed to investigate the prevalence of murmurs and arrhythmias in Argentine polo ponies by field screening using only a stethoscope and an iPhone heart monitoring device. As the previous study in polo horses reported murmurs at 34.6% and the highest prevalence of arrhythmias was reported at 32%, the hypothesis of this study is that the prevalence of murmurs found in Argentine polo ponies is not different from the previous studies by more than 10%, as is the prevalence of arrhythmias.

## MATERIALS AND METHODS

This study was approved by the Ethical Committee of the Faculty of Veterinary Medicine, Chiang Mai University Animal Care and Use Center. The approval code was FAC-ACUC; S29/2562.

### Animals

The animals used in this study were 196 permitted Argentine polo ponies, both geldings and mares, from polo clubs in Thailand. The ponies were between 6 – 20 years old and had body condition scores between 3 – 4 out of 5, estimated by using Carroll and Huntington's body condition scoring (Carroll and Huntington, 1988) as shown in Table 1.

**Table 1** Carroll and Huntington's body condition score system from Carroll and Huntington, 1988.

| Score | Neck | Back and Ribs | Pelvis |
|---|---|---|---|
| 0<br>Very Poor | Marked 'ewe' neck.<br>Narrow and slack at base. | Skin tight over ribs.<br>Spinous processes sharp and easily seen. | Angular pelvis-skin tight.<br>Deep cavity under tail and either side of croup. |
| 1<br>Poor | 'Ewe' neck.<br>Narrow and slack at base. | Ribs easily visible<br>Skin sunken either side of backbone.<br>Spinous processes well defined. | Rump sunken, but skin supple.<br>Pelvis and croup well defined.<br>Deep depression under tail. |
| 2<br>Moderate | Narrow but firm. | Ribs just visible.<br>Backbone well covered.<br>Spinous processes felt. | Rump flat either side of backbone.<br>Croup well defined, some fat.<br>Slight cavity under tail. |
| 3<br>Good | No crest (except stallions).<br>Firm neck. | Ribs just covered-easily felt.<br>No 'gutter' along back.<br>Spinous processes covered, but can be felt. | Covered by fat and rounded.<br>No 'gutter'.<br>Pelvis easily felt. |
| 4<br>Fat | Slight crest.<br>Wide and firm. | Ribs well covered-need firm pressure to feel.<br>'Gutter' along back bone. | 'Gutter' to root of tail.<br>Pelvis covered by soft fat-felt only with firm pressure. |
| 5<br>Very Fat | Marked crest.<br>Very wide and firm.Folds of fat. | Ribs buried-cannot felt.<br>Deep 'gutter'.<br>Back broad and flat. | Deep 'gutter' to root of tail.<br>Skin distended.<br>Pelvis buried-cannot felt. |

## History taking and physical examination

History associated with performance and diseases of each pony was taken from the club's veterinarians and polo athletes. Vital signs including heart rate, respiratory rate, dehydration status, capillary refill time, and mucous membrane color were taken from the ponies while they were resting. Heart rate was obtained by cardiac auscultation, heartbeat was count for 15 seconds then multiplied by 4. Respiratory rate was taken by observation rise and fall of flank area for 15 seconds then multiplied by 4. Examinations of external appearance and clinical signs of heart diseases (increased jugular distension, subcutaneous or ventral edema, coughing, tachypnea, exercise intolerance, etc.) were done in each pony stall before murmurs and arrhythmias screening was performed.

## Cardiac murmurs and arrhythmias screening

After physical examination, the horse's left thorax was wiped using a soaked sponge to make the thorax clean from dirt and sand and to make good electrocardiography. Then, a stethoscope (MDF 797, MDF® instrument) was placed on the 3rd to 5th left intercostal space, between the shoulder and the olecranon levels. Point of maximum intensity (PMI) and time of murmurs were noted, and murmur intensity was graded on a scale from 1 to 6, adapted from Jago and Keen (2017) as shown in Table 2.

**Table 2** Murmur grading description adapted from Jago and Keen, 2017

| Grade | Description |
|---|---|
| 1 | Soft murmur which can be detected in extended auscultation |
| 2 | Murmur which can be audible but softer than S1 sound |
| 3 | Murmur which has intensity equal to S1 sound |
| 4 | Murmur which is louder than S1 sound |
| 5 | Murmur which is louder than S1 sound and can palpate thrill |
| 6 | Very loud murmur which can be audible with stethoscope off |

Electrocardiogram (ECG) was recorded for 30 seconds by iPhone heart monitoring device (Alivecor veterinary heart monitor, AliveCor, Inc) with the Alivecor application version 2.1.4. The frequency response of the device is 0.62 to 40 Hz, with a sampling rate of 300 samples per second. The device was cased on an iPhone 5s with iOS version 10.3.4 as shown in Figure 1. The positive electrode of the device was turned down and rotated 30° caudally by the dorsoventral line, and the device application represented base to apex electrocardiograms. The electrocardiogram was read from the application in the iPhone by the recorder immediately after the recording was done. Both cardiac auscultation and electrocardiography were done by only one researcher throughout the study as shown in Figure 2.


**Figure 1** An iPhone ECG heart monitor (Alivecor veterinary heart monitor) cased on iPhone 5s (iOS 10.3.4), the negative electrode is located lower of the case and the positive electrode is located upper of the case.

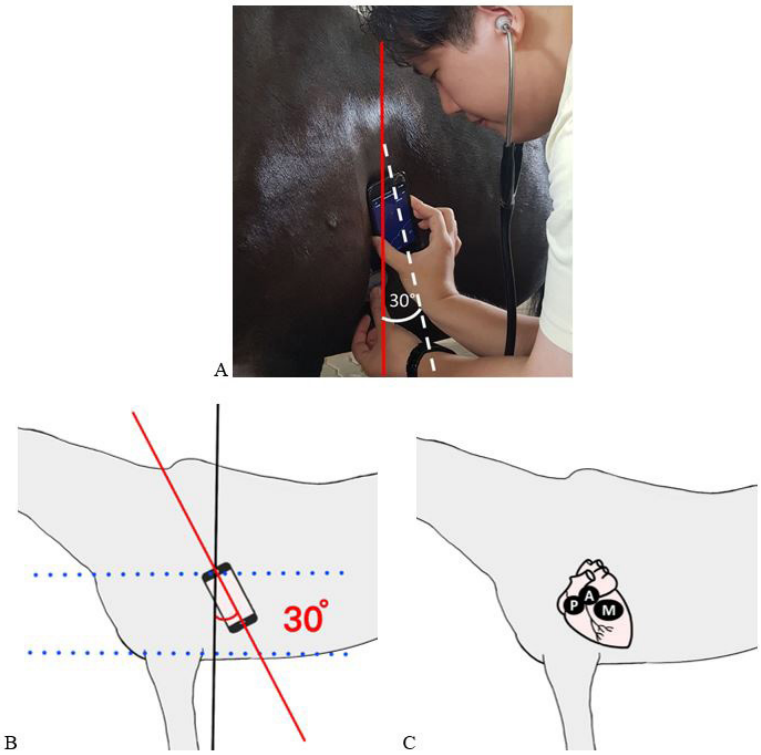



**Figure 2** Cardiac auscultation and iPhone ECG recorder used in ponies. (A); Both the auscultation and ECG recording were done at the same time for 30 seconds to count heart rate, determine heart sound and heart rhythm, and record electrocardiograms. (B); An Alivecor veterinary heart monitor device cased on iPhone 5s (iOS 10.3.4) was placed rotated 30 degrees backward in the same area, the negative electrode was placed on the base and positive electrode was placed on the apex of the heart, the ECGs were recorded by Alivecor application version 2.1.4. (C); Locations where a stethoscope was placed to determine and grade murmurs between 3rd and 5th left intercostal space are included pulmonary valve (P), aortic valve (A), mitral valve (M).

### Statistical analysis

Sex and age of the ponies were two factors examined in this study. Dividing by sex, there were mares and geldings. Dividing by age, the ponies were divided into 3 age range groups: 6 - 10 years, 11 - 15 years, and 16 - 20 years. The age range was justified by the duration of training; because all ponies began training at the same age, the older ponies would have accumulated more training hours.

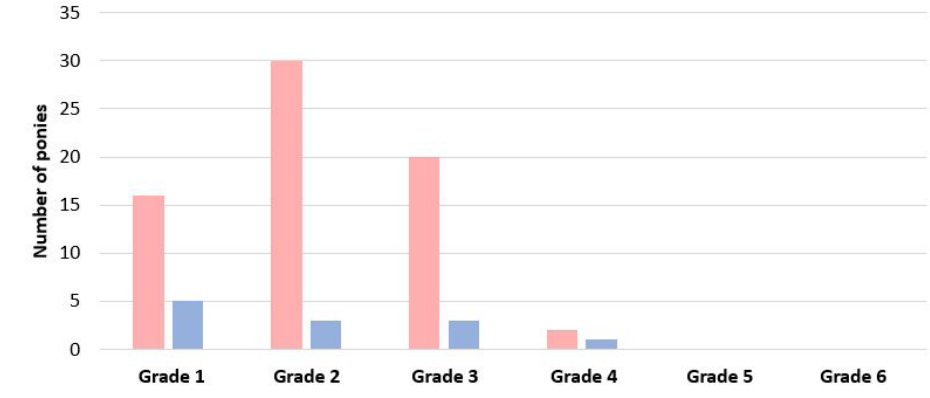
The associations among murmurs, sex, age groups, and high-grade murmurs were analyzed by Pearson's chi-square test and Fisher's exact test (in case of assumption was not met in the chi-square test); likewise, the associations among the arrhythmias, sex, and age groups. The association between murmurs and arrhythmias was also analyzed by the same method. The comparison of murmurs between each sex, and arrhythmias between each sex were done by using a proportion test. All analysis was done by using a commercial statistical software package (R program, version 4.0.3, R Foundation).

## RESULTS

One hundred and ninety-six Argentine polo ponies were included; there were 162 mares and 34 geldings. All ponies were between 6 – 20 years old. They were still being used in polo games and had no history of heart diseases or poor sport performance. General physical examinations showed all of the vital signs were in the normal range. No signs of heart diseases showed in external appearance observation. From the screening by using stethoscope and iPhone ECG, 98 ponies (50%) were suspected to have cardiac abnormalities; 61 of these 98 ponies had only murmurs (31.1%), 18 had only arrhythmias (9.2%), and 19 had both conditions (9.7%).

### Cardiac murmurs

Cardiac murmurs were shown in 80 ponies (40.8%), including 61 ponies with only murmurs and 19 ponies with both murmurs and arrhythmias; 68 were mares with ages of 11.25 ± 2.88 years old, and 12 were geldings with ages of 11.25 ± 3.22 years old. Overall, the numbers of ponies found with murmurs grades 1, 2, 3 and 4 were 21 (10.7%), 33 (16.8%), 23 (11.7%) and 3 (1.5%), respectively. Grade 2 murmur was the most frequent, and no grade 5 or 6 murmurs were found in this study. Almost all of the murmurs were early diastolic murmurs with PMI at the mitral to apex of the heart, with the exception of 5 ponies: a 15 years old gelding with grade 4 holosystolic murmur, a 15 years old gelding with grade 3 early systolic murmurs, and 3 mares aged 9, 13 and 18 years old, with early systolic murmurs grade 3, 3, and 4, respectively, all 5 ponies had PMI at mitral valve location. Sex had no significant association with occurrence of murmurs ($P = 0.6$) and grade of murmurs ($P = 0.20$); the number of ponies in each grade of murmurs categorized by sex is shown in Figure 3. As with sex, age had no significant association with murmurs ($P = 0.20$). However, the frequency of high-grade murmurs, which are defined as murmurs grade 3 and over, was significantly higher in the group of ponies aged 11 – 15 years old than the other two groups ($P = 0.04$) as shown in Table 3.




| | Grade 1 | Grade 2 | Grade 3 | Grade 4 | Grade 5 | Grade 6 |
|---|---|---|---|---|---|---|
| Mare | 16/162 (9.9%) | 30/162 (18.5%) | 20/162 (12.3%) | 2/162 (1.2%) | 0/162 (0%) | 0/162 (0%) |
| Gelding | 5/34 (14.7%) | 3/34 (8.8%) | 3/34 (8.8%) | 1/34 (0.6%) | 0/34 (0%) | 0/34 (0%) |
| P-value | 0.6 | 0.3 | 0.8 | 1 | NA | NA |

Grades of murmur

**Figure 3** Number of ponies with murmurs in each grade categorized by sex. There is no significant association between sex and murmurs (P = 0.60), nor is there a association between sex and murmur grades (P = 0.20), and the proportion of ponies in each grade is not significantly different between the sexes.

**Table 3** Number of ponies in each grade of murmur categorized by age group

| | Age (years) | | | Total (n = 196) |
|---|---|---|---|---|
| | 6-10 (n = 92) | 11-15 (n = 84) | 16-20 (n = 20) | |
| Normal | 58 | 44 | 14 | 116 |
| Murmur grade | | | | |
| 1 | 8 | 12 | 1 | 21 |
| 2 | 19 | 12 | 2 | 33 |
| 3 | 6 | 15 | 2 | 23 |
| 4 | 1 | 1 | 1 | 3 |
| 5 | 0 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 |
| Total murmurs / Total ponies | 34 / 92 | 40 / 84 | 6 / 20 | 80 / 196 |
| High-grade murmurs / Total murmur | 7 / 34 | 16 / 40 | 3 / 6 | 26 / 80 |
| % high-grade murmur in total murmurs | 20.6 | 40 | 50 | 32.5 |
| % high-grade murmur in total ponies | 7.5 | 19.3* | 15 | 13.3 |

*Significantly higher than the other two groups (P = 0.04)
High-grade murmur is defined as murmur grade 3 and over

## Arrhythmias

The electrocardiography revealed 37 ponies (18.8%) with cardiac arrhythmias, including ponies with only arrhythmias (18 ponies) and ponies with both murmurs and arrhythmias (19 ponies); 30 were mares and 7 were geldings. The arrhythmias found can be categorized into four conditions: second-degree atrioventricular block (2AVB) Mobitz type I, sinoatrial block (SAB), premature atrial contraction (PAC), and atrial fibrillation (AF). The numbers of ponies in each condition were 32 (16.8%), 3 (1.5%), 1 (0.5%) and 1 (0.5%), respectively. The representative ECGs are shown in Figure 4. The number of ponies in each condition categorized by sex is shown in Figure 5, and also categorized by age group in Table 4. Ultimately, having arrhythmias was not found to be associated with sex ($P > 0.90$) or age ($P = 0.20$).

No significant association was found between murmurs and arrhythmias ($P = 0.20$), or between high-grade murmurs and arrhythmias ($P = 0.20$).

**Table 4** Number of ponies in each type of arrhythmia categorized by age group

| | Age (years) | | | Total (n = 196) |
|---|---|---|---|---|
| | 6-10 (n = 92) | 11-15 (n = 84) | 16-20 (n = 20) | |
| Normal | 76 | 65 | 18 | 159 |
| Arrhythmias | | | | |
| Secondary degree AV-block, Mobitz I | 12 | 18 | 2 | 32 |
| Sinoatrial block | 3 | 0 | 0 | 3 |
| Premature atrial contraction | 0 | 1 | 0 | 1 |
| Atrial fibrillation | 1 | 0 | 0 | 1 |
| Total arrhythmias / Total ponies | 16 / 92 | 19 / 84 | 2 / 20 | 37 / 196 |
| % total arrhythmias in total ponies | 17.4 | 22.6 | 10 | 18.9 |

The definition of each arrhythmia is given as follows. Second degree AV-block, Mobitz I: regularly P-P intervals but P-R intervals are progressive longer before P-wave is followed by QRS complex. Premature atrial contraction: every P-wave is normal and followed by the QRS complex but there are premature beats that occur before the expectation. Sinoatrial block: every P-wave is followed by QRS complex but P-P intervals are irregular and interrupted with pause which is equal to the multiple of P-P interval. Atrial fibrillation: P-waves are replaced by fibrillation and R-R intervals are irregular.


**Figure 4** The representative ECGs of cardiac arrhythmias in ponies recorded by iPhone ECG recorder (iPhone 5s with iOS version 10.3.4, cased with Alivecor veterinary heart monitor device and recorded by Alivecor application version 2.1.4). (A); Normal ECG, the rhythm is regular and every beat is consists of P-wave, QRS complex and T-wave. (B); Second degree AV-block, Mobitz I, P-P intervals are rhythmically regular but P-R intervals are progressively longer before P is not following by QRS complex (arrows). (C); Premature atrial contraction, every P-wave is normal and followed by QRS complex but there is a premature beat (arrow) which occurs before the expectation. (D); Sinoatrial block, every P-wave is followed by QRS complex but P-P intervals are irregular and interrupted with pause which is equal to the multiple of P-P interval. (E); Atrial fibrillation, P-waves are replaced by fibrillation and R-R intervals are irregular. Speed was set at 25 mm/sec, and sensitivity was set at 20 mm/mV.


| | Second degree AV-block | Sinoatrial block | Premature atrial contraction | Atrial fibrillation |
|---|---|---|---|---|
| Mare | 26/162 (16.0%) | 3/162 (1.8%) | 1/162 (0.6%) | 0/162 (0%) |
| Gelding | 6/34 (17.6%) | 0/34 (0%) | 0/34 (0%) | 1/34 (2.9%) |
| P-value | 0.9 | 0.9 | 1 | 0.5 |

**Figure 5** Number of ponies in each type of cardiac arrhythmia categorized by sex. There is no significant association between sex and the occurrence of arrhythmias ($P > 0.90$), nor is there a association between sex and the types of arrhythmia ($P = 0.40$), and the proportion of ponies in each arrhythmia is not significantly different between the sexes.

# DISCUSSION

## Murmurs

The prevalence of murmurs in this study is 40.8%, which is slightly higher than a previous study that reported the prevalence of murmurs in a group of polo horses consisting of Thoroughbreds, Arabians and Anglo-Arabians at 34.6% (Mokhber Dezfouli et al., 2019). In other studies of athlete horses, the prevalence of murmurs was reported at 81.1% in 846 Thoroughbreds racehorses and 31% in 752 Standardbred racehorses; however, after they conducted echocardiography in those horses, most of the murmurs were determined as non-clinically significant (Kriz et al., 2000; Zucca et al., 2010). Another study also done in Thoroughbreds reported prevalence of murmurs in the horses that used in flat racing and national hunt at 32% and 66% respectively (Young et al., 2008).

For high-grade murmurs, the prevalence in this study was 13.3%, which is close to the prevalence of high-grade murmurs in flat racing and national hunt Thoroughbred racehorses which have been found at 10% and 17%, respectively (Young et al., 2008).

Though the prevalence of murmurs in this study is higher than previous prevalence found in polo horses, most of them were early diastolic murmur at mitral to apex of the heart, which commonly found in horses with no heart disease. However, we still cannot conclude that all of them were not associated with cardiac problems. According to Patteson and Cripps (1993) and Jago and Keen (2017), murmurs are defined as the sounds of irregular blood flow that can be heard from the heart or large vessels, excluding the normal audible sound of the cardiac cycle. These sounds can occur in equines as a result of ventricular filling and ejection, which are physiological conditions, as well as pathological conditions such as heart valve regurgitation and ventricular septal defect; thus, determining the sounds as physiological murmurs or pathological murmurs is difficult to do (Patteson and Cripps, 1993; Reef, 1995; Hewetson, 2013). The physiology and pathologies have to be confirmed by other methods.

The limitations of this screening is that the auscultation was performed on only one side of the thorax; though cardiac murmurs can be heard more easily on the left thorax, the right thorax auscultation should also be done due to the tricuspid murmur can be heard more clearly on this side, especially those with low intensity. Due to time constraints and the fact that this study was part of a larger project focused on studying the left-side heart and did not necessitate the use of all 196 ponies, some ponies were not auscultated on the right side of the thorax, and some right-side auscultation data was not recorded. Only 63 ponies had both left and right sides auscultation recordings; of these, 19 had no murmurs on both sides, 44 had left-side murmurs ranging from grade 1 to 4 (all 26 ponies with high-grade murmurs were included), and some also had right-side murmurs. However, all of the right-side murmurs heard in these ponies were early diastolic murmurs with intensity below grade 3. Due to right-side murmurs information was not completed, the prevalence of murmurs in this study might not include all the ponies who had low-grade right side murmurs. Another limitation is using only one person to grade murmurs since murmur grading is subjective and depends on the experience and hearing ability of the observer. Therefore, using more than one person and interobserver variability should be better.

We found no significant association between sex and murmurs in this study. According to studies in dogs, sex is a predisposing factor of murmurs; this condition can be found in males more often than females as it might be associated with an estrogen-induced protective effect in females (Thrusfield et al., 1985; Serfass et al., 2006). However, a previous study in horses revealed no significant relationship between sex and heart murmurs (Hewetson, 2013). Age is associated with murmurs in canines and humans. According to a previous study, the prevalence of heart murmurs increases with age due to the heart valve degeneration (Serfass et al., 2006). In the same way, studies in horses have also found that murmurs are found frequently in older horses (Kriz et al., 2000; Young et al., 2008). In addition, training is one factor that can increase the prevalence of murmurs. A study of young Thoroughbred horses found the prevalence and grade of murmurs increased after the horses received training for 9 months (Young and Wood, 2000). Age and training might be interrelated in polo horses. According to Bello et al. (2019), polo training can induce cardiac fatigue which might lead to cardiac alteration in long-term practice.

In the present study, polo ponies were from 6 – 20 years old and every pony had been trained since they were 4 years old; thus, the older ponies had longer duration experience training and had more chance to alter their cardiac structure. For this reason, murmur frequency in older horses should be higher, but we found the highest frequency of murmurs and high-grade murmurs in the group of ponies aged 11 – 15 years old instead of in the group of 16 – 20 years old. Thus, no significant association between age and murmurs was found. The much lower number of ponies in the 16–20 year old age group might have impacted the frequency of murmurs observed in this group. Since the clubs reported that the ponies in the 16–20 year age group had more health problems (musculoskeletal issues, behavioral problems, and poor performance), a retirement rate was greater than other two groups. However, because no cardiac examinations were performed on these retired ponies, a number of ponies having murmurs and/or arrhythmias in this age group may have been excluded before the study was done, thus affecting the prevalence found.

## Arrhythmias

From screening with the iPhone heart monitor in this study, 37 ponies (18.8%) from 196 had cardiac arrhythmias, which can be divided into 18 with only arrhythmias (9.2%) and 19 with both arrhythmias and murmurs (9.7%). Abnormal ECGs found can be categorized into four types: 2AVB (16.3%), SAB (1.5%), PAC (0.5%) and AF (0.5%). 2AVB was the most frequent arrhythmia found in this study, same as in previous studies. In previous study in 50 horses used in different sports including flat racing, polo, and jumping; they found arrhythmias in 32%, which can be divided into SA (10%), sinus tachycardia (8%), wandering pacemaker (8%), and first-degree atrioventricular block (6%). The ECG recording was done when the horses were in resting stage (Fakur et al., 2010). Another study done in 21 dressage horses found 2 types of arrhythmias when the horses were in resting stage; these included 2AVB (19%) and supraventricular premature complex (4.8%) (Barbesgaard et al., 2010).

Like murmurs, arrhythmias are also found commonly in horses; however, they can be either physiological circumstances or pathological findings (Reef, 2014). Almost all of the arrhythmias found in this study tend to have no clinical importance. 2AVB was define as the interrupt of impulse sending through the Atrioventricular node and bundles of His, the ECG of the ponies showed P-wave with no QRS complex following. All 2AVB found in this study were categorized in Mobitz type I which characterized by the progressively increase of P-R intervals before P-wave was not followed by QRS complex. SAB is defined as a failure or a delay to conduct the impulse produced from the sinoatrial node to the atria, the ECG of SAB shows normal P-wave followed by QRS complex but P-P intervals are irregular and interrupted with pauses which is equal to the multiple of P-P interval. According to previous studies, both arrhythmias can physiologically occur from high-vagal tone in equine species, and most of them do not affect the horses' health and performance (Menzies-Gow, 2001; Buhl, 2010). However, to confirm the clinical significance of these arrhythmias, electrocardiography during or immediately after exercise is recommended. This is because the parasympathetic activity will be diminished and true arrhythmias will appear; if the horse is unable to exercise, the atropine response test can be performed to eliminate parasympathetic effects as well (Reef, 2014).

PAC and AF are non-physiological arrhythmias observed in this study. PAC was define as a premature impulse sending from atria, the ECG showed that every P-wave was normal and following by QRS complex but there were premature beats. This arrhythmia was found in a 13-year-old mare with no murmur on both sides of the thorax and no history of poor performance. The ECG of this pony showed premature beats with normal P-waves followed by normal QRS complexes. According to previous studies, PAC is commonly found in horses with myocarditis or enlarged atria, but it is an uncommon cause of poor performance (Menzie-Gow, 2001; Marr and Bowen, 2010; Reef et al., 2014). However, 24-hour ECG monitoring is recommended to identify the frequency of PAC and atrial ectopy, which indicates that PAC may progress to AF (Reef et al., 2014). Moreover, the underlying cause of PAC should be found for proper treatment and riding safety assessment since horses with occasional PACs but no performance limiting or severe underlying heart disease can still be ridden (Menzie-Gow, 2001; Marr and Bowen, 2010).

The only arrhythmia that tends to be of clinical importance and might impact the horse's sport performance in this study is AF, which is a disorder of impulse production in atria, the ECG characterized by the absent of P-waves, which are replaced by fibrillation waves, and R-R intervals are irregular. In this study, this arrhythmia was found in only one 9 years old gelding. A previous study on the prevalence of AF in horses revealed that AF found in the hospital-based population was 2.3%, and it is more common in warmblood horses due to their larger atriums, which may affect electrical conduction (Leroux et al., 2013). Another study reported in accordance that AF can develop even when there are no cardiac structural problems—especially in large breeds because they have large atriums together with strong vagal tone. Also, it might have occurred from underlying causes such as mitral or tricuspid regurgitation as both of them can lead to atrium enlargement; thus, echocardiography should be done further to find if there is an underlying cause or not (Menzies-Gow, 2001).

Sex is reported as a factor associated with arrhythmias in canines. According to a study done in 1,189 dogs, the prevalences of almost all types of arrhythmias are significantly higher among males. (Noszczyk-Nowak et al., 2017) On the other hand, in this study, as well as prior studies of dressage horses and Standardbred racehorses, we found no difference in the prevalence of arrhythmias between mares and geldings (Barbesgaard et al., 2010; Slack et al., 2015).

In this study, the highest frequency of arrhythmias was found in the group of ponies aged 11 – 15, and the statistical analysis showed no significant association between age and arrhythmias; however, the 16 – 20 age group had a much smaller number of ponies, which may have influenced the results. A previous study in dressage horses also reported no association between aging and arrhythmias (Barbesgaard et al., 2010). However, aging was revealed to be a risk factor for the development of arrhythmias in a study of Standardbred racehorses; the explanation for this was related to the training since accumulated training hours might cause alteration of atriums. The older horses had more training hours; therefore, the heart alteration rate was greater, increasing the probability to have AF, supraventricular arrhythmias and ventricular ectopy (Slack et al., 2015).

Though iPhone heart monitor is practical to use in field screening for detecting arrhythmias, there are numerous factors that have to be considered prior to recording the ECG, including hair length and thickness, dirt and sand staining, and the wetness of the horse's thorax. ECG recording with the device is more difficult in horses with thick and long hair than in horses with thin and short hair because thick hair inhibits water from reaching the skin and makes the skin dry, causing electrical conduction ineffective. Furthermore, ECG artifacts can be caused by a thorax soiled with dirt and sand, thus the measurer should clean the horse's thorax before place the device on. In addition, the wetness of thorax is also important, the ECG recording will be distorted if applying too much water or too little, adequate water applying is when the thorax is wet but not dripping with water.

## CONCLUSIONS

Owing to the prevalence of murmurs and arrhythmias in Argentine polo ponies found in this study, cardiac examination in polo horses should not be overlooked. However, the prevalence stated in this study is based on field screening to scope the likelihood of cardiac problems. To determine the clinical relevance of murmurs and arrhythmias, further cardiac examinations including echocardiography and during- or after-exercise electrocardiography are recommended as most of them can occur either physiologically or pathologically in equine species.

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## AUTHOR CONTRIBUTIONS

**Pemika Issariyodom**: Conceptualization, Methodology, Investigation, Data curation, Writing-Original draft
**Angkana Kidtiwong**: Investigation, Resource, Writing-Reviewing and editing
**Kannika NA Lampang**: Formal analysis, Data curation, Writing-Reviewing and editing
**Wanpitak Pongkan**: Validation, Writing-Reviewing and editing
**Porrakote Rungsri**: Methodology, Resources, Writing-Reviewing and editing, Supervision, Project administration, Funding acquisition.

## CONFLICT OF INTEREST

The authors have declared no conflict of interest.

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