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RETROSPECTIVE STUDY ON THE PREVALENCE OF TENDON INJURY IN RACEHORSES USING ULTRASOUND IN SELANGOR, MALAYSIA

By

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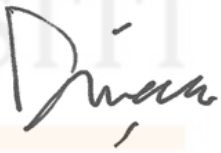

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ABSTRACT

This retrospective study examined the prevalence, characteristics, and associated risk factors of tendon injuries in racehorses evaluated using ultrasonography at Selangor Turf Club, Selangor, Malaysia, between 2022 to 2024. A total of 120 racehorses were assessed, of which 75 were confirmed to have tendon injuries, resulting in an overall prevalence of 62.5%. The Superficial Digital Flexor Tendon (SDFT) was identified as the most frequently affected structure and the left forelimb was the most commonly affected limb, representing 58.7% of all injuries. Demographic and race-related variables including age, sex, body weight, and race distance were analyzed. Although no significant associations were identified with the affected limb or type of tendon injury, sex and body weight were associated with the likelihood of returning to racing. These findings provide updated epidemiological insights into tendon injury patterns in Malaysian racehorses and highlight the predominance of SDFT involvement and forelimb susceptibility in this population.

Keywords: Racehorse, Tendon injury, Ultrasonography, Superficial Digital Flexor Tendon, Risk factors.

ABSTRAK

Kajian retrospektif yang dijalankan di Kelab Lumba Kuda Selangor, Malaysia, dari tahun 2022 hingga 2024 ini mendedahkan prevalens kecederaan tendon yang tinggi iaitu 62.5% dalam kalangan 120 kuda lumba yang dinilai menggunakan ultrasonografi, dengan Tendon Fleksor Digital Superficial (SDFT) dan kaki hadapan kiri menjadi struktur serta anggota badan yang paling kerap terjejas (58.7%). Walaupun analisis pemboleh ubah demografi dan berkaitan perlumbaan seperti umur, jantina, berat badan, dan jarak larian tidak menunjukkan kaitan signifikan dengan anggota badan atau jenis kecederaan tendon, jantina dan berat badan didapati mempunyai perkaitan dengan kebarangkalian kuda ini untuk kembali berlumba. Penemuan ini menyediakan pandangan epidemiologi yang penting, menekankan predominansi penglibatan SDFT dan kerentanan kaki hadapan dalam populasi kuda lumba Malaysia.

Kata kunci: Kuda Lumba, Kecederaan Tendon, Ultrasonografi, Tendon Fleksor Digital Superficial, Faktor Risiko.

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DVM 5 Lycan

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CHAPTER 1

1.0 INTRODUCTION

Horse racing in Malaysia dates back to the 1800s, introduced by British traders (Malayan-racing.com, 2015). Although it originated as a foreign sport, it quickly gained popularity among local enthusiasts and became a prominent event. In Malaysia, the sport primarily involves flat racing on a level track over set distances. As the industry continues to grow, there is increasing emphasis on racehorse welfare alongside the financial benefits. Racehorses are prone not only to musculoskeletal and soft tissue injuries but also to cardiovascular and respiratory complications (Cruz et al., 2007). The frequent occurrence of such injuries has heightened awareness and interest in understanding their causes and implementing preventive strategies. This concern becomes even more urgent in cases where injuries are severe enough to require euthanasia.

Tendon and ligament injuries are among the most frequent types of injuries seen in equine athletes, significantly affecting performance and contributing to increased rates of morbidity and mortality in both racehorses and horses involved in other sporting disciplines (Williams et al. 2001). In horses, the efficiency of movement largely depends on two key structures that store and release elastic energy: the Superficial Digital Flexor Tendon (SDFT) and the Suspensory Ligament (SL). In contrast, other structures, such as the extensor tendons of the digits, primarily function to position the limb and bear much lower loads; they are not significant sources of elastic energy. Consequently, while the SDFT and SL are highly susceptible to atraumatic injury (an injury without direct external trauma) in equine athletes, the extensor tendons generally exhibit a low prevalence of failure (Goodship and Birch 2001).

Superficial digital flexor tendon (SDFT) injuries are among the most frequent musculoskeletal problems in Thoroughbred racehorses, with reported prevalence rates ranging from 11-30%, and they continue to be a major contributor to racehorse attrition (Marr et al., 1993; Williams et al., 2001; Takahashi et al., 2004). Horses suffering from SDFT injuries typically require a break from training and competition (Reef, 2001). The recovery period can vary significantly, ranging from 6 to 26 months, depending on the severity of the initial injury (Marr et al., 1993; Ross et al., 2011). Despite treatment, between 40% and 80% of horses fail to return to competitive racing, where a triumphant return is often defined as completing at least 5 races post-injury (Dowling et al., 2000).

While various imaging modalities are available for evaluating tendons in horses, ultrasonography remains the primary technique for detecting and assessing tendonitis. Ultrasound is both widely accessible and cost-effective within standard equine veterinary practice (Smith, 2008). Its utility extends beyond simply localizing the lesion and measuring its severity. To maximize its value for the horse's future, the ultrasound findings must be integrated with assessments of various risk factors that may have contributed to the injury. Since many studies rely solely on simple univariable or descriptive analyses, it's crucial to use advanced multivariable statistical analyses to accurately assess the complex relationships among multiple contributing factors and the injury event (Tamura et al., 2018). By integrating objective ultrasound findings, clinicians can establish a more accurate prognosis, leading to more informed decisions on treatment, management, and welfare for the horse and ultimately allowing a better prediction of the animal's likelihood of returning to racing.

The aim of this study was to establish the prevalence of tendon injuries among the racehorse population in Selangor, Malaysia, utilizing ultrasound imaging as the preferable diagnostic tool. A central focus was to identify which specific tendons are most frequently affected in horses diagnosed with an injury. Furthermore, the study aimed to investigate the association between various risk factors and the occurrence of these tendon injuries, thereby providing valuable, objective epidemiological data to inform the development of more effective injury prevention strategies and improved surveillance programs for equine athletes in the region.

1.1 RESEARCH PROBLEM STATEMENT

Tendon injuries are among the most common musculoskeletal issues affecting racehorses, often leading to prolonged recovery periods, reduced performance, or even early retirement. Early detection and accurate classification of such injuries are crucial for effective intervention, management and prevention. While ultrasound imaging is widely used for diagnosing tendon injuries, there is limited retrospective data on the prevalence, severity, and distribution of these injuries across different types of racehorses and race categories. The lack of comprehensive data on how often specific tendons are affected and how injury severity correlates with risk factors limits the development of targeted preventive and rehabilitation strategies. Therefore, this study aims to retrospectively assess the prevalence and patterns of tendon injuries in racehorses using ultrasound imaging, identify commonly affected limbs and tendons and evaluate the relationship between injury severity and risk factors.

1.2 RESEARCH QUESTIONS

1. What is the prevalence of tendon injury in racehorses in Selangor, Malaysia?
2. Which limb and tendons are most commonly affected by injury in racehorses?
3. Is there a correlation between the tendon injury and its risk factors?

1.3 RESEARCH HYPOTHESIS

1. 1. Prevalence of tendon injury in racehorses

    H0: There is no high prevalence of tendon injury among racehorses.

    H1: There is a high prevalence of tendon injury among racehorses.

2. The tendon is most commonly affected

    H0: The superficial digital flexor tendon (SDFT) of the forelimbs is not the most commonly affected tendon among injured racehorses.

    H1: The superficial digital flexor tendon (SDFT) of the forelimbs is the most commonly affected tendon among injured racehorses.

3. Association between risk factors and tendon injury

    H0: There is no significant correlation between age, body weight, or race distance and the likelihood of tendon injury in racehorses.

    H1: There is a significant correlation between age, body weight, and race distance and the likelihood of tendon injury in racehorses.

1.4 RESEARCH OBJECTIVES

1. To determine the prevalence of tendon injuries in racehorses using ultrasound imaging in Selangor, Malaysia.
2. To identify which limb and tendons are most commonly affected in racehorses with diagnosed injuries.
3. To evaluate how various risk factors and the affected limb as well as the type of tendon injury influence a horse's likelihood of returning to future racing.

2.0 LITERATURE REVIEW

2.1 THOROUGHBRED OF HORSES

The Thoroughbred is considered the most valuable horse breed in the world and has been highly regarded as a racehorse for centuries (Cassidy, 2002). Over the course of 300 years, the breed has undergone intense selection to develop athletic traits that enhance performance in specific types of races. While environmental factors, training, and management significantly affect athletic traits, it is widely accepted that genetics determines a horse's racing capabilities (Routledge, 2005). Racing ability in Thoroughbreds is likely polygenic, it is influenced by multiple genes involved in anatomical, metabolic, and physiological traits that together support elite racing performance. Consequently, a racehorse's success depends on both a favorable environment and inheriting an optimal combination of DNA variants at key genetic locations that affect performance. One such genetic location is the MSTN gene, where variation has recently been shown too predict a Thoroughbred's suitability for different race distances strongly (Binns et al. 2010; Hill et al. 2010a; Hill et al. 2010b; Tozaki et al. 2010).

This gene, which is known to affect muscle growth in many mammalian species, contains a specific single-nucleotide polymorphism (SNP), at position g.66493737C/T, in its first intron. This SNP is closely linked to racing speed: horses with two copies of the C allele (C/C) are best suited for short, fast races (1,000–1,600 meters), those with one copy of each allele (C/T) excel at middle distances (1,400–2,400 meters), and horses with two T alleles (T/T) perform better in long-distance races (over 2,000 meters)(Grobet et al. 1997; McPherron & Lee 1997a; McPherron, Lawler & Lee 1997b; Schuelke et al. 2004; Mosher et al. 2007). The strong genetic influence of the MSTN locus on race distance is supported by a high heritability estimate (h^2 =

0.94) (Tozaki et al., 2011). Additional evidence for the C allele's role in speed comes from studies associating it with measured speed traits and from data on the Quarter Horse, where the C/C genotype is found at a high frequency of 83% (Hill et al., 2010). Functionally, changes in the expression of MSTN gene transcripts are among the most prominent in the skeletal muscles of Thoroughbreds after their first year of race training at two years old. Although the effects of the g.66493737C/T SNP have been well documented in modern Thoroughbreds, the origin and evolutionary history of this variation remain unclear (Hill et al., 2010). To investigate this, researchers combined molecular genetics with pedigree analysis using both modern and historical horse samples to trace the ancestry of this economically important allele in Thoroughbreds (Bower et al., 2012).

2.2 TENDON FUNCTION

The primary energy expenditure during locomotion is due to the muscular effort required to support the animal's weight and perform the work necessary to move both the animal's center of mass (CM) and its body segments. To conserve muscular energy, animals that walk on land engage in a continuous trade-off between the potential and kinetic energy of their CM. However, when moving at faster speeds (such as hopping, trotting, or running), they switch to bouncing gaits (like a spring) to conserve muscle work (Cavagna, Heglund & Taylor, 1977). Since the potential and kinetic energy of the Center of Mass (CM) move together (are "in phase") during these faster gaits, the primary mechanism for conserving energy is through the storage and subsequent recovery of elastic strain energy within the animal's limb tendons and ligaments (Alexander, 1988).

The superficial digital flexor tendon (SDFT) and the suspensory ligament (SL) are the main structures involved in this energy storage process. They are subjected to greater mechanical strain than tendons such as the deep digital flexor tendon (DDFT) and the common digital extensor tendon (CDET), which contribute minimally to energy return (Wilson et al., 2001). During galloping, the SDFT can experience in vivo strains up to 16% (Stephens et al., 1989), which is comparable to its in vitro failure strain range of 15–17% (Dowling et al., 2002; Gerard et al., 2005). In contrast, the CDET shows much lower in vivo strain, around 2.5%, well below its in vitro failure strain of 9.7% (Batson et al., 2003; Birch et al., 2008a). Despite being anatomically situated between the SDFT and SL, the DDFT functions primarily in flexing the distal phalangeal joint during the latter part of the swing phase and shows distinct muscle architecture and fiber type compared to the SDFT (Butcher et al., 2009). In vivo data also indicate that the DDFT is subjected to lower forces and strains than both the SDFT and SL during motion (Platt et al., 1994; Butcher et al., 2007).

A tendon's mechanical function is closely tied to its physical properties. Although there is considerable variation in SDFT stiffness and strength among individual horses (Birch, 2007), within the same horse, the SDFT typically has a lower elastic modulus compared to the CDET. This lower stiffness allows the SDFT to stretch and recoil more effectively, enabling it to efficiently store and release energy throughout the gait cycle (Batson et al., 2003). These functional differences stem from variations in the tendons' structural and molecular composition.

2.3 RISK FACTOR ASSOCIATED WITH TENDON INJURY

In a study focused on hurdle racing, several factors were linked to an increased risk of superficial digital flexor (SDF) tendinopathy, including firmer ground conditions (going), longer race distances, a higher proportion of a horse's career spent in flat racing, participation during the summer season, and a prior history of SDF tendinopathy (Reardon et al., 2012). Age was also identified as a significant risk factor, with older horses being more susceptible, a trend supported by earlier research (Williams et al., 2001; Perkins et al., 2005b). Interestingly, horses running in the middle or later parts of the race schedule were found to be at lower risk of developing SDF tendinopathy than those racing earlier in the day. This could be attributed to unmeasured variables, or differences in the quality of horses entered in early races. These findings contrast with those from hurdle racing, where the likelihood of SDF tendinopathy was lower in horses racing later in the day (Reardon et al., 2012). A similar trend was noted in relation to race timing, where races held in the morning or evening showed a reduced incidence of tendinopathy compared to afternoon races, although this observation's impact may be minimal given that only a small percentage of races occurred during these times (Reardon et al., 2012).

2.4 PREVALENCE OF TENDON INJURY AMONG RACEHORSES

Tendon injuries are among the most prevalent musculoskeletal issues affecting horses across various disciplines, with racehorses being the most extensively studied. Musculoskeletal injuries account for approximately 82% of all injuries in racehorses participating in both National Hunt and flat racing, and nearly half of these (46%) involve tendons or ligaments (Williams et al., 2001; Ely et al., 2004). A 12-year epidemiological study identified tendon injuries as the leading cause of retirement among racing Thoroughbreds in Hong Kong (Lam et al., 2007). Additionally, ultrasound diagnoses revealed that around 15% of National Hunt and flat racehorses sustain tendon or ligament injuries within a single training season (Ely et al., 2004; Kasashima et al., 2004). The forelimbs are particularly susceptible, with 97–99% of tendon injuries occurring in this region, primarily affecting the superficial digital flexor tendon (SDFT) in 75–93% of cases, followed by injuries to the suspensory ligament (SL) (Kasashima et al., 2004; Lam et al., 2007; Ely et al., 2004). Overstrain injuries affecting the superficial digital flexor tendon (SDFT) and the suspensory ligament (SL) are among the most frequently encountered musculoskeletal issues in performance horses. These injuries contribute significantly to the loss of racing Thoroughbreds and raise important welfare concerns. An epidemiological study conducted on British racetracks between 1996 and 1998 (Williams et al., 2001) found that injuries involving the SDFT, deep digital flexor tendon (DDFT), and SL occurred at a rate of 0.78 per 1,000 starts in flat racing. While these figures highlight how common tendon injuries are during races, they do not account for those that happen during training sessions. An earlier report by Rossdale et al. (1985) focused on training-related injuries at Newmarket, noting that tendon injuries were responsible for about 10% of diagnosed lameness cases that prevented horses from engaging in canter work. These injuries were identified as a major cause of training-related downtime.

2.5 DIAGNOSTIC AND EVALUATION OF TENDON INJURY

The diagnostic approach to flexor tendon injuries of the equine distal limb is extremely complex. An initial thorough physical examination along with palpation, observation of gait/lameness, and analgesic confirmation of the affected area is critical. After identifying the affected area, further diagnostics can be performed to determine the cause and severity of the disease process. These include ultrasonography, thermography, radiography, nuclear scintigraphy, computed tomography, and magnetic resonance imaging.

Ultrasonography is a commonly used and cost-effective imaging tool in equine veterinary medicine, particularly for identifying and evaluating tendonitis. Ultrasonographic images can be used to assess the severity of tendon injuries, including echogenicity, fibre alignment, size, shape, margination and tendon position. Of these, echogenicity, size and fibre alignment are the most commonly assessed features. However, CSA is the most objective measure of tendon pathology and can be accurately evaluated using ultrasound (Smith et al. 1994; Pickersgill et al. 2001).

On ultrasound, the normal superficial digital flexor tendon (SDFT) typically appears uniformly hyperechoic in transverse views. In contrast, in a longitudinal view, it displays bright, parallel linear echoes that correspond to the alignment of tendon fibers. Compared to the neighboring deep digital flexor tendon, the SDFT usually shows slightly lower echogenicity (Smith, 2008). Injuries to the superficial digital flexor tendon (SDFT) most often occur in the mid-metacarpal region of the forelimbs. They can present in one or multiple areas, sometimes affecting several limbs. These injuries may involve the central core or outer edges of the tendon, however,

research suggests the core is more frequently affected. Lesion characteristics vary, including the portion of the tendon's cross-sectional area involved and the overall length of the injury (Ely et al., 2004; Kasashima et al., 2004; Lam et al., 2007).

CHAPTER 3

3.0 METHODOLOGY

3.1 STUDY AREA

The study area was the Selangor Turf Club Equine Hospital, located in Seri Kembangan, Selangor, Malaysia.

3.2 STUDY DESIGN

This study was a retrospective cohort study, and data on tendon injuries in racehorses were collected from the Selangor Turf Club.

3.3 STUDY POPULATION

All the racehorses that were registered under the Selangor Turf Club and participated in the races were counted for this study.

3.4 SELECTION CRITERIA

Inclusion criteria

a) Only horses that were officially recorded and competing under the Selangor Turf Club.
b) Included injuries that occurred during races or post-race evaluations.
c) Horses with sufficient documentation regarding the demographical data, affected limb, type of tendon injury, and return to race.

Exclusion criteria

a) Any cases where the diagnosis was unclear, undocumented, or not related to tendon pathology.
b) Any cases of incomplete data of the racehorses.

3.5 SAMPLING METHOD AND PROCEDURE

In this study, convenience sampling was used to obtain the data, as this referred to the selection of racehorse cases based on the availability and accessibility of relevant ultrasound records. Since the study was retrospective, it relied on archived clinical or diagnostic data from the Selangor Turf Club Equine Hospital.

3.6 DATA COLLECTION TOOLS

The data were collected by reviewing the available electronic or physical files of medical records of the participating racehorses between 2022 and 2024. The collected data were evaluated to identify the location and were categorized based on demographic factors as well as race classifications.

3.7 DATA ANALYSIS

The data were analyzed using descriptive statistics to evaluate the presence of tendon injuries in racehorses and their association with demographic variables. Descriptive statistics were used to summarize the prevalence of tendon injuries, as well as demographic variables such as age, sex, and race distance of the horses. The Chi-square test was applied to examine associations between the risk factors and the affected limb, type of tendon injury, and the return to race of the horses.

All data were analyzed using statistical software (SPSS), with a significance level set at $p < 0.05$.

The overall prevalence was calculated based on:

$$\textbf{Prevalence (\%)} = \frac{\text{Number of cases}}{\text{Total population at risk}} \text{ X } 100\ \%$$

CHAPTER 4

4.0 RESULTS

4.1 PREVALENCE AND DEMOGRAPHIC DATA

The total number of racehorses evaluated using ultrasonography in Selangor, Malaysia, from 2022 to 2024 was **120**. Out of these, **75 horses** were confirmed to have tendon injuries based on ultrasonographic assessment. The prevalence of tendon injury over the three years was **62.50%**, indicating that more than half of the examined horses showed some degree of tendon pathology. Year-by-year evaluation showed that tendon injury prevalence was highest in **2023**, at **76.19%** (32 out of 42 cases), followed by **2024** at **63.04%** (29 out of 46 cases). The lowest prevalence was recorded in **2022** at **43.75%** (14 out of 32 cases).

Figure 1: The chart below shows the prevalence of tendon injury in racehorses using ultrasound in Selangor, Malaysia, from 2022 to 2024

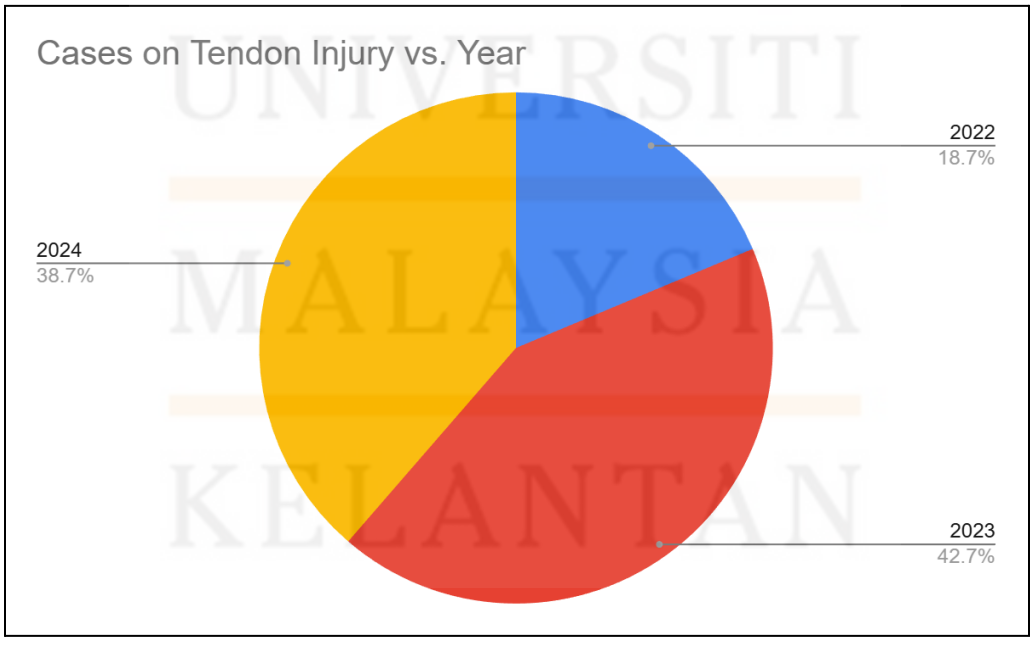

Figure 2: The chart below shows the total cases on tendon injury in racehorses in Selangor, Malaysia from the year 2022-2024 by affected limb.

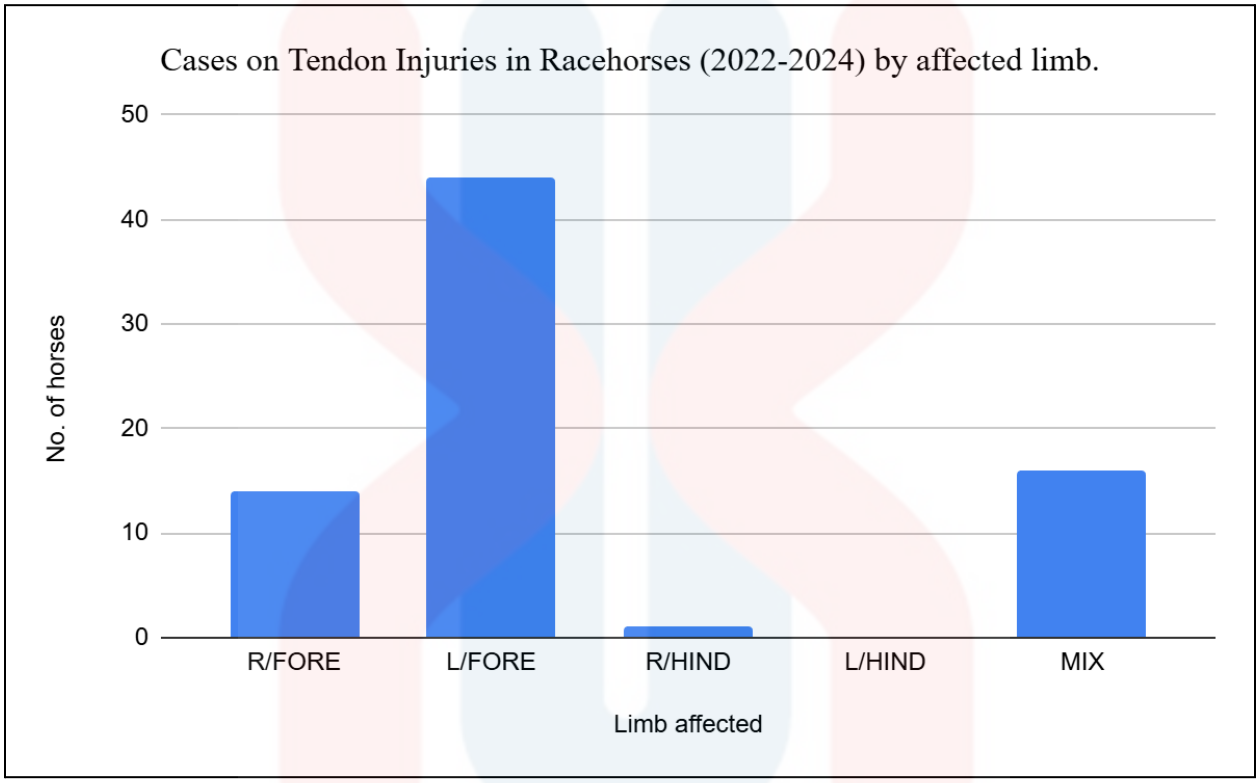

Table 1: Demographic data of the racehorses for this study (n = 75).

Risk factors	No. of Horses (%)
Sex	
1. Male	71 (94%)
2. Female	4 (5.3%)
Age	
1. Gelding (4-6)	24 (32%)
2. Adult (7-10)	48 (64%)
3. Senior (11-15)	3 (4%)
Body Weight (kg)	
1. Underweight (400-449)	6 (8.0%)
2. Light (450-499)	38 (50.7%)
3. Moderate (500-549)	29 (38.7%)
4. Heavy (550-599)	2 (2.7%)
Distance (m)	
1. A (1000-1499)	59 (78.7%)
2. B (1500-1999)	13 (17.3%)
3. C (2000-2499)	3 (4.0%)

4.2 STATISTICAL ANALYSIS

The association between risk factors and the outcomes has been categorized into three groups: limb affected, Type of Tendon Injury and Return to Race. Only sex has an association with the type of tendon injury and body weight has an association with return to race. The remaining variables show no association. Note that the significance is at p-value < 0.05.

Table 2 : Analysis of the risk factor associated with the Limb affected, Type of Tendon Injury and Return to Race in Racehorses (n= 75).

a) Limb Affected

Risk factors	Fisher's Exact Test	*p*-Value
Sex	0.228	0.973
Age	8.989	0.174
Body weight (kg)	3.234	0.954
Distance (m)	4.304	0.636

b) Type of Tendon injury

Risk factors	Fisher's Exact Test	*p*-Value
Sex	18.242	<0.001
Age	4.86	0.561
Body weight (kg)	11.047	0.273
Distance (m)	2.429	0.876

c) Return to Race

Risk factors	Fisher's Exact Test	*p*-Value
Sex	0.576	0.335
Age	2.135	0.344
Body weight (kg)	10.106	0.018
Distance (m)	3.159	0.206

CHAPTER 5

5.0 DISCUSSION

Research on the prevalence of tendon injuries in Malaysian racehorses is currently limited. Accordingly, this study focuses on racehorse records from Selangor Turf Club, Selangor, Malaysia, covering the past three years (2022–2024) and examines the associated risk factors. It is not possible to determine the nationwide prevalence of tendon injuries in Malaysia, as the data were collected exclusively from the Selangor Turf Club. Malaysia also has two other turf clubs located in Perak and Penang. Therefore, including data from all three turf clubs would provide a more accurate estimate of tendon injury prevalence nationwide. Due to time constraints, however, this study was limited to records from the Selangor Turf Club only.

The data analysis of tendon injury prevalence across the three-year study period (2022–2024) at the Selangor Turf Club revealed significant annual variation. Of the 75 total recorded cases, the lowest frequency occurred in 2022 with 14 injuries (18.7%). A substantial increase was observed in 2023, which recorded the highest number of incidents at 32 cases (42.7%). This trend persisted into 2024, which accounted for 29 cases (38.7%). The combined data from the latter two years (2023 and 2024) represent 81.4% of all reported tendon injuries. An important factor likely explaining the low prevalence of tendon injuries in 2022 (14 cases, 18.7%) compared to the subsequent years is the lingering effect of the COVID-19 pandemic on the Malaysian racing industry. Severe lockdowns and restrictions in 2020 and 2021 led to the cancellation or drastic reduction of race meetings, placing significant financial pressure on stakeholders. The increase of reported cases of tendon injury in the following years suggests a potential shift in injury risk factors or the effectiveness of diagnostic reporting practices between

2022 and the following years. Possible contributing factors for this spike in 2023, which should be further investigated, include changes in racing intensity, alterations in track surface maintenance, or the introduction of stricter veterinary surveillance, leading to increased detection of tendon pathologies.

The Superficial Digital Flexor Tendon (SDFT) was the most commonly affected structure, accounting for 67 cases (89.3% of all tendon injuries recorded in the study). In contrast, involvement of other major tendons was comparatively rare. The Deep Digital Flexor Tendon (DDFT) was affected in only 2 cases (2.7%), while the Achilles Tendon (AT) was the least frequently injured, with a single case (1.3%). Mixed tendon injuries, defined as concurrent damage to more than one tendon, were identified in 5 cases (6.7%). Analysis of limb involvement revealed a marked predominance of injuries to the left forelimb, accounting for 44 cases (58.7%) of the total. Injuries to the right forelimb were less common, with 14 cases (18.7%). In contrast, hindlimb involvement was minimal, with only 1 case (1.3%) recorded in the right hind limb. Injuries involving multiple limbs were observed in 16 cases (21.3%).

The superficial digital flexor tendon (SDFT) and suspensory ligament (SL) serve as the primary energy-storing structures in the equine forelimb. They are exposed to greater strains than the deep digital flexor tendon (DDFT) and common digital extensor tendon (CDET), which contribute little to energy storage (Wilson et al., 2001). Although the DDFT lies on the palmar side between the SDFT and SL, its muscle exhibits distinct architecture and fiber composition compared to the SDF muscle, and its main role appears to be flexing the distal phalangeal joint during the late swing phase rather than storing and releasing energy (Butcher et al., 2009).

Tendon function is closely linked to its mechanical properties. While the SDFT varies widely in strength and stiffness among horses (Birch, 2007), within an individual horse, the SDFT consistently has a lower elastic modulus, making it less stiff than the CDET. Variations in mechanical properties stem from differences in tendon structure and molecular composition between individual horses. High strains, such as those experienced by the SDFT during rapid locomotion, can cause localized damage to the collagen fibrils. In vitro studies have shown that loading tendon fascicles to 80% of their failure strain induces fibrillar damage and fibril sliding (Lavagnino et al., 2006). Such microdamage is associated with increased MMP-1 gene expression, and certain fibrils may experience higher strains, thereby increasing their risk of injury (Kastelic et al., 1978). If tenocytes fail to repair microdamage, it can accumulate and eventually result in clinical injury. Moreover, tendons that require high mechanical strength, such as the SDFT, may be protected from remodeling because collagen degradation and replacement could temporarily weaken the tendon (Laurent, 1987). Microdamage can occur after a single loading event at 80% of failure strain (Lavagnino et al., 2006), and repetitive loading during high-speed exercise may cause isolated microdamage without immediately visible injury (Arnoczky et al., 2008a). Abnormal loading may result from muscle fatigue, altered neuromuscular responses, or uneven surfaces (Kai et al., 1999).

Previous literature suggests that SDFT injury risk may increase due to fatigue of the DDF muscle. During fast locomotion, the DDFT stores minimal energy but stabilizes the metacarpophalangeal joint during hyperextension. Because the DDF muscle contains a high proportion of fast-twitch fibers, it is prone to fatigue. Fatigue could destabilize the joint, exposing the SDFT to higher strains and potential fibril microdamage (Butcher et al., 2007).

Overall, the high strains experienced by the SDFT contribute significantly to its elevated injury risk. Epidemiological studies further support this, showing that forelimbs which bear approximately 60% of the horse's weight at rest and even more during galloping, are more susceptible to injury, especially during activities like high-speed galloping and jumping (Wilson et al., 2001; Butcher et al., 2007).

Ultrasonography is a practical and non-invasive modality for diagnosing and characterizing SDFT injuries (Rantanen et al.,2011; Smith and Cauvin, 2014). Ultrasonographic data, including the variables in the present study, are useful for assessing the severity of SDFT injury (Smith and Cauvin, 2014). The severity of the tendon injury can be graded in relation to the DACB system and the cross-sectional area of the lesion (CSAL) work together to provide a complete ultrasound assessment of tendon injury severity. While DACB describes the qualitative features of the lesion such as fibre Disruption (D), Anechoic (A) fluid-filled core areas, Coalescing (C) hypoechoic zones, and Bordered (B) well-defined margins and the CSAL quantifies the percentage of the tendon cross-section affected. Higher DACB scores and larger CSAL values indicate more extensive structural damage, greater fibre loss, and a more severe tendon injury, which are often associated with longer healing times and a more guarded prognosis. However, DACB and CSAL were not assessed in this study, as the data required for these evaluations were incomplete or unavailable (Smith and Cauvin, 2014).

In this study, risk factors including age, sex, body weight, and racing distance were analyzed to evaluate their association with the affected limb and the type of tendon injury, as well as future racing outcomes, specifically the likelihood of horses returning to competition.

Based on the analyzed data, sex has no significant association with the limb affected and the type of tendon injury in the horses. However, there is an association between sex and returning to race. A previous study demonstrated that the risk of SDFT injury is higher in male than female horses (Kasashima et al., 2004; Takahashi et al., 2004), sex was not associated with a triumphant return to racing in our study. However, in this study, there is an association with sex and return to racing. This is suggestive of bias, as it may be related to the disproportionately small number of females in our study population (5.3% of the total). Several other studies indicate that male horses face a higher risk of serious or catastrophic injury than females (Estberg et al., 1996b, 1998; Cohen et al., 1999; Hernandez et al., 2001). However, research into catastrophic injuries has acknowledged that this observed gender-associated difference may be influenced by management decisions concerning seriously injured horses (Estberg et al 1996b). Specifically, female horses may be more likely to receive treatment for serious injuries to preserve their potential breeding career, whereas male horses might be more frequently euthanized (Estberg et al 1996b). While data supporting this management-bias hypothesis are currently unavailable, alternative explanations for a gender effect include the direct or indirect influence of male hormones on tissue properties or animal behavior, or on extrinsic factors such as specific training methods or racing patterns.

Besides that, age has no significant association with the limb affected and the type of tendon injury in the horses and the return to race. A previous study showed that increased rates of SDFT injuries in older horses (Williams et al., 2001; Kasashima et al., 2004). Another study demonstrated no significant association between age and the return to racing after SDFT injury

(Marr et al., 1993), similar to these results. Several previous investigations have established an association between increasing age and an increased general risk of serious musculoskeletal injury (MSI) in racehorses (Hill et al., 1986; Estberg et al., 1996b; Bailey et al., 1997; Williams et al., 2001). Specifically, a recent study in Japan found that racehorses aged ≥3 years were more than twice as likely to sustain injuries to the Superficial Digital Flexor Tendon (SDFT) or the Suspensory Apparatus (SA) than 2-year-olds (Kasashima et al., 2004). Moreover, Williams et al (2001) documented a dramatic increase in the rate of tendon or ligament injuries (measured as cases per 1,000 starts) in Thoroughbreds aged ≥5 years when compared with younger horses. This heightened risk with age is corroborated by findings that older horses experience changes in tendon microstructure and mechanical strength, which may predispose them to exercise-related tendon injury (Gillis et al., 1997; Patterson-Kane et al., 1997; Smith et al., 1999). Additionally, a horse's age is often complicated by factors such as cumulative exposure to training and racing. Since older horses have had more opportunities to train and race, they face a greater risk of exposure to repetitive micro-trauma, which is theorized to be a predisposing factor for clinical MSI in racehorses (Pool and Meagher 1990; Mohammed et al 1991).

From the data, body weight has no association with the limb affected and the type of tendon injury in horses but has an association in return to race. Based on the data analyzed, horses with body weight in the range from light (450 kg-499 kg) have higher association of the horse returning to race compared with horses that are considered underweight (400 kg -499 kg), moderate (500 kg - 549 kg) and heavy (550 kg - 599 kg), with 58.5% of the horses returning back to future racing. However, this finding may be biased, as the light body weight category had the largest number of horses recorded over the 3-year period, followed by the underweight, moderate, and heavy categories. A previous study found that mean body weight at race time was

significantly associated with the risk of Superficial Digital Flexor Tendon (SDFT) injury; specifically, horses with higher mean body weight faced a greater risk than lighter horses. Alternatively, the increased load could be directly related to biomechanics. The presence of a jockey or sandbag increases the vertical ground reaction force on the horse's limbs (Clayton et al., 1999; Schamhardt, Merkens & van Osch, 1991), and the SDFT injury may have developed as a consequence of the resulting increased load on the forelimbs being transferred to the SDFT. Furthermore, other characteristics correlated with body weight, such as pastern or forelimb length, may also have contributed to the occurrence of SDFT injury.

From the data analyzed, race distance has no association with the limb affected and the type of tendon injury, and return to race of the horse. In a previous study, horses that consistently raced over longer distances were found to be more likely to develop SDFT injuries than those running shorter distances. Prolonged exertion may lead to fatigue in the superficial digital flexor muscle and associated musculature, thereby increasing the mechanical load on the SDFT (Williams et al., 2001; Webbon, 1973). The superficial digital flexor muscle normally helps reduce high-frequency limb oscillations that could otherwise contribute to tendon microdamage (Wilson et al., 2001), and fatigue-induced impairment of this function during extended running may predispose the tendon to injury. Furthermore, during galloping, the core temperature of the SDFT has been shown to rise to 43°-45°C (Wilson & Goodship, 1994). Repeated exposure to such elevated temperatures may adversely affect the viability and metabolic activity of the tendon’s matrix-producing cells (Birch, Wilson & Goodship, 1997). As longer races involve greater time spent running, the SDFT is consequently exposed to elevated temperatures for a longer period, which may further increase injury risk.

This study is subject to several key limitations. Firstly, rehabilitation and medical treatment protocols can differ significantly across cases, influenced by lesion severity, the racehorse's rating/value, and the specific trainer's policy, introducing variability that is difficult to fully account for. Furthermore, there is significant potential for selection bias in the study population, primarily stemming from missing or unreliable data and inherent biases. The observed prevalence and the results of the analyzed data may be affected by the unavailability of a comprehensive medical history, making it difficult to reliably associate an injury with the horse's most recent race; the injury could be a re-detection of a prior ailment or result from training-related trauma rather than race-day exertion. Furthermore, the likelihood of a horse returning to racing is subject to significant owner and veterinary discretion. The eligibility criterion requiring all horses to be involved in rehabilitation with the explicit goal of returning to racing means that horses with the most severe injuries, whose owners decide on immediate retirement based on poor prospects for future race prize earnings or breeding value, are underrepresented. This systemic underrepresentation of career-ending injuries due to owner/economic decisions may have critically influenced our results, potentially explaining why conventional risk factors such as age, sex and body weight are not found to be associated with the return to racing.

6.0 CONCLUSION AND RECOMMENDATION

The study revealed a high prevalence of tendon injuries (62.5%) among racehorses evaluated at Selangor Turf Club between 2022 and 2024, with the majority occurring in the Superficial Digital Flexor Tendon (SDFT) and predominantly affecting the left forelimb. Annual variation in

cases was observed, with notable increases in 2023 and 2024 compared with 2022, likely reflecting changes in racing activity and diagnostic practices. Risk factor analysis showed that sex, age, body weight, and race distance had limited associations with the type or location of tendon injury, though body weight and sex were associated with the likelihood of returning to racing. These findings emphasize the SDFT's high susceptibility to mechanical strain and the importance of careful monitoring and management of racehorses to prevent tendon injuries.

Future studies should aim to include data from all turf clubs in Malaysia to provide a more accurate estimate of tendon injury prevalence nationwide. It’s also recommended that the turf club implement a more robust system for retrieving and tabulating historical records, ensuring data consistency and completeness. This will facilitate easier trend analysis and more comprehensive future research. Additionally, standardized data collection methods during races and ultrasound diagnosis findings will help minimize data gaps and ensure that future studies can include more comprehensive datasets rather than excluding incomplete records. Finally, preventive strategies, such as targeted conditioning programs and workload management, should be implemented to reduce the risk of injuries, particularly to the SDFT and forelimbs.

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