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Research article

Clinical study of palmar foot pain in 30 polo ponies with forelimb lameness in Thailand

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Abstract

Palmar foot pain is an important chronic problem that impairs the abilities of sport horses. Though there are several research on different types of horses, there is a lack of information regarding polo horses, which are known for using in unique sport. Therefore, this research aimed to find the prevalence of palmar foot pain in polo ponies with forelimb lameness in Thailand. The horses included in this study were 30 Argentine polo ponies: 10 geldings and 20 mares, aged from 7 to 20 years old. All were barefoot and had not exercised for at least 2 months. The ponies underwent lameness examination procedures with subjective and objective evaluation, including a trot on a straight line, left and right lunging, a full forelimb flexion test and a toe wedge test. Close inspections of hoof conformation, hoof percussion and hoof testing were done before performing a palmar digital nerve block. The result showed that 25 (83.33%) of 30 polo ponies had forelimb lameness, which can be divided into 56.7% with unilateral forelimb lameness, and 26.7% with bilateral forelimb lameness. There were 17 (56.7%) polo ponies that responded positively to the full flexion test and 25 (83.33%) that responded positively to the hoof tester and percussion at the frog area. However, only 9 ponies (30%) were positive to palmar nerve block. In conclusion, this study reveals a notable incidence of forelimb lameness and palmar foot pain. Understanding palmar foot pain prevalence is vital for further equine health management.

Keywords: Lameness, Palmar digital nerve block, Palmar foot pain, Polo ponies, Thailand

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INTRODUCTION

Typically, horses move in four distinct gaits: walk, trot, canter, and gallop. The normal gait cycle initiates with landing on the palmar digital foot, a critical element of the hoof mechanism responsible for braking and providing limb support. However, the loading of the hoof can potentially inflict damage on the palmar foot structure, compromising its functionality. While palmar foot pain is commonly associated with conditions like navicular disease or syndrome, it is crucial to recognize that lameness, an abnormal motion, can lead to disruptions in training and riding, ultimately diminishing the overall performance of horses.

The complexity and potential long-term implications of palmar foot pain in equine health were demonstrated in many previous literatures. Schneider et al., 2003 reported that half of palmar foot pain instances commonly implicate multiple structures, with notable involvement in the deep digital flexor tendon (DDFT), navicular bone, navicular bursa, and collateral ligament of the distal interphalangeal (DIP) joint. In a separate study, tendinitis of the DDFT was identified in 59% of horses experiencing palmar foot pain, and 14% of this group exhibited an additional lesion in the navicular bone (Bluden, 2006). Additionally, 31% of the horses exhibited desmitis of the collateral ligament of the DIP joint (Dyson et al., 2005). While palmar digital neurectomy has shown efficacy in improving lameness for horses unresponsive to medical therapy (Gutierrez-Nibeyro et al., 2010), those with core lesions in the DDFT face challenges with recurrent or persistent lameness 10-20 months post-surgery (Jackman et al., 1993; Gutierrez-Nibeyro et al., 2015). This indicates a guarded prognosis for horses attempting to return to full athletic function or their previous level of exercise, primarily due to a substantial occurrence of soft tissue injuries (Dyson et al., 2005) and navicular bone lesions (Sherlock et al., 2008).

A previous survey in England revealed that forelimb lameness affects approximately 18.6% of horses, with palmar foot pain emerging as the predominant cause (Dyson, 2005; Vet Rec, 2013). Notably, a study conducted by Gutierrez-Nibeyro found that palmar foot pain was prevalent in warmblood horses at 68% and in non-warmbloods (Quarter, Thoroughbred, Irish sport horse) at 32% (Gutierrez-Nibeyro et al., 2015).

Polo, a sport known for its demanding nature involving rapid stops, sudden turns, and high-speed running, poses a heightened risk for the development of forelimb lameness in horses (Paul et al., 2011). Additionally, the hoof conformation typically observed in Thoroughbred cross-breeds, characterized by a long toe-low heel structure, may contribute to forelimb lameness and palmar foot pain in polo ponies. Despite these potential factors, the prevalence of palmar foot pain and its associated factors in polo horses remains unclear, with limited studies available on this specific aspect. Therefore, this study aims to determine the prevalence of palmar foot pain accompanied by forelimb lameness in polo horses in Thailand by using subjective and objective evaluation.

CLINICAL HISTORY AND SYMPTOMS

Ethics

The animals used in this study were approved by the Laboratory Animal Center, Chiang Mai University. The approval code is ACUC-AF No. 2563/AG-0005. Owners' permission for using their polo ponies in this study was declared via consent form.

Study Design

The lameness examination was done on 30 randomly selected horses from two polo clubs in Chonburi, Thailand. All of the horses were athletes, barefoot and had not exercised for at least 2 months. The ponies were examined to exclude those with unhealthy conditions such as relevant abnormalities in hoof conformation, such as grow ring, laminitis, hoof quarter crack, and having a lameness score greater than 4/5 or non-weight bearing.

Medical records

Signalment including age, sex, body weight by standard horse weight tape and body condition score were collected. History of previous illness, previous lameness and treatment was also recorded. All ponies underwent a physical examination to assess their heart rate, respiratory rate, gut sound, body temperature, hydration status, capillary refill time and digital pulse.

Lameness examination

On the first day of the study process, the lameness was examined by both subjective and objective assessments. The subjective ones were observed by two clinicians and scored from 0-5 using Ross grading (Ross, 2011) as shown in Table 1.

Table 1 Lameness score from Ross, 2011

Score	Description
0	Sound.
1	A subtle head nod is observed, may be inconsistent at time.
2	Obvious lameness is observed. The head nod is seen consistently.
3	Pronounced head nod is seen, several centimeters.
4	Severe lameness with extreme head nod. The horse can still be trotted.
5	The horse does not bear weight on the limb.

The objective measurement was performed by using an inertial sensor system (Lameness locator®: Equinosis, LLC, Columbia, United States); inertial sensor data was collected, processed, and analyzed by software. These sensors enable the detection of head and pelvic movement asymmetries during motion, but for this study, only the measurement of head movement was used. The first sensor accelerometer was put on the dorsal midline at the poll, the second sensor was put on the midline of the tuber sacrale, and a gyroscope was attached to the dorsal aspect of the right front pastern with an elastic wrap and tape (Figure 1).

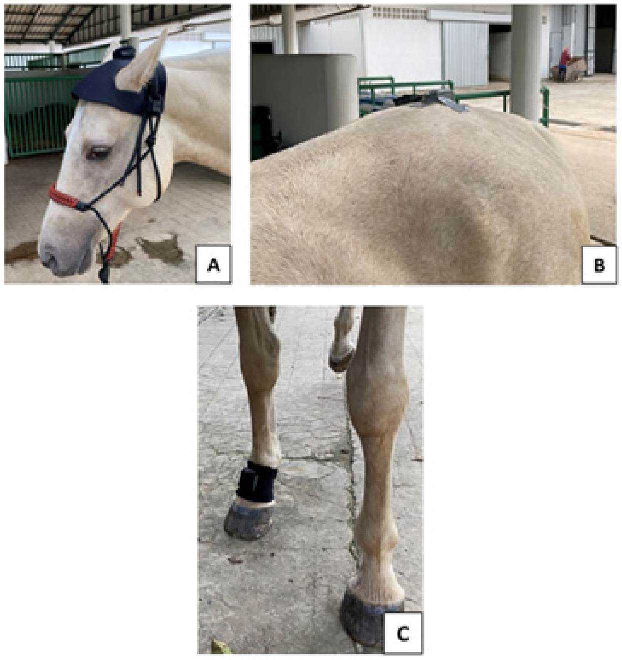

Figure 1 Inertial sensors attached on the horse: (A) The first sensor accelerometer was put on the dorsal midline at the poll, (B) the second sensor was put on the midline of the tuber sacrale, and (C) a gyroscope was attached on the dorsal aspect of the right front pastern with an elastic wrap and tape

To begin, the polo ponies were trotted with a loose leading rope at a steady speed along a concrete surface in a straight line of 30 meters in length, forward and backward, for 2 rounds to get a minimum of 25 strides. Then, the ponies were trotted in left and right circles by lunging. After that, a full flexion test was done on both the left and right forelimbs before trotting the ponies in a straight line again. All of these procedures were recorded by the digital video camera (Sony Handycam: HDR-PJ720E; Sony Europe B.V., Weybridge, United Kingdom).

After that, a toe wedge test was performed as a manipulative test for the toe of each forelimb's hoof, side by side. A wood board was placed beneath the toe of one forelimb and wedged for one minute while another forelimb was held by an assistant. If the horses feel pain in their toes, they will jump back which means positive to the wedge test.

Close inspection

A digital camera (Fujifilm® XA-2: Fujifilm Corporation, Tokyo, Japan) was used to obtain digital photographs of the frontal aspect of the hoofs, heel blub, solar surface, and lateral view of both sides. The camera was positioned 60 centimeters from the hoof using a 1-meter measurement stick. The veterinarians then selected one of the lame legs for perineural nerve block.

Hoof test

The hoof test was performed using a hoof tester, starting at the medial or lateral sides of the sole and continuing to shift pressure at 2-3 centimeters around the hoof until the entire surface of the sole was tested before moving to the frog (cranial, caudal, and center) and both medial and lateral sides of the heel. Next, the percussion test was done by knocking a hoof hammer on the frog and sole. The results of both tests were recorded as positive or negative. The polo ponies stood square with equal weight bearing on a concrete surface for observation of their posture.

Perineural nerve block

Palmar digital nerve block (PD) was done to localize a pain lesion in the palmar area of the hoof. The hair at the palmar aspect of the pastern was trimmed and scrubbed to prepare the nerve block with 70% alcohol. The palmar digital nerve block was performed by palpating the palmar aspect of the pastern, medial, and lateral to digital vein and artery. Then 26-gauge ½" was inserted in a medial to the distal direction of the pastern to the edge of ungular cartilage. Lidocaine HCL (Lidocaine 2%: UNION DRUG LABORATORIES LTD. Bangkok, Thailand) was injected subcutaneously over the medial and lateral palmar digital nerves, using 1.5 ml per site. After completing the injection for 5 minutes, no sensation should be felt in the bulb of the heel; a pinpoint check was performed by covering the polo pony eye and putting the pinpoint at the dorsal coronate compared to the bulb of the heel. The ponies were re-checked for lameness examination 10 minutes after the PD nerve block with the same speed.

Radiography

On day 2, the hooves of both forelimbs of each polo pony was radiographed. The horses were under sedation by using a Xylazine HCl (X-LAZINE 100 L.B.S. LABORAY LTD, PART.Bangkok, Thailand) dosage of 0.5–1.0 mg/kg, IV. The frog clefts were packed with putty dental impression material (Dmg Silagum, DMG, Germany) to eliminate air shadows.

The radiography was done using portable x-ray equipment (Poskom 40HF X-Ray, Merry Ray Corporation, United States) and a digital system DR X-ray (VIVIX-S 1417W, Viework, Republic of Korea). A minimum output of 80 KV and 15 mA were set. For each polo pony, five standard images of hoof projection were taken, including upright pedal, lateral-medial, palmaroproximal-palmar distal oblique, and dorsopalmar 0º. For dorsoproximal-palmar distal oblique (upright pedal) view, the toe of the hoof was put on a positioning box, and the dorsal wall angle was approximately 85˚to the horizontal. The x-ray beam was kept horizontal, and the center was 2-3 cm proximal to the coronary band at the midline of the foot. The lateral-medial projection was performed with a flat block to bring the solar surface of the sole to the center of the x-ray beam. The beam position was horizontal and centered on the end of the navicular bone (approximately 1 cm below the coronary band at a point midway between the dorsal and palmar aspects of the coronary band). The palmaroproximal-palmar distal oblique view of the x-ray beam was centered between the blub of the heel at the base of the pastern at an angle of 45˚ to the horizontal. In the last view of the dorsopalmar 0º view, the x-ray beam was centered midway between the coronary band and the ground surface.

The radiographic finding was examined in three views, including the lateromedian, dorsoproximal-palmarodistal oblique and the palmaroproximal-palmarodistal oblique as ahown in Table 2. The severity grade was given from 0 to 4 by assessing the corticomedullary, radiolucent zone and symmetry of the left and right navicular bone shapes by following Dyson, 2011. (Table 3)

The hooves were then cleaned with a hoof brush, put on wet soapy water, and wrapped in soaked cotton with duct tape overnight to prepare for hoof ultrasonography on day 3.

Table 2 Radiographic assessment in each plane adapted from Dyson, 2011

View of radiography	Structure to examine for grading
Lateromedian	• Thickness of the palmar cortex • Demarcation cortex and spongiosa • Periarticular osteophytes
Dorsoproximal-palmarodistal oblique	• Bipartite/tripartite • Trabecular architecture of the spongiosa • Proximal/distal border of entheseophytes fracture • Fracture
Palmaroproximal-palmarodistal oblique	• Palmarcortex thickness and fracture • Number, size, shape and position of radiolucent zones at distal border of the navicular bone • Centric/acentric radiolucent osseous cyst-like lesion in the spongiosa

Table 3 Radiographic grading of navicular bone following Dyson, 2011

Grade	Radiographic findings
0	• Good corticomedullary demarcation; fine trabecular pattern. • Flexor cortex of uniform thickness and opacity. • No lucent zones along the distal border of the bone/several (<6) narrow conical lucent zones along the horizontal distal border. • Right and left navicular bones symmetrical in shape.
1	• As above, but lucent zones on the distal border of the navicular bone more variable in shape.
2	• Slightly poor definition between the palmar cortex and the medulla due to subcortical increased opacity. • Crescent-shaped lucent zone in the central eminence of the flexor cortex of the bone. Several (<8) lucent zones of variable shape along the distal border of the navicular bone. • Mild entheseophyte formation on the proximal border of the navicular bone. • Navicular bones asymmetrical in shape.
3	• Poor corticomedullary definition due to increased opacity of the medulla. • Thickening of the dorsal and flexor cortices. • Poorly defined lucent areas in the flexor cortex of the bone. Many (>7) radiolucent zones along the distal horizontal or sloping borders of the navicular bone. Lucent zones along the proximal border of the bone. • Large entheseophyte formation on the proximal border of the bone. • Radiopaque fragment on the distal border of the navicular bone.
4	• Large cyst-like lesion within the medulla of the navicular bone. • Lucent region in the flexor cortex of the navicular bone. • New bone on the flexor cortex of the navicular bone.

Ultrasonography at the hoof

On day 3, ultrasonography was done. The ponies were prepared by following these steps. First, the hair on the palmar aspect of the pastern was clipped with 40–50 mm blade to produce high-quality images. Then, alcohol saturation was sprayed on the palmar area, and ultrasound gel was applied. Next, an ultrasound machine (VINNO 5 vet ultrasound scanner version 1.6.51.261, VINNO Corporation, Suzhou, China) was used to examine the internal structure of the palmar area. The microconvex transducer was placed in the midline depression proximal to the bulbs of the heel and directed toward the toe in longitudinal and transverse directions for a scan of an abnormal pattern of the DDFT, navicular bursa, navicular bone, collateral sesamoid ligament and a palmar recess of the distal interphalangeal joint. The polo ponies that were restless from the ultrasound probe were sedated using the same protocol as in radiography.

The data was recorded and interpreted. DDFT was assessed by dorsal surface (bulging or change in fiber), pattern (present or absent), and alteration in echogenicity. The navicular bursa was graded from 0 to 3 and assessed by effusion and proliferation. Both structures were graded following Barrett et al. (2023).

Statistical analysis

The sample size was calculated from the previous study of Taylor et al. (2002) by using G-power 3.1.9.4 program (G*Power, Heinrich Heine University Düsseldorf, North Rhine-Westphalia, Germany). Since this research aims to observe prevalence of palmar foot pain assessed by three different observations: two veterinarians and the lameness locator, a repeated measure design with a factor of 3 and a correlation of 0.5 was calculated. And, as the required power at 95%, and an error of 5%, was unknown, the calculation resulted in a minimum sample size of 29. To account for potential errors, an additional sample was added, bringing the total to 30 subjects. Descriptive statistics was used to present the information of age, sex, body weight, degree of hoof angle, prevalence of lameness, lameness improvement and palmar foot pain. Veterinarians' opinions and lameness locator agreement tests were done using logical interpretation of kappa.

RESULTS

Number of horses with lameness

The thirty ponies who were randomly selected for this study can be divided into groups of 10 geldings and 20 mares. All of the horses ranged in age from 7 to 20 years (according to the document), with an average age of 13.07 ± 2.6 years.

The lameness assessment by three examiners revealed that 28 (93.33%) of the ponies were lame. However, not all of these 28 ponies were considered lame by all of the examiners; the number of lame ponies was obtained by combining the opinions of Veterinarian 1 (Vet 1), Veterinarian 2 (Vet 2) and the lameness locator (LL), who judged that 26 (86.67%), 26 (86.67%) and 24 (80%) of the horses were lame, respectively. The lameness assessed by two veterinarians and the lameness locator was shown in Figure 2.

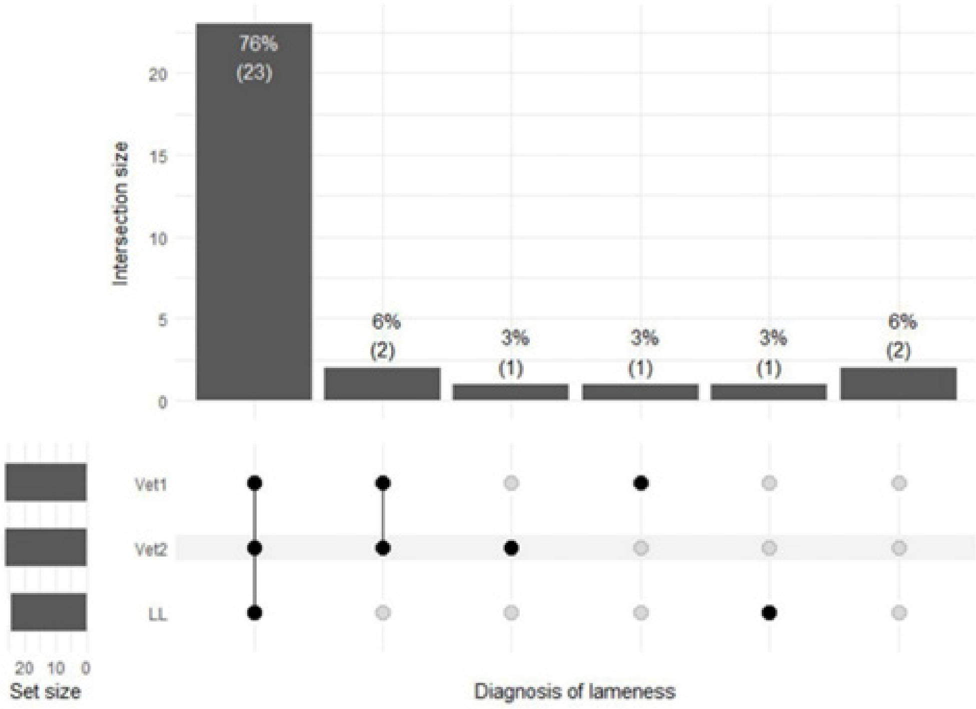

Figure 2 An exclusive agreement of lameness diagnosis in 30 horses between 3 opinions from Veterinarian 1 (Vet 1), Veterinarian 2 (Vet 2) and lameness locator (LL). The back dots represent presence of lameness and grey dots represent absence. Set size shows number of horses with lameness in each opinion.

Among these 28 lame ponies, the lameness can be divided into left and right forelimbs, following the determination of examiners. There were 15 ponies that were concluded to have left-forelimb lameness by at least one examiner, while right-forelimb lameness was determined in 21 ponies, as shown in Figure 3.

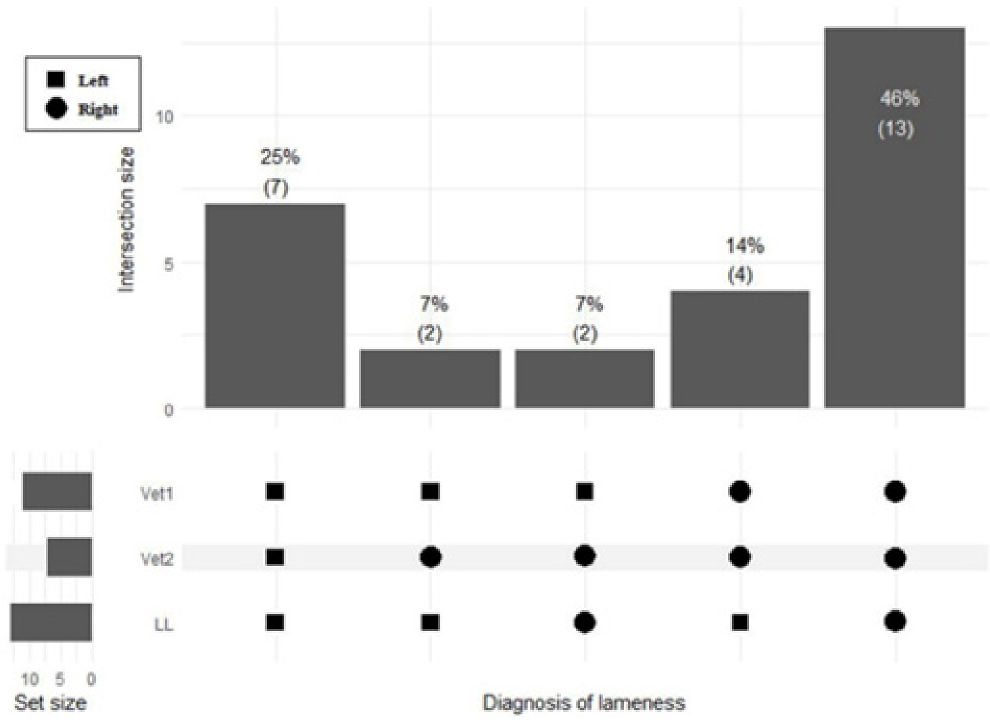

Figure 3 An exclusive agreement of leg-sides that present lameness between 3 opinions from Veterinarian 1 (Vet 1), Veterinarian 2 (Vet 2) and lameness locator (LL) in 28 horses who had been determined as lame. Squares represent left-forelimb lameness and circles represent right-forelimb lamensess. Set size shows number of horses with left-forelimb lameness in each opinion.

Lunging in left and right circles was done by 25 ponies; 14 of those showed lameness during lunging, which can be divided into 7 ponies (26.7%) with bilateral forelimb lameness and another 7 (56.7%) with unilateral forelimb lameness. (Table 4) On lunging in the left circle, there were 13 (52%), 10 (40%), and 14 (56%) lame ponies diagnosed by Vet 1, Vet 2, and LL, respectively; and there were 14 (56%), 11 (86.67%), and 14 (56%) lame ponies diagnosed by Vet 1, Vet 2, and LL, respectively, on luging in the right, as shown in Figure 4.

Table 4 Number of ponies with lameness positive in the same side of lunging, both sides of lunging, opposite with lunging side and lameness negative

Circle (Lameness)	Number of ponies (n = 25)
Same side as target	6 (24%)
Both-sided	7 (28%)
Opposite side	1 (4%)
Negative	11 (44%)

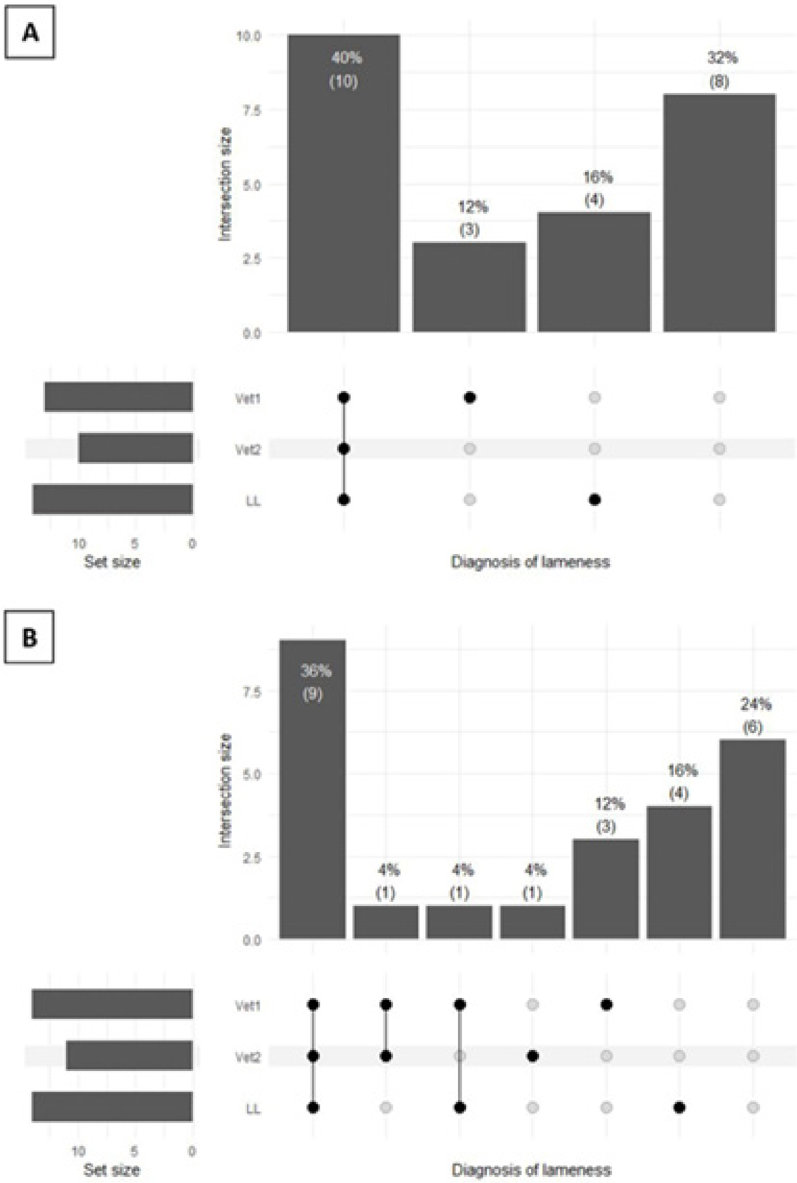

Figure 4 An exclusive agreement of lameness diagnosed by Veterinarian 1 (Vet 1), Veterinarian 2 (Vet 2) and lameness locator (LL) in 25 ponies; (A) circles to the left and (B) circles to the right. Black dots represent presence of lameness and grey dots represent absence. Set size shows number of horses with lameness in each opinion.

Hoof conformation of long toe and low heel was examined in 21 ponies; 19 of 21 had this conformation, and can be separated in 3 group related with lameness: conformation found at same side as lameness, both sides and opposite site of lameness as shown in Table 5 and Figure 5.

Table 5 Conformation of long toe and low heel with related side of forelimb in 21 ponies

Conformation (long toe low heel)	n = 21
Same side as target	1 (4.7%)
Both-sided	17 (80.9%)
Opposite side	1 (4.7%)
Negative	2 (9.5%)

Figure 5 The conformation of long toe and low heel at the left front hoof on a polo pony, the hoof angle is 44 degree.

There were 17 of 30 ponies (56.7%) that were positive for the full flexion test, and 25 of 30 ponies (83.3%) that responded positively to hoof testing and percussion at the frog area.

There were 9 (32.14%) from 28 polo ponies that responded positively to a palmar digital nerve block, cut off by improving more than 50% or shifting to the opposite side. The result of the improvement is shown in Figure 6. The percentages of improvement, body weight, age and hoof angle of each group are presented in Table 6.

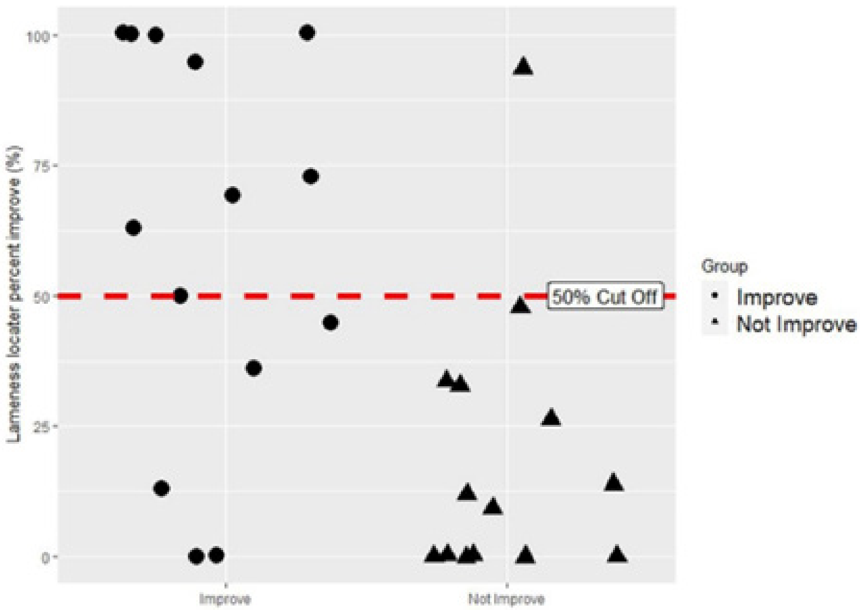

Figure 5 Improvement (%) from lameness locator is determine using 50% cut off. There were total of 14 and 14 horses in improved and not improved group, respectively.

Table 6 Percentages of lameness improvement after PD nerve block, body weight (BW), age and degree of hoof angle in left and right forelimbs between improved and not improved group presented in range and mean ± SD, no significant difference found between each group.

	Improved (n = 14)		Not improved (n = 14)	
Parameter	**Range**	**Mean ± SD**	**Range**	**Mean ± SD**
%Improved (%)	0 - 100	60.22 ± 37.41	0 – 93.4	19.2 ± 26.56
BW (kg.)	405 – 470	435.57 ± 18.23	380-483	442 ± 25.81
Age (years)	7-20	13.85 ± 3.03	9-16	12.35 ± 2.24
Degree of hoof angle at left forelimb	44-56	49.83±3.27	47-56	51.37 ± 2.72
Degree of hoof angle at right forelimb	44-56	49.91±3.31	47-56	51.12 ± 3.09

Radiographic and Ultrasonographic findings

Radiographic outcomes showed grade 1 to 2 navicular bone lesions in 9 ponies with positive palmar digital nerve block. The lesions can be seen in the right and left navicular bones, which were asymmetrical in shape. Variable shapes and sizes of lucent zones were on the distal border of the navicular bone, and subcortical was increased in opacity. (Figure 7).

Ultrasonography discovered the lesions in the navicular bursa and DDFT, as shown in Figure 8. There were 5 ponies with effusion in the navicular bursa and 2 with proliferation. DDFT fiber changes were observed in 9 ponies; most were hyperechogenic, as shown in Table 7

Figure 7 Left forelimb radiography: (A) dorsoproximal-palmarodistal oblique radiographic view showed radiolucent zone along the distal border of the navicular bone, the lesion was assessed as grade 2; (B) palmaroproximal-palmarodistal oblique view presented a crescent-shaped lucent area in the flexor cortex of the navicular bone of the sagittal ridge.

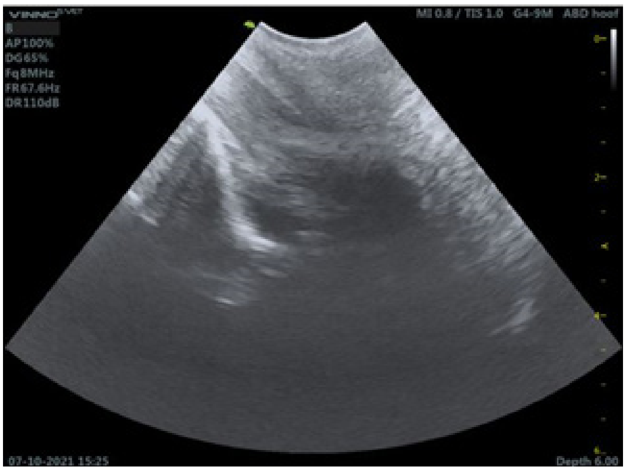

Figure 8 Ultrasonography of left forelimb, the ultrasound transducer was placed on the bulb of the heel in the longitudinal section, an effusion at navicular bursa with grade 3 severity was found.

Table 7 Ultrasonographic findings in 9 ponies with positive palmar digital nerve block

Horse	Left Forelimb					Right Forelimb				
	Navicular bursa (grade)		Pattern Change DDFT in Fiber	Echogenic DDFT		Navicular bursa (grade)		Pattern Change DDFT in Fiber	Echogenic DDFT	
	effusion	proliferation		hyper	hypo	effusion	proliferation		hyper	hypo
1	0	0	P	P	A	1	0	P	P	P
2	0	0	P	P	P	0	0	P	P	A
3	0	0	P	P	A	1	0	P	A	A
4	2	0	A	A	A	1	2	P	P	A
5	3	0	A	P	A	2	2	P	P	A
6	0	0	P	P	A	0	0	A	A	A
7	0	0	A	A	A	1	0	P	A	P
8	0	0	P	P	A	0	0	P	P	A
9	0	0	A	P	A	0	0	P	P	A

A = Absent, P = Present, N/A= Not analyzed

Navicular bursa effusion and proliferation grading (0-3): 0 = normal, 1 = mild, 2 = moderate, 3 = severe

DISCUSSION

Prevalence of lameness

This study surveyed prevalence of lameness with palmar foot pain in polo ponies from two clubs in Chonburi, Thailand. The results showed that forelimb lameness had a high incidence of 80% in mild grades (1-2 out of 5). This supports a previous study that reported the average lameness grade was 2.21 out of 5 with 56.2% primarily in forelimb in western performance horses (Johnson et al., 2021). The prevalence of lameness in riding school horses (Warmblood, Thoroughbred, Warmblood × Thoroughbred, Cob, Irish Sports Horse or other) was also found highly at 82%, and 55% of these lame horses displayed gait abnormalities, too (Dyson and Pollard, 2020). Burden et al. (2013) reported lameness in polo ponies at 45% for both left and right forelimbs. The resulting categories for work discipline were dressage, show jumping, eventing, racing and others (including reining, endurance and general purpose). In a previous study, 72.5% of horses under training that were deemed by their owner to be free of lameness showed motion asymmetries (Rhodin et al., 2017). Moreover, Rhodin et al. found that forelimb lameness was related to the following breed categories: Warmblood and Warm blood cross, Thoroughbred, Thoroughbred cross and others (Polo Pony, Irish Sports and Quarter Horse). Thoroughbred cross breed, especially, had a higher risk of injury than Warmblood and Warm blood cross breeds (Parkes et al., 2013).

Referring to the result of our study, the right forelimb was more affected than the left forelimb by 10%, and 33.3% of ponies showed signs of lameness on the bilateral forelimb. On the other hand, 30% of horses were identified as left forelimb lame, while a lesser 15% were identified as right forelimb lame in a previous study report (Burden et al., 2013). However, the prior study in polo ponies showed that there was more frequent right forelimb lameness in this kind of sport horse due to a predominantly clockwise exercise regimen (Pfau et al., 2016). The speeds of polo horses during turns showed that at small radii, the horizontal speed of horses during turning is likely to be limited by friction (Tan and Wilson, 2011), which may also affect bone and tendon. Also, the frequency of bilateral forelimb lameness was 17.1% for western performance horses. Moreover, the high-performance horses showed that 50% of them had evidence of forelimb and contralateral lameness. 21% of horses had evidence of forelimb and ipsilateral hindlimb lameness.

Prevalence of palmar foot pain

There was about one-third of polo ponies with positive palmar digital nerve blocks in this study. However, since intra-articular and navicular bursa anesthesia were not included in the study protocol, the researchers could not identify the source of lameness. Referring to the results from previous research, which had done the ten-year retrospective examination of horses at the Centre for Equine Studies of the Animal Health Trust (AHT), there was 24.51% prevalence of palmar foot pain (Parkes et al., 2013). Also, the primary region of lameness was most frequently localized by palmar digital nerve block in 26.03% of western performance horses and reining horses (Johnson et al., 2021).

Imaging diagnosis

There were grades 1 to 2 lesions found in the navicular bone of nine polo ponies. Fortunately, the high quality of the x-ray generator and appropriateness of the position make the navicular bone potentially detectable as abnormal via radiographically. But the absence of significant radiological changes in this study does not mean that the navicular bone is structurally normal, nor does is preclude the bone as a potential source of pain-causing lameness (Dyson, 2008).

In our study, there were 5 ponies with effusion in the navicular bursa, and 2 of them also had proliferation. DDFT fiber changes were observed in 9 ponies; most were hyperechogenic. In a previous study, they reported that they found a variety of lesions in the horses who had positive palmar digital nerve block, such as effusion of the distal interphalangeal joint, DDFT lesion, and collateral distal interphalangeal joint desmopathy; however, they mentioned that the types of foot conformation are considered a limitation for ultrasonography, such as high and contracted heels, collapsed heels, and long toe of the polo ponies' feet (Rabba et al., 2011). This is especially true for assessing the DDFT. A blind zone from the foot conformation influences the angle of incidence of the sound beam to the DDFT fibers and to the navicular bone flexor surface. It cannot be imaged correctly through the heels or frog. Another study reported that the frog is used to detect abnormalities of soft tissue structures within the hoof and navicular bones that are confined to the sole and middle of the hoof (Sage and Turner, 2000; Busoni and Denoix, 2001). Although the use of a microconvex probe at the distal level was attempted in a scan on the bulb of heels to better explore this region, it is possible that we underestimated the extent of DDFT lesions, leading to some false negative results (Grewal et al., 2004).

Potential Contributors to Palmar Foot Pain in Polo Ponies

Hoof angle

The dorsal hoof angle in the studied polo ponies averaged 50.7º. Prior research indicates that the angle of the dorsal hoof wall to the ground surface typically ranges from 45 to 55º in the forelimb, representing the normal range of hoof angles in horses. Among the ponies in this study, 21 exhibited a conformation of a long toe and low heel, predominantly on one side of the forelimb. However, lameness was observed on the same side in only one instance.

Minor conformation abnormalities were noted in the polo ponies, there was no significant association between injury type and angles of the distal phalanx (Dyson et al., 2011). Nonetheless, a modest correlation was identified between hoof wall and heel angles and angles of the distal phalanx. Conformations such as toe in and toe out are likely to contribute to the development of suspensory branch desmitis. Additionally, ponies with long pasterns face an increased risk of tendinitis in both the proximal and distal parts of the superficial digital flexor tendon (SDFT) and deep digital flexor tendon (DDFT) (Ross, 2011). This configuration may result in a flatter sole, rendering it more susceptible to injury and lameness (Hampson et al., 2011).

Hoof trimming

We found 83% of the polo ponies responded positively to the hoof tester and percussion at the frog area. Typically, during polo season or training, the polo ponies will be shoed and trimmed every 25–30 days. After the end of the season, they will be barefoot and rest in the paddock for at least two months to allow the hooves to rest from the horseshoe. The hooves need time to adapt to the horse's weight and environment without the protection of shoes. But in shoeing, the farrier will have to remove the sole to make space between the hoof and horseshoe. It may cause more sensitivity in the sole. However, from previous studies the resultant flat sole may 300 be more vulnerable to injury and lameness (Hampson et al., 2011).

Horse breed

Thoroughbred horses are well known for their susceptible hooves. Although they have a lower probability of experiencing palmar foot pain when compared to dressage horses, the most prevalent cause of lameness in this breed is still palmar foot pain (Pilsworth et al., 2010). As the polo ponies' breed in this study was the Argentine polo pony, which is a crossbreed of Criollo, Quarter and Thoroughbred, forelimb lameness in polo ponies might be correlated with the conformation of the long toe, underrun heel and long pastern, which are characteristic of Thoroughbreds, resulting in more tension in the DDFT and friction of the navicular bone. Previous study shows that one third of Thoroughbreds in New Zealand presented “broken back” hoof pastern axis (Labuschagne, 2017). It is one of the characteristics of long toe low heel.

Limitation

This research has some limitations. To begin, despite the fact that the soft and hard tissue in the hoof was generally evaluated with PD nerve block, radiography, and ultrasonography, navicular bursitis was unable to be assessed owing to a lack of local anesthetic on the navicular bursa. Furthermore, a mild-grade lesion of hard tissue in the hoof may not be noticed on the radiograph.

CONCLUSIONS

In conclusion, this study demonstrates that thirty polo ponies from two polo clubs had a high incidence of forelimb lameness and an interesting number of palmar foot pain. There appears to be no laterality to this forelimb lameness. Hoof conformation issues in the forelimb have a lesser impact on lameness on the same side but exhibit a more pronounced effect on the opposite limb. Other factors such as hoof imbalance, hoof trimming and shoeing, age of the horses and exercise on hard or irregular surface may also serve as predisposing factors of lameness and palmar foot pain. These aspects warrant specific and in-depth exploration in future studies. Understanding the prevalence of palmar foot pain in different horse breeds is essential for informed management and intervention strategies in equine health.

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AUTHOR CONTRIBUTIONS

Krisana Watchrarat: conceptualization, methodology, investigation, data curation, writing-original draft, visualization, funding acquisition.
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CONFLICT OF INTEREST

The authors have declared no conflict of interest.

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