



EVALUATION OF RACE PERFORMANCE AFTER TENDON INJURIES IN RACE HORSES WITH SPECIAL RESPECT TO LESION RELATED PARAMETERS

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Summary

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The study aimed to assess the race performance after injury of the palmar metacarpal tendon region in Thoroughbred and Arabian racehorses. A special scoring system was established to evaluate the performance of the horses for each race after the injury, objectively in this study. Thus, individual total race earnings, the rates of ranking among the top four in at least two and three races and the number of participated races after injury were also analysed. The performance scores after injury were found to be lower in tendinitis cases compared to peritendinitis cases ($P=0.0004$). It was found that the success rate was lower in cases with tendon lesions than in cases without lesions in terms of race performance after injury ($P=0.006$). Injuries causing tendon thickening and also tendon echogenicity alterations had negative effects on race performances after injury ($P=0.01$ and $P=0.04$, respectively). Also individual total race earnings were lower in cases with tendon thickening compared to those without thickening ($P=0.02$). According to the results of this study, it is recommended to take prophylactic measures for tendinitis in cases with tendon thickening and echogenicity changes detected by ultrasound in the early stages of tendinitis to be able to display a good race performance after injury.

Key words: Arabian, performance scores, race performances, tendinitis, Thoroughbred, ultrasound

INTRODUCTION

Injuries of tendons and ligaments, especially those of the superficial digital flexor tendon (SDFT) (O'Meara *et al.*, 2010; Kalisiak, 2012; Witte *et al.*, 2016), which are among the most common musculoskeletal injuries observed in athletic

horses (Oikawa & Kasashima, 2002), may cause poor performance (Witte *et al.*, 2016; Alzola *et al.*, 2018; Caliskan *et al.*, 2020a) and they even end the horse's sporting life (Belt, 1995; Seyrek-Intas *et al.*, 2002; Witte *et al.*, 2016; Alzola *et al.*,

2018). Comparison of the prevalence of tendinitis between Thoroughbred and Arabian racehorses, which developed due to their high-speed running capacities, revealed no statistically significant differences ($P>0.05$). Therefore, it was thought they have similar biomechanical properties (Caliskan *et al.*, 2020b). Accordingly, it may be considered to have a high risk of poor/career ending race performance due to tendinitis in both racehorse breeds participating in high speed races. However, a significant relation was found in terms of the degree of tendinitis with race numbers and distances three months prior to injury ($P<0.05$) (Caliskan *et al.*, 2020c). Tendon and ligament injuries are even believed to be potentially more threatening for sport horses' future career than fractures (Gillis *et al.*, 1997).

The healing process after tendinitis takes 6–16 months (Belt, 1995; Gillis *et al.*, 1997; Whitcomb, 2004). When tendinitis occurs in the horse, necessity for keeping away the horses from races for an average of 6–12 months arises (Whitcomb, 2004; Tamura *et al.*, 2018; Caliskan *et al.*, 2020a). Because of the prolonged-expensive treatment and rehabilitation processes during this time (Whitcomb, 2004; Witte *et al.*, 2016), the racing industry and especially the horse owner incur high economic losses (Caliskan *et al.*, 2020a). The race careers are shorter after injury in horses which suffer from tendinitis (Witte *et al.*, 2016; Caliskan *et al.*, 2020a) due to molecular and biomechanical changes of the tendon after tendinitis (Genovese *et al.*, 1996; Dowling *et al.*, 2000; Oikawa & Kasashima, 2002; Whitcomb, 2004; Alzola *et al.*, 2018) and to high recurrence rate (Marr *et al.*, 1993; Genovese *et al.*, 1996; Oikawa & Kasashima, 2002; O'Sullivan, 2007; Kalisiak, 2012; Witte *et al.*, 2016; Alzola *et al.*,

2018). Because of the persistent scar tissue occurring between fascicles after tendinitis in the healed tendon, tissue cannot regain its original mechanical properties and elastic modulus like before (O'Meara *et al.*, 2010). The tendon lesion and also the healing phase should be evaluated periodically by ultrasonography (Dowling *et al.*, 2000; Whitcomb, 2004; O'Sullivan, 2007; Alzola *et al.*, 2018; Tamura *et al.*, 2018; Caliskan *et al.*, 2020a). The decision for returning to races should be based on these findings (Genovese *et al.*, 1996; 1997; Oikawa & Kasashima, 2002; Alzola *et al.*, 2018; Tamura *et al.*, 2018; Caliskan *et al.*, 2020a). The severity of the lesion, defined based on the cross-sectional area (CSA) and the length of the lesion, affects the outcome of tendinitis and hence return rates to races (Marr *et al.*, 1993; Genovese *et al.*, 1997). Besides, tendon thickening related to tendon injuries have a negative effect on the ratio of return to races ($P<0.05$) (Caliskan *et al.*, 2020a). It was also emphasised that evaluation of the length of the SDFT injury by ultrasonography is an easy, reliable and important prognostic tool in terms of tendinitis outcome (Genovese *et al.*, 1997; Kalisiak, 2012). An increase in the lesion length, especially if it is longer than 12 cm (Kalisiak, 2012), increases the risk to be unable to return to racing after SDFT injury (Kalisiak, 2012; Tamura *et al.*, 2018).

There are lots of studies about returning to races after tendon injuries (O'Sullivan, 2007; O'Meara *et al.*, 2010; Caliskan *et al.*, 2020a) yet there is no accepted method to measure the performance of racehorses before and/or after medical or surgical treatment (O'Meara *et al.*, 2010). The race factors related time, handicap and/or earnings are generally used to measure the race performance of horses (Thiruvankadan *et al.*, 2009).

The aim of this study was to assess the race performances after tendon injuries in Thoroughbred and Arabian racehorses. For this purpose, flexor tendon injury or peritendinitis findings in the palmar metacarpal region detected by clinical and ultrasonographical (US) examinations were evaluated. The US findings were associated with return and success rates in the post-injury period with a special scoring system established first time in this study.

MATERIALS AND METHODS

Horses

The study material consisted of Thoroughbred (n=62, 52.5%) and Arabian (n=56, 47.5%) racehorses competing or training at different hippodromes in Turkey which consulted the Horse Surgery Clinics of Veterinary Faculty of Bursa Uludag University with complaints of lameness/pain and/or swelling of the metacarpal region. The signed consent of the patient owner/responsible person was obtained for the possible examination and treatment procedures to be applied to each of the participants in the study.

The study material consisted of 120 cases belonging to 118 purebred Thoroughbred (n=62, 52.5%) and Arabian horses (n=56, 47.5%) two of which having a bilateral injury. There were 37 mares (31.4%) and 81 stallions (68.6%). Of the thirty-seven mares, 19 were Thoroughbred (51.4%) and 18 were Arabian (48.6%). Of the eighty-one stallions, 43 were Thoroughbreds (53.1%) and 38 were Arabians (46.9%). Ages ranged from 2 to 9 years (mean age 4.1 ± 1.6 years).

Examinations

- History and clinical examinations
Information about histories and complaints was received from the horse owners and/or trainers. In the clinical examination, lameness, if observed, was graded as mild, moderate and severe. Local inflammation on metacarpal palmar regions was evaluated by inspection and palpation in terms of changes in shape (curvature), irritation/wounds, heat, swelling, redness. Perimeter measurements at four different levels on the metacarpal regions (ultrasound examination levels) of the injured and contralateral extremity were recorded.
- Ultrasonographic examinations
For the US examinations of the tendons, a portable (MCV Concept-Dynamic Imaging[®] Co., London, UK) and a stationary (Sonostar-Dynamic Imaging[®], London, UK) device were used with linear (5–7.5 MHz) and microconvex (6–7.5 MHz) probes (Dynamic Imaging[®] Co., London, UK), and also standoff pads. The examination was made in a dark room with the horse distributing its bodyweight equally to all four legs. Both forelimbs were examined in all examinations of the horses.

The metacarpal SDFT, deep digital flexor tendon (DDFT), accessory ligament of the DDFT (DDFT-AL), and suspensory ligament (SL) were evaluated. The tendon measurements were taken on four levels starting 2.5 cm distal to the accessory carpal bone with equal distance¹. US scans, from proximal to distal, made on transversal planes at four different levels, and scans on longitudinal planes were made at three different levels. Assessment of the tendon cross-sectional area (CSA) and the

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lesion cross-sectional hypoechoic area (CSHA) were made on transverse scans of the tendons. Measurements of total cross-sectional area (T-CSA) and total cross-sectional hypoechoic area (T-CSHA) of the lesion were obtained from the computer program of the ultrasound device. At each measurement levels, palmarodorsal (PD) and lateromedial (LM) diameters, circumferences (mm) and CSA (mm²) of each displayed tendon were measured. To identify any rising in tendon CSA, the measurements were compared with the values of reference for each horse breed. If the difference between corresponding tendon CSA's was greater than 20% compared on two limbs, the bigger one was "thickened" (Belt, 1995; Oikawa & Kasashima, 2002; Seyrek-Intas *et al.*, 2002). Tendons with an increase in CSA of less than 20% compared to the contralateral one were considered "not thickened". If there was just thickening of the tendon without a distinct lesion, it was defined as strain. The tendon echogenicity was evaluated in terms of homogeneity of the remaining tendon tissue excluding the lesion. Also, parallelism of the fibrillar alignment, and the longitudinal size of the lesions were assessed, if present. Peritendinous tissues were investigated in terms of the pathologies such as fluid accumulations (oedema and bleeding) and/or fibrous tissue formation. If there were anechoic changes (oedema, bleeding, other fluids) or more hyperechoic changes (fibrosis) outside of the tendon structure was defined as peritendinitis. The echogenicity, localisation, severity and shape of the tendon lesions were evaluated on transversal scans. The lesions were defined as circumscribed if they were sharply delineated. If the lesions spread on the CSA of the tendon, they were described as diffuse lesions. If several foci were present, they

were considered multifocal-type lesions. The tendon lesions were classified as central (located in the middle of the tendon CSA), peripheral (located around the middle of the tendon-CSA) and marginal (located on the border of the tendon-CSA). Anechoic, hypoechoic or hyperechoic lesions were determined in terms of echogenicity. Lesion severity was defined based on longitudinal size and the CSHA of the lesion. Based on these, if the lesion was smaller than 50% of T-CSA and/or shorter than 100 mm in length, it was defined as mild lesion. If the lesion was 50-75% of T-CSA and/or 100-160 mm in length, it was defined as moderate lesion. If the lesion was greater than 75% of T-CSA and/or longer than 160 mm, it was defined as severe (Marr *et al.*, 1993).

Evaluation of race performance

Race records were obtained from the Turkish Jockey Club web site and analysed to evaluate race performance of the horses after injury. The number of races, placements and revenues of the horses, which raced after injury, were determined. In order to evaluate the success of the horses returning to racing after injury, a special scoring system was defined first time in this study. Both the number of races and the placements were evaluated by creating a special scoring system. The total number of races and the number of placements (top 4 degrees) were determined for each horse and horses were grouped winning at least two races and at least three races. Additionally, the number of races with a placement was multiplied by a coefficient of '4' for each first place, '3' for each second place, '2' for each third place and '1' for each fourth place. The sum of these points revealed the post-injury race performance score of each

Table 1. Post-injury race performance score for each case calculating formula

Rank in the races after injury	Coefficient	Number of races in which the horse ranked among the top four		Total score (Coefficient × Number of races)
1 st place	4	...		Total score for 1 st place (TS ₁)
2 nd place	3	×	...	Total score for 2 nd place (TS ₂)
3 rd place	2		...	Total score for 3 rd place (TS ₃)
4 th place	1		...	Total score for 4 th place (TS ₄)

Post-injury race performance score for each case = $\sum_{i=1}^4 TS_i$

horse (Table 1). Racing performance scores were associated with the ultrasonographic parameters of the tendon lesion.

Statistical methods

The statistical analyses were made by Statistical Package for the Social Sciences (SPSS Inc, Chicago, USA) 13.0 program. Statistical significance was set at $P < 0.05$. Fisher's Exact Chi-Square and Pearson Chi-Square tests were used to evaluate the cases with top four placements at least two times and at least three times after injury in terms of tendon thickness and echogenicity, localisation, echogenicity, severity and shape of the lesion, and peritendinous alterations (Sumbuloglu & Sumbuloglu, 1997; Kan, 2006).

Pearson correlation coefficient, Spearman correlation test, Kruskal-Wallis, Mann-Whitney U and Pearson Chi-Square tests were used to evaluate the performance scores. The assessments were made in terms of sizes-echogenicities-homogeneities of the tendons, presence of tendinitis vs. peritendinitis, severity of the tendinitis, presence of a lesion, localisations-shapes-sizes-echogenicities of the tendon lesion(s) and also total race revenues for each horse (Sumbuloglu & Sumbuloglu, 1997; Kan, 2006).

Fisher's Exact Chi-Square, Pearson Chi-Square, Mann-Whitney U and Kruskal-Wallis tests were used to evaluate the amount of revenues in their life for each horse which returned to races after injury according to the types of the lesion, peritendinitis and presence of tendon thickness (Sumbuloglu & Sumbuloglu, 1997; Kan, 2006).

RESULTS

According to the clinical and US findings, in 85.0% (n=102) and 15.0% (n=18) of the cases tendinitis and peritendinitis were identified, respectively. The affected tendons were SDFT (87.3%, 89/120), DDFT (7.8%, 8/120), and both SDFT and DDFT (4.9%, 5/120) simultaneously.

Tendon lesions were determined in 59.2% (71/120) of the cases. In 40.8% (49/120) of the cases without a lesion, strain or peritendinitis was detected. The rate of the cases with tendon lesions which were able to return to races after injury was 54.8% (46/84) and the rate for horses without tendon lesion was 45.2% (38/84).

A significant difference was detected with regard to the numbers of the races after injury between the cases with (average 8.2 races) and without (average 17.6 races) tendon lesions ($P=0.008$). Ac-

cordingly, the rate of participation in races after injury was higher in cases without tendon lesions compared to those with lesions (P=0.008).

The rate of ranking among the top four in at least three races was higher in cases without tendon lesions (48.9%, 24/49) compared to the cases with lesions (28.2%, 20/71) (P=0.02, Table 2). At the same time, the rate of the cases not returning the races and/or not ranking among the top four were higher in cases with lesions (57.7%, 41/71) compared to the cases without lesions (34.7%, 17/49) (P=0.01).

A statistically significant difference was detected in terms of performance scores in races after injury between the cases with and without tendon lesions (P=0.006). In races performed after injury, 62 cases got a performance score of "0". Forty two of them (67.7%) had tendon lesions whereas 20 of them (32.3%) did not have. Cases with tendon lesion received an average score of 8.0 points whereas cases without lesion received a score of 18.8 points. Accordingly, cases without a lesion which returned to races

after injury had higher performance scores than cases with a lesion (P=0.006).

Severity and properties of tendon lesion

Mild lesions were found in 42.5% (n=51), moderate lesions in 15.8% (n=19) and one severe lesion was only found (0.8%). Core lesions were encountered in 29.6% (n=21), peripheral lesions in 15.5% (n=11) and marginal lesions in 14.1% (n=10) of all circumscribed lesions. Forty-two circumscribed (35.0%), 6 diffuse (5.0%) and 23 multifocal (19.2%) lesions were identified in all tendon lesions (n=71). Twenty-six anechoic (21.7%), 44 hypoechoic (36.7%) and 1 hyperechoic (0.8%) lesion was detected. There were no significant differences between the cases with different parameters (echogenicities-localisations-severity-shapes) of the tendon lesions in terms of race performance, ranks among the top four in at least two and three races, and individual total race earnings (P>0.05).

Table 2. The rates of ranking among the top four in at least three races after injury between the cases with and without tendon lesion

Rates of ranking among the top four in at least three races	Lesion				Total	
	Yes		No		n	%
	n	%	n	%		
Cases ranking among the top four in at least three races	20	28.2 ^a	24	48.9 ^b	44	36.7
Cases ranking among the top four in less than three races	10	14.1	8	16.3	18	15.0
Cases not returning the races and/or not ranking among the top four	41	57.7 ^a	17	34.7 ^b	58	48.3
Total	71	59.2	49	40.8	120	100.0

Differences between ratios bearing different letters on the same lines are statistically significant (P=0.02).

Table 3. Race performances after injury of the cases with tendon thickening and those without

Race performance after injury	Tendon thickening				Total	
	Yes		No		n	%
	n	%	n	%		
Ranking among the top four	37 ^a	41.1	20 ^b	66.7	57	47.5
Not ranking among the top four	21	23.3	6	20.0	27	22.5
No return to races	32 ^a	35.6	4 ^b	13.3	36	30.0
Total	90	75.0	30	25.0	120	100.0

Differences between ratios bearing different letters on the same lines are statistically significant (P=0.03).

Thickening of the tendon

The thickened tendon rate was 75.0% (n=90) based on the US examinations. Tendon thickening was higher in tendinitis cases than peritendinitis cases (P<0.001). In addition, there was a significant difference with regard to thickening in tendons with and without lesions (strain) in tendinitis cases (P<0.05).

The difference between the number of races participated after injury was significant statistically between the cases with tendon thickening and those without (P=0.01). It was found that cases with tendon thickening raced 10.7 times and cases without thickening raced 17.7 times after injury. Besides, 88.9% (32/36) of the cases which did not return to races after injury had a thickening of the tendons. However, cases with tendon thickening participated in fewer races after injury (P=0.01).

Race performances and ranking among the top four after injury of the cases without tendon thickening were higher than those with (P=0.03, Table 3). The cases with tendon thickening received an average of performance score of 10.7 points whereas the cases without thickening: 17.7 points (P=0.01). Accordingly, the

cases without tendon thickening (20/30, 66.7%) were more successful in the races after injury than those with tendon thickening (41.1%, 37/90). Besides, 58.9% (53/90) of the cases with tendon thickening and 30.0% (9/30) of the cases without tendon thickening got a performance score of "0" after tendon injury. So, the performances scores of the cases with tendon thickening were significantly lower than those without thickening (P=0.01).

The rates of ranks among the top four in at least two races after injury were higher in the cases without tendon thickening (63.3%, 19/30) (P=0.007, Table 4). Accordingly, tendon injuries which cause thickening in the tendon affected negatively the rate of ranks among the top four in at least two races after injury (P=0.007).

Race earnings were lower in cases with tendon thickening compared to those without tendon thickening, parallel to the race performances (P=0.02). According to their individual total race earning average the cases with tendon thickening gained 57,778.63 Turkish Liras (TRY) (6,237.61 €) whereas those without thickening gained an average of 123,823.25 TRY (13,367.59 €). At the same time, it was determined that 13.3% (12/90) of the cases with tendon thickening and 3.3%

Table 4. Rates of ranks among the top four in at least two races after injury in the cases with/without tendon thickening

Rates of ranks among the top four in at least two races after injury	Tendon thickening				Total	
	Yes		No			
	n	%	n	%	n	%
Cases ranking among the top four in at least two races	32	35.6 ^a	19	63.3 ^b	51	42.5
Retired and/or not ranking among the top four	58	64.4 ^a	11	36.7 ^b	69	57.5
Total	90	75.0	30	25.0	120	100.0

Differences between ratios bearing different letters on the same lines are statistically significant (P=0.007).

(1/30) of those without thickening to have won no prize money in the races in which they participated.

Echogenicity of the tendon

Tendon echogenicity in areas outside the lesion was homogeneous in 55.8% (67/120) while heterogeneous in 44.2% (53/120). The structure of the tendon was homogeneous in all cases which were evaluated as peritendinitis based on the ultrasound examination (100.0%, 18/18). Tendon echogenicity of the tendinitis cases appeared heterogeneous in 52.0% (53/102), whereas 48.0% (49/102) showed a homogeneous structure.

There was a homogeneous tendon structure in 38.0% (27/71) of the cases with a tendon lesion and a heterogeneous appearance in 62.0% (44/71) of the cases without a lesion. Statistically significant difference in tendon echogenicity between both groups was found (P<0.001). Accordingly, there was a high probability of heterogeneous tendon echogenicity in the cases with lesions and a homogeneous echogenicity in the cases without lesions (P<0.001). The cases with homogeneous tendon structure participated an average of 15.0 races with average score of 15.6

points of performance after injury whereas the cases with heterogeneous tendon an average of 8.3 races with a score of 8.5 points (P=0.02).

Besides, 48.4% (30/67) of the cases with homogeneous tendons and 51.6% (32/53) of the cases with heterogeneous tendons got a performance score of "0" after tendon injury. So, the performance scores of the cases with heterogeneous tendons were lower than those with homogeneous (P=0.04) structure.

Peritendinous alterations

Peritendinous alterations like haemorrhage, fibrosis, oedema, fibrin accumulation, congestion, dermatitis and tendovaginitis as accompanying findings were diagnosed in 50.0% (60/120) of the cases. Only one type of peritendinous alteration was detected in some horses, more than one alteration was found in some others. In tendinitis cases, the rate of peritendinous alterations was 41.2% (42/102).

The tendinitis cases (85.0%, 102/120) participated in an average of 9.8 races after injury whereas peritendinitis cases (15.0%, 18/120) performed 24.8 races on average (P=0.04). It was remarkable that the horse which performed 81 races and

also had run the most races after injury was one of the peritendinitis cases (P=0.04).

Besides, tendinitis cases (85.0%, 102/120) received an average score of 9.6 points whereas peritendinitis cases (15.0%, 18/120) gained a score of 28.3 points. Of the cases with a performance score of "0" from races after injury, 95.2% had tendinitis and 4.8% had peritendinitis. However, the highest performance score of 107 points got a horse with peritendinitis. As a result, tendinitis cases had lower performance scores after injury than peritendinitis cases (P=0.0004).

Peritendinous fibrin accumulated (3.3%, 4/120) cases received an average score of 27.5 points after injury whereas non-peritendinous fibrin accumulated cases (96.7%, 116/120) received a score of 11.9 points (P=0.02). The performance scores from races after injury in cases with peritendinous fibrin accumulation were higher compared to those without (P=0.02). One of the peritendinous fibrin accumulated cases (3.3%, 4/120.) had peritendinitis and 3 of them (75.0%, 3/4) had tendinitis. Two of the tendinitis cases with peritendinous fibrin had just tendon strain (50.0%, 2/4) and the others had mild tendon lesions (50.0%, 2/4).

Nevertheless, the cases with peritendinous alterations earned 66.179.09 TRY (7,144.50 €) and the cases without peritendinous alterations earned 82.400.48 TRY (8,900.89 €) average race revenues (P=0.12).

There were no statistically significant differences between the cases with different peritendinous modifications (such as bleeding, oedema, dermatitis, fibrosis) with regard to the race performances, ranks among the top four in at least two and three races, and individual total race earnings.

DISCUSSION

Evaluation of race performances after tendon injuries

Tendon injuries may cause poor performance (Witte *et al.*, 2016; Alzola *et al.*, 2018; Caliskan *et al.*, 2020a, c) and also end the horse's sporting life (Belt, 1995; Seyrek-Intas *et al.*, 2002; Witte *et al.*, 2016; Alzola *et al.*, 2018). Tendon molecular structure and biomechanical properties change permanently after tendinitis. Therefore, the damaged tendons cannot work normally for long periods of time (Dowling *et al.*, 2000; Whitcomb, 2004). In connection with this, the prognosis is poor in terms of returning to racing, especially in horses that have begun training in less than six months after injury (Dowling *et al.*, 2000; O'Sullivan, 2007). Because of the high potential of recurrence in the rehabilitation process, decision about returning to races should be based on the periodic ultrasonographic assessments of the healing tendon (O'Sullivan, 2007; Alzola *et al.*, 2018; Tamura *et al.*, 2018; Caliskan *et al.*, 2020a).

It has been reported that getting back to previous performance with optimal recovery and minimal sequelae may be achieved (Dowling *et al.*, 2000; Gillis, 2007) if the horses' training schedule is organised according to US findings during the healing phase of tendinitis (Dowling *et al.*, 2000; Whitcomb, 2004; Gillis, 2007).

The time, handicap and/or earnings are generally evaluated to measure the race performance of horses (Thiruvankadan *et al.*, 2009). Some performance parameters have been evaluated to determine the race success after tendinitis in some clinical studies such as earnings (O'Meara *et al.*, 2010; Thiruvankadan *et al.*, 2009), total distance raced post-injury (Witte *et al.*, 2016), maximum racing post rating

(O'Meara *et al.*, 2010; Witte *et al.*, 2016), and number of races after injury (O'Meara *et al.*, 2010; Kalisiak, 2012; Witte *et al.*, 2016; Alzola *et al.*, 2018). Caliskan *et al.* (2020a) found that returning rate to races at least once after injury was 70.0% (84/120). It was reported that out of tendinitis cases 82.1% (69/84), and out of peritendinitis cases 17.9% (15/84) returned to the races after injury (Caliskan *et al.*, 2020a). In the present study, the number of races, rates of entering degrees in at least two and three races, individual total race earnings and also the performance scores of the horses (established in this study) participated in races after injury were evaluated to show more objectively the success rate of tendinitis cases returning to race after injury. In this context, the importance of the prognostic value of the US findings and whether it had an impact on the racing performance of horses after tendon injuries was assessed.

Our results indicate that the racing performance after injury in cases with tendinitis was weaker than in horses with peritendinitis, hence the prognosis as well.

Evaluation of thickening of the tendon

It is important to evaluate the dimensions of tendons in the US diagnosis of tendon pathologies (Rantanen, 1996; Oikawa & Kasashima, 2002; Whitcomb, 2004; Henklewski & Atamaniuk, 2008; Caliskan *et al.*, 2020a) especially to diagnose pathologies which show just an increase in tendon CSA without a lesion (Rantanen, 1996; Henklewski & Atamaniuk, 2008; Caliskan *et al.*, 2020a) and also in acute tendinitis (Rantanen, 1996). An increase in tendon CSA, which is evidence of fibrillar damage, was associated with re-injury in horses that started training

(Dowling *et al.*, 2000) or raced again afterwards of the tendinitis (Watkins, 1999).

In order to determine the region of enlargement of the tendon or ligament, the tendons of the superficial and deep digital flexor muscles, distal check and suspensory ligaments should be measured by ultrasonography (Belt, 1995; Wrigley, 2002; Whitcomb, 2004). An increase of more than 20% of the CSA of the tendon is accepted significant even if no lesions are detected by ultrasound (Oikawa & Kasashima, 2002; Seyrek-Intas *et al.*, 2002; Caliskan *et al.*, 2020a). Subclinical changes associated with tendinitis can be diagnosed by this way and prophylactic measures are recommended in time (Whitcomb, 2004; O'Sullivan, 2007; Henklewski & Atamaniuk, 2008; Caliskan *et al.*, 2020a).

In the present study, perimeter measurements were recorded at four different levels of the metacarpal areas of the both forelimbs (ultrasound examinations were made on the same levels) to determine whether the extremity was thickened or not. Then, the tendinous and peritendinous tissues were evaluated in terms of their size by US examinations and the tissues that caused the thickening were determined. Thickening was associated with tendinous/ peritendinous oedema, bleeding and similar changes in acute cases and increased fibrous tissue in chronic cases (Caliskan *et al.*, 2020a).

Based on the results of this study which are in accordance with other reports (Watkins, 1999; Oikawa & Kasashima, 2002; Whitcomb, 2004; Henklewski & Atamaniuk, 2008; Caliskan *et al.*, 2020a), it is strongly recommended to take prophylactic measures in case of an increased CSA of a tendon because of lesion predisposition and potentially low race performance.

Evaluation of echogenicity of the tendon

One of the most common US findings in tendinitis is alteration of echogenicity (Wrigley, 2002). This is also important for the evaluation of the tendon healing process (Watkins, 1999; Gillis, 2007; O'Sullivan, 2007). If the healing tissue in the tendon has a uniform axial alignment, it has a good prognosis (Dowling *et al.*, 2000). In the presented study, it was found that horses with heterogeneous tendon structure in comparison to those with homogeneous tendon echopattern participated in fewer races after injury, and also their performance scores were lower. On the basis of these results, irregularity in tendoechogenicity was found to have negative effects on the number of races and performance scores of the horses returning to races. In this respect, prophylactic measures should be taken in horses if their tendons have structural changes in their echopattern.

Evaluation of the presence of a tendon lesion

The CSA, length and echogenicity of a lesion and also CSAs of the contralateral tendons have to be evaluated (Henklewski & Atamaniuk, 2008; Kalisiak, 2012; Caliskan *et al.*, 2020a,b,c) to determine the prognosis and to monitor the tendon healing processes on US examination (O'Sullivan, 2007; Caliskan *et al.*, 2020a).

Kalisiak (2012) determined the lesion length according to the length of hypoechogenic zone of the lesion (L-HYP). The tendon lesions were evaluated in three groups by Kalisiak (2012) according to their length as 1–8 cm, 9–12 cm and longer than 13 cm. Kalisiak stated that if the tendinitis grade based on L-HYP decreases, post-injury race career would be better (increased possibility of participating more than 6 races) (Kalisiak,

2012). Similarly, Tamura *et al.* (2018) emphasized that if the length of the lesion increases, the risk of failure to successfully return to races increases after injury (Tamura *et al.*, 2018). In the presented study, lesion severity was defined based on longitudinal size and the CSHA of the lesion as mild, moderate or severe lesion (Marr *et al.*, 1993). These lesion length assessment values were longer than the values in Kalisiak's study. There were no significant differences with regard to lesion echogenicity and severity. It was thought that if another classification from different studies (Genovese *et al.*, 1996; 1997; Gibson *et al.*, 1997; Kalisiak, 2012) were used to determine the lesion length, the rate of severe lesions would be higher and the evaluations might have been different. Besides, assessments should be supported with a higher number of cases in terms of the lesion severity.

Witte *et al.* (2016) correlated the post-injury race performance with the lesion severity. They have found that injured horses had shorter careers after injury and also if severity of the lesion increases, retirement (without further treatment after injury) rate of the horses with tendinitis increases (Witte *et al.*, 2016). In the presented study, no statistically significant difference was determined according to the different parameters of the lesion in terms of the number of races, similar to the study about the return rates to races after tendon injury (Caliskan *et al.*, 2020a). As also mentioned in the literature (Witte *et al.*, 2016), these results showed that post-injury performance of the cases with tendon lesions were not satisfactory even if they were able to return to races.

Evaluation of peritendinous changes

Additional information may be obtained by US examination to clearly identify changes in the peritendineum defined during the clinical examination and to decide the proper treatment (Seyrek-Intas *et al.*, 2002; Caliskan *et al.*, 2020a). In the present study, different peritendinous findings such as haemorrhage, fibrosis, congestion, oedema, fibrin accumulation, dermatitis, tendovaginitis and also intertendinous adhesions which forms a hyperechoic double border were determined by ultrasonography.

The race performance of the cases with adhesions were not evaluated statistically due to their small number (n=6) in the present study. However, 3 of these cases did not return to races, and the other 3 cases raced at most 2 races after injury but could not enter the rankings. Although, no statistically significant difference was found between in the cases with and without peritendinous alterations in terms of rates of return to race (Caliskan *et al.*, 2020a), in cases with adhesions detected by ultrasonography, race performance may be adversely affected, as the other researchers have also indicated (Gibson *et al.*, 1997; Watkins, 1999).

When the average race gains were evaluated, the cases with peritendinous alterations gained 66.179.09 TRY (7,144.50 €) while those without peritendinous alterations gained 82.400.48 TRY (8,900.89 €). According to these averages, although not statistically significant, total race earnings were found to be lower in patients with peritendinous changes ($P>0.05$).

The connections that develop between the surrounding structures and the healed tendon, especially short and restrictive adhesions, compromise or completely prevent the gliding function of the tendon

(Watkins, 1999; McIlwraith, 2002). Controlled movement at an early stage prevents the development of such restrictive adhesions and makes it easier for the tendon to regain its gliding function while the tendon is healing (Watkins, 1999; McIlwraith, 2002). In the peritendinous fibrin accumulated cases, higher performance scores after injury should be associated with the fact that these horses had been away from races for at least 10 months during the recovery period and had a more appropriate rehabilitation period after early diagnosis as dedicated in the literature (Watkins, 1999; McIlwraith, 2002).

CONCLUSION

In summary, according to the results of the presented study, although they were more in number, the tendinitis cases raced less ($P=0.004$) and had lower performance scores after injury than the peritendinitis cases ($P=0.0004$). The race performance after injury, and also prognosis, is poor in tendinitis cases compared to peritendinitis cases. Besides, the individual total race earnings were lower in the cases with tendon thickening compared to those without thickening ($P=0.02$).

The presence of a lesion was found to be associated with thickening, and also the heterogeneous appearance of the tendon ($P<0.05$ and $P<0.001$, respectively). It was found that success rate was lower in the cases with tendon lesions than in cases without lesions with regard to race performances after injury ($P=0.006$). However, the evaluations of the different parameters of the lesions should be supported by more comprehensive studies with a higher number of cases because the number of cases with severe lesion and also the total number of cases were relatively low in this study.

The results of this study show that injuries, causing tendon thickening and also tendon echogenicity alterations, had negative effects on race performances after injury. As a result, prophylactic measurements are highly recommended with regard to tendinitis, in the cases with thickening of the tendon and echogenicity changes which can be detected by ultrasound in early stages of tendinitis.

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