Evaluation of horseshoe characteristics and high-speed exercise history as possible risk factors for catastrophic musculoskeletal injury in Thoroughbred racehorses

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Objective—To evaluate horseshoe characteristics and high-speed exercise history as risk factors for catastrophic musculoskeletal injury in Thoroughbred racehorses.

Animals—377 horses (37,529 race starts).

Procedures—Shoe characteristics included material, toe grab height, heel traction device, pads, and rim shoes. Racing variables were obtained from a computerized database. Forty-three horses that had a musculoskeletal injury and then failed to race or train for 6 months (cases) and 334 noninjured horses from the same race in which a horse was injured (controls) were compared regarding risk factors.

Results—Overall, 98% of race starts were associated with aluminum shoes, 85% with toe grabs, 32% with pads, and 12% with rims on forelimb horseshoes. Among 43 horses with musculoskeletal injury, sex (geldings), an extended interval since last race, and reduced exercise during the 30 or 60 days preceding injury were risk factors for catastrophic injury. Odds of injury in racehorses with toe grabs on front shoes were 1.5 times the odds of injury in horses without toe grabs, but this association was not significant (95% confidence interval, 0.5 to 4.1).

Conclusions and Clinical Relevance—Results suggest that horses that return to racing after an extended period of reduced exercise are at high risk of catastrophic musculoskeletal injury. Results regarding the use of toe grabs as a possible risk factor for catastrophic injury were inconclusive because the probability of declaring (in error) that use of toe grabs was associated with an increased risk of musculoskeletal injury (eg, odds ratio > 1.0) was 38%. (*Am J Vet Res* 2005;66:1314–1320)

Catastrophic musculoskeletal injuries in Thoroughbred racehorses, although infrequent, may lead to the decision to euthanatize them for medical or economic reasons.[1] In previous studies, the overall reported incidence rate of catastrophic musculoskeletal injury per 1,000 race starts was 1.2 in Florida,[2] 1.4 in Kentucky,[3] and 1.7 in California.[1,4] However, a cluster of catastrophic musculoskeletal injuries over a short period can raise questions about the safety of training and racing conditions. Several epidemiologic studies have been conducted to identify risk factors that predispose horses to such injuries. In New York, racing surface, total number of starts, season, number of seasons raced, and age of the horse were significantly associated with risk of musculoskeletal injury in Thoroughbreds.[5] In California, the incidence of catastrophic musculoskeletal injuries was associated with sex and age of the horse,[1,4] use of toe grabs,[6] and racing history during the 6 months preceding injury.[7,8] In Kentucky, Thoroughbreds found during a prerace veterinary inspection to have a preexisting pathologic condition (eg, injury of the suspensory apparatus or the tendon of the superficial digital flexor muscle of the forelimb) were at higher risk of musculoskeletal injury[9,10]; race class and race length[10] as well as high Beyer's numbers and decreased exercise during the month preceding injury[11] were also significantly associated with risk of injury. In Florida, sex, number of days since last race, and racing surface were identified as risk factors for catastrophic musculoskeletal injury in Thoroughbreds.[2]

A previous study[2] conducted in Florida revealed that horses with ≥ 33 days since their last race were 2.5 times as likely to have a catastrophic musculoskeletal injury during racing as were horses with ≤ 13 days since their last race. This result supports the hypothesis that horses with a preexisting injury are more likely to have periods of reduced activity, have an extended interval between races, and be at higher risk for bone fracture.[12,13] However, a limitation of that study in Florida[2] was that information concerning high-speed exercise histories of study horses was not available.

The finding in a California study[6] that suggested that the use of toe grabs increased the risk of catastrophic musculoskeletal injury drew considerable attention in Florida's Thoroughbred industry. If the association between toe grabs and catastrophic musculoskeletal injury is causal, discontinuing the use of toe grabs would decrease the incidence of such injuries in Thoroughbreds. Further studies of the relationship between shoe characteristics and musculoskeletal injury may support the hypothesis that such association is causal. The objective of the study reported here was to examine the relationship between selected shoe

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characteristics and high-speed exercise history as possible risk factors for catastrophic musculoskeletal injury in Thoroughbred racehorses at 2 racetracks in Florida.

Materials and Methods

Horses—There are 4 Thoroughbred racetracks in Florida. Study horses were selected from 2 racetracks because racetrack administrators were interested and willing to participate in the study. Racing calendars were from May to January and January to March. At each racetrack, most race-day programs included dirt (80% to 90% of each race-day's races) and turf races (10% to 20%).

Horseshoe survey—From 1999 to 2001, shoe data were collected from every horse in each race at 2 racetracks by a track veterinary assistant (with ≥ 30 years of professional experience working as a farrier on Thoroughbred racehorses). Front and rear left feet of each horse were examined by the same track veterinary assistant during the routine inspection carried out by a judge in the paddock enclosure before the race. Shoe characteristics that were evaluated in this study included material (aluminum or steel), toe grab type (steel bar affixed to the ground surface of the shoe; none, very low [≤ 2 mm], low [> 2 and ≤ 4 mm], regular [> 4 and ≤ 6 mm], or high (> 6 and ≤ 8 mm]), presence of a heel traction device (bar [shoes not open at the heel], bends [edges of shoe are rounded and distinct], stickers, block heels, other, or none), presence of pads (full, rim, none), and rim shoes (yes or no). Two types of shoes[a,b] were classified as having very low toe grabs. Quarter Horse toe grabs were classified as high toe grabs. The horse name, age, and sex (female, colt, or gelding) were gathered from the race-day official program. The sensitivity and specificity of the observer's (veterinary assistant) ability to identify horseshoe characteristics were not determined.

Selection of cases and controls—The definition of a case was any horse that was observed by the official racetrack veterinarian to be lame on the racetrack during or immediately following a race and was recorded in the racetrack veterinarian's report as having a musculoskeletal injury (determined by physical examination) and that then failed to race or train for 6 months. Injury confirmation and specific diagnoses were supplied by attending veterinarians at the request of the racetrack veterinarian. Horses with injuries that did not involve musculoskeletal structures or horses that incurred an accident were excluded. Forty-three cases were included in the study. All noninjured horses from the same race in which a horse was injured served as controls (n = 334). History of previous injury in case and control horses was not known.

High-speed exercise data—Number of lifetime race starts, number of days since last race, and cumulative number of furlongs raced or trained during the 30 and 60 days preceding injury among cases and controls were obtained from a computerized commercial racehorse database.[c] To compare exercise histories among cases and controls, the date of injury (last race) for each case horse was considered the date of the last race for the race-matched control horse. Officially timed workouts represent clocked exercise sessions at or near racing speeds. An exercise history (officially recognized) at racing speed was reconstructed for each horse. Workouts were combined sequentially in time with races to calculate the number of furlongs during the 30 and 60 days preceding injury (8 furlongs = 1 mile). Any reference to exercise events and distances refers only to racing and officially timed workouts and does not include daily training sessions or unofficially timed workouts.

Statistical analyses—Conditional logistic regression[14] was used to model the odds of being a case horse as a function of shoe characteristics and high-speed exercise history evaluated in the study. Initial screening of potential risk factors for musculoskeletal injury was performed by use of univariable conditional logistic regression (age, sex, and shoe characteristics) or the Wilcoxon rank sum test (high-speed exercise variables). Continuous variables (age, total number of lifetime race starts, days since last race, and cumulative number of furlongs in the

Table 1—Frequency distribution of horseshoe variables in 37,529 race starts in Thoroughbred racehorses.

Variable	Forelimb (%)	Hind limb (%)
Material		
None	< 0.1	0.1
Aluminum	98.4	99.7
Steel	< 0.1	< 0.1
Rubber	0.1	< 0.1
Toe grab		
None	15.0	9.8
Very low	39.9	15.5
Low	32.8	28.4
Regular	12.0	46.0
High	< 0.1	0.1
Rims present		
Yes	11.9	8.6
No	87.9	91.3
Heel traction device		
None	98.7	83.4
Bar	0.6	< 0.1
Bends	0.1	8.0
Stickers	< 0.1	0.3
Block heels	0.1	7.9
Other	0.4	0.1
Pads		
None	68.0	99.7
Full	0.2	< 0.1
Rim	31.6	0.1

Table 2—Site of primary injury in 43 Thoroughbred racehorses (cases) that incurred a catastrophic musculoskeletal injury during racing at 2 racetracks in Florida from 1999 to 2001.

Injury site	No. of horses
Condyles of the femur (medial, lateral)	2
Third metacarpal	3
Carpus	4
Humerus	1
P1, P2	3
Fetlock	1
Femur	1
Tibia	1
Ilium	1
Third metatarsal	2
Multiple injuries	
Sesamoid, P1	1
Sesamoid, condyle	1
Sesamoid, condyle, P1	1
Sesamoid, third metacarpal	1
Sesamoid, fetlock	4
Sesamoid, fetlock, condyle	3
Sesamoid, fetlock, condyle, third metacarpal	1
Sesamoid, fetlock, third metacarpal	1
Sesamoid, fetlock, third metacarpal, P1	1
Both sesamoids	2
Both sesamoids, fetlock	8
Total	**43**

P1 = First phalanx. P2 = Second phalanx. Fetlock = Metacarpophalangeal joint.

30 and 60 days preceding injury) were categorized into 2 groups on the basis of their frequency distribution (median). A univariable level of significance of $P \leq 0.20$ was required for a potential risk factor to be entered in a starting model. A model with a hierarchical structure was specified by adding terms for biologically plausible interactions between independent variables. Variables for age and sex were included as required variables in the final model because results from previous studies[1,2,4] indicate that they are associated with risk of musculoskeletal injury; presence of toe grabs on front shoes was also included as a required variable because it was a specific exposure factor of interest in the study. A backward model selection procedure was used in a sequential fashion, starting with a full model. The level of significance was $P \leq 0.10$ for the Wald test statistic of each model parameter in the reduction process. In the final models, adjusted **odds ratios (ORs)** and their 95% **confidence intervals (CIs)** were reported. In this study, the OR was used as an epidemiologic measure of association between a factor (eg, toe grab) and risk of musculoskeletal injury. Thus, if a particular factor was not associated with risk of musculoskeletal injury, the OR was 1. The greater the departure of the OR from 1 (either larger or smaller), the stronger the association was between the factor and risk of musculoskeletal injury. The upper and lower limits of a 95% CI indicate that one can be 95% confident in the assertion that the true OR falls within this interval. If the interval is broad, its precision is low.

Results

Horseshoe survey—During 1999 to 2001, shoe variable data were collected from 37,529 race starts. Overall, 98% of all race starts were made while horses wore aluminum shoes, 85% of race starts were made with toe grabs, 32% were made with pads, and 12% were made with rims on the forelimb horseshoe **(Table 1)**.

Musculoskeletal injures—Forty-three horses with catastrophic musculoskeletal injury during racing were identified from 1999 through 2001 at the 2 racetracks. Multiple-site injuries involving the forelimb sesamoid bones and another anatomic location were most commonly involved (23 [54%] horses; **Table 2**).

Table 3—Frequency distribution of host factors (age and sex), shoe characteristics, and crude odds ratio (OR) and 95% confidence interval (CI) of investigated exposure factors among 43 Thoroughbred racehorses with musculoskeletal injury and 334 noninjured racehorses.

Variable	Cases (%)	Controls (%)	OR	95% CI	*P* value
Age (y)					
2–3	24 (56)	192 (57)	1.00	Reference	NA
4–9	19 (44)	142 (43)	2.00	0.23–17.02	0.52
Sex					
Female	15 (37)	150 (45)	1.00	Reference	NA
Colt	16 (35)	133 (40)	ND	ND	ND
Gelding	12 (28)	51 (15)	4.56	1.35–15.39	0.01
Front toe grab					
None	6 (14)	60 (18)	1.00	Reference	NA
Very low	20 (47)	118 (35)	1.92	0.65–5.66	0.23
Low	9 (21)	110 (33)	0.79	0.26–2.41	0.69
Regular	8 (18)	45 (14)	1.78	0.51–6.22	0.36
High	0 (0)	1 (0.3)	ND	ND	ND
Front rim					
No	39 (91)	283 (85)	1.00	Reference	NA
Yes	4 (9)	50 (15)	0.58	0.19–1.74	0.33
Front heel traction device					
None	43 (100)	328 (99)	1.00	Reference	NA
Bar	0 (0)	2 (0.6)	ND	ND	ND
Bends	0 (0)	1 (0.3)	ND	ND	ND
Stickers	0 (0)	0 (0)	ND	ND	ND
Block heels	0 (0)	0 (0)	ND	ND	ND
Other	0 (0)	1 (0.3)	ND	ND	ND
Front pads					
None	32 (74)	222 (67)	1.00	Reference	NA
Full	0 (0)	0 (0)	ND	ND	ND
Rim	11 (26)	111 (33)	0.80	0.55–1.16	0.24
Hind toe grab					
None	6 (14)	47 (14)	1.00	Reference	NA
Very low	7 (16)	62 (19)	0.81	0.17–3.74	0.79
Low	7 (16)	82 (25)	0.62	0.18–2.07	0.44
Regular	23 (54)	142 (43)	1.22	0.41–3.63	0.71
High	0 (0)	1 (0.3)	ND	ND	ND
Hind rim					
No	38 (88)	293 (88)	1.00	Reference	NA
Yes	5 (12)	40 (12)	1.03	0.36–2.97	0.94
Hind heel traction device					
None	37 (86)	283 (85)	1.00	Reference	NA
Bar	0 (0)	0 (0)	ND	ND	ND
Bends	4 (9)	19 (6)	ND	ND	ND
Stickers	0 (0)	0 (0)	ND	ND	ND
Block heels	2 (5)	31 (9)	ND	ND	ND
Other	0 (0)	0 (0)	ND	ND	ND
Hind pads					
None	43 (100)	333 (100)	1.00	Reference	NA
Full	0 (0)	0 (0)	ND	ND	ND
Rim	0 (0)	0 (0)	ND	ND	ND

NA = Not applicable. ND = Not determined.

Risk of musculoskeletal injury—In the univariable analysis, shoe characteristics were not significantly associated with risk of musculoskeletal injury ($P \geq 0.23$; **Table 3**). Median number of cumulative high-speed furlongs during the 30 ($P = 0.01$) and 60 ($P = 0.03$) days preceding injury was significantly lower in case horses than in control horses (**Table 4**). Median total number of races was significantly ($P = 0.01$) higher for geldings (26 races) than for females (7 races) or colts (9 races), and median age of geldings (4 years) was significantly ($P = 0.01$) higher than that of females or colts (3 years; **Table 5**).

In the multivariable analysis, the final model included terms for age, sex, front toe grab, number of days since last race, and cumulative number of furlongs during the 30 (**Table 6**) and 60 days (**Table 7**) preceding injury. Addition of 2-way interaction terms did not contribute to the final models for risk of musculoskeletal injury, and these terms were removed from the models. Geldings, horses with an extended interval since their last race, and horses with reduced exercise during the 30 or 60 days preceding injury had higher odds of having a musculoskeletal injury. The 95% CI for the OR of toe grab height (none vs very low, low, or regular) included 1.0 (Tables 6 and 7).

Table 4—High-speed exercise variables among 43 Thoroughbred racehorses (cases) with catastrophic musculoskeletal injury and 334 noninjured racehorses (controls).

Variable	Cases	Controls	*P* value
Total No. of lifetime race starts	8 (4–14)	9 (5–22)	0.22
No. of days since last race	23 (15–33)	20 (13–32)	0.19
Cumulative No. of furlongs during the 30 days preceding injury	16 (12–20)	19 (15–24)	< 0.01
Cumulative No. of furlongs during the 60 days preceding injury	29 (24–35)	32 (25–41)	0.03

Data reported as median (first and third quartiles).

Table 5—Comparison of age and number of lifetime race starts among females, colts, and geldings.

Variable	Females (n = 165)	Colts (149)	Geldings (63)
Age (y)	3 (3–4)[a]	3 (3–4)[a]	4 (4–6)[b]
No. of lifetime race starts	7 (4–14)[a]	9 (5–21)[a]	26 (1–39)[b]

Data reported as median (first and third quartiles).
[a,b]Within each row, different superscript letters indicate significant ($P < 0.05$) differences among groups.

Table 6—Multivariable conditional logistic regression models for risk of catastrophic musculoskeletal injury among Thoroughbred racehorses (includes data for cumulative number of furlongs during 30 days preceding injury).

	Model 1*			Model 2*		
Variable	OR	95% CI	*P* value	OR	95% CI	*P* value
Age (y)						
2–3	1.00	Reference	NA	1.00	Reference	NA
4–9	1.42	0.18–11.16	0.73	1.55	0.20–11.82	0.67
Sex						
Female or colt	1.00	Reference	NA	1.00	Reference	NA
Gelding	5.40	1.45–20.06	0.01	4.85	1.33–17.62	0.01
Front toe grab						
None	1.00	Reference	NA	ND	ND	ND
Very low	2.93	0.92–9.27	0.06	ND	ND	ND
Low	0.93	0.30–2.91	0.91	ND	ND	ND
Regular	1.63	0.44–5.98	0.45	ND	ND	ND
Front toe grab						
None	ND	ND	ND	1.00	Reference	NA
Very low, low, regular	ND	ND	ND	1.54	0.58–4.12	0.38
No. of days since last race						
0–21	1.00	Reference	NA	1.00	Reference	NA
22–426	1.90	0.90–4.02	0.08	1.98	0.93–4.22	0.07
Cumulative No. of furlongs during 30 days preceding injury						
20–37	1.00	Reference	NA	1.00	Reference	NA
6–19	2.78	1.23–6.27	0.01	2.59	1.16–5.79	0.01

*For model 1, toe grab exposure includes 4 categories: none, very low, low, and regular. For model 2, toe grab exposure includes 2 categories: none versus very low, low, and regular.
See Table 3 for remainder of key.

Table 7—Multivariable conditional logistic regression models for risk of catastrophic musculoskeletal injury among Thoroughbred racehorses (includes data for cumulative number of furlongs during 60 days preceding injury).

	Model 3*			Model 4*		
Variable	**OR**	**95% CI**	***P* value**	**OR**	**95% CI**	***P* value**
Age (y)						
2–3	1.00	Reference	NA	1.00	Reference	NA
4–9	1.45	0.18–11.35	0.71	1.55	0.19–12.14	0.67
Sex						
Female or colt	1.00	Reference	NA	1.00	Reference	NA
Gelding	6.15	1.65–22.92	< 0.01	5.44	1.51–19.59	< 0.01
Front toe grab						
None	1.00	Reference	NA	ND	ND	ND
Very low	2.65	0.81–8.63	0.10	ND	ND	ND
Low	1.07	0.33–3.44	0.90	ND	ND	ND
Regular	1.52	0.39–5.98	0.54	ND	ND	ND
Front toe grab						
None	ND	ND	ND	1.00	Reference	NA
Very low, low, regular	ND	ND	ND	1.60	0.57–4.49	0.36
No. of days since last race						
0–21	1.00	Reference	NA	1.00	Reference	NA
22–426	2.27	1.04–4.96	0.03	2.39	1.09–5.27	0.02
Cumulative No. of furlongs during 60 days preceding injury						
33–62	1.00	Reference	NA	1.00	Reference	NA
8–32	1.91	0.87–4.18	0.10	1.90	0.87–4.12	0.10

*For model 3, toe grab exposure includes 4 categories: none, very low, low, and regular. For model 4, toe grab exposure includes 2 categories: none versus very low, low, and regular.
See Table 3 for remainder of key.

Discussion

In present study, case and control horses were matched on the basis of race because of potential differences between racetrack design and maintenance, track surface condition, season, race purse and distance, age, and sex of the horse. Selection of cases was limited to horses that appeared lame on the racetrack during or immediately following a race (or horses excused for lameness from the detention barn by the state veterinarian) and that were recorded in the racetrack veterinarian's report as having a musculoskeletal injury and then failed to race or train for 6 months. Thus, it is possible that more horses than those included in this study may have had musculoskeletal injuries, but their identification was difficult because the official racetrack veterinarian only follows up horses identified as lame; attending veterinarians are not required to provide full disclosure of all injured horses. Another limitation in our study was exposure misclassification (eg, presence or absence of toe grab or toe grab height). Identification of horseshoe characteristics was conducted on every study horse by a track veterinary assistant. However, the accuracy of the observer's ability to correctly identify horseshoe characteristics was not assessed. Thus, it is difficult to determine the magnitude of exposure misclassification potentially present in this study. Overall, results of this study indicate that geldings, horses with an extended interval since their last race, and horses with reduced exercise during the 30 or 60 days preceding injury were associated with an increased risk of musculoskeletal injury.

In this study, the odds of catastrophic musculoskeletal injury in racehorses shod with toe grabs on front shoes were 1.5 times the odds in horses without toe grabs, after controlling for age, sex, number of days since last race, and cumulative number of furlongs at high speed during the 30 days preceding injury, but this association was not significant (95% CI, 0.5 to 4.1; *P* = 0.38). The hypothesis that use of toe grabs is a risk factor for catastrophic musculoskeletal injury has been tested in 2 previous studies[6,15] conducted in California. In the first study[6] conducted in California, the odds of catastrophic musculoskeletal injury in horses shod with low and regular toe grabs on front shoes were 1.8 (95% CI, 0.6 to 4.7) and 3.5 (95% CI, 1.2 to 10.3) times, respectively, the odds in horses without toe grabs. Although age and sex were controlled in that study,[6] track, track surface condition, race purse and distance, season, and high-speed exercise history were not. It is possible that some of the risk attributed to toe grabs in that study may have been caused by other factors associated with toe grabs, such as high-speed exercise history, track, and race-related factors.[15,16] In addition, selection of control horses in that study[6] was limited to 46 horses that had died or were euthanatized at California racetracks. Therefore, the results of that study[6] may be applicable only to horses that died at racetracks and not to the entire racehorse population in California.[16] In the present study, the distribution of front toe grab height was similar among 334 control horses (none, 18%; very low, 35%; low, 33%; and regular, 14%) and the shoes worn during the 37,529 race starts surveyed at the 2 Florida racetracks (none, 15%; very low, 40%; low, 33%; and regular, 12%). Although the survey data most likely included multiple observations per horse, we believe that the distribution of toe grab height among control horses was a good approximation of that in the horse population at the 2 Florida racetracks. Initial assessment of toe grab height did not reveal a significant linear association with risk of injury (model 1). Thus, toe grab height was categorized as none versus very low, low, and regular height to simplify interpretation of the OR (model 2). In the second study[15] conducted in California, although a significant association was not found, the odds of subclinical to mild suspensory apparatus injury in horses either racing or in race training that were shod with toe grabs on front shoes were 2.8 (95% CI, 0.6 to 13.0) times the odds in horses without toe grabs, after controlling for age and accumulated high-speed distance during the week preceding injury. In that study, 5 control horses (without a diagnosis of suspensory apparatus injury by the date of injury of each injured horse) were randomly selected for each case horse.[15] Mild injuries have the potential to develop into severe or catastrophic injuries.[15] Thus, it is possible that some horses with subclinical to mild suspensory apparatus injury in that study[15] may have been misclassified as uninjured; horses misclassified this way contributed to the population of control horses and may have biased the estimated OR toward the null (OR, 1.0). Results of the present study conducted in Florida were inconclusive because the probability of declaring (in error) that use of toe grabs was associated with an increased risk of musculoskeletal injury (eg, odds ratio > 1.0) was 38%.

Consistent with findings from studies in Florida[2] and California,[1,4] geldings had an increased risk of musculoskeletal injury (OR, 4.9; 95% CI, 1.3 to 17.6), compared with females or colts. Initial assessment of sex revealed that in races in which a colt was injured, all horses in that race were colts. Consequently, horses were grouped as females or colts versus geldings to simplify interpretation of the OR. Females and colts are more likely to race less frequently or to be retired from racing sooner than geldings because of their potential for breeding or sale purposes; for example, in this study, median total number of races was significantly higher for geldings (26 races) than for females (7 races) or colts (9 races), and median age of geldings (4 years) was significantly greater than that of females or colts (3 years). In a previous study[2] conducted in Florida, the total number of races was significantly higher for geldings (17 races) than for females (10 races) or colts (9 races). In addition, age of geldings (4 years) was significantly greater than that of females or colts (3 years).[2]

In this study, the odds of catastrophic musculoskeletal injury in racehorses with ≥ 22 days since their last race were 1.9 times the odds in horses with < 22 days since their last race, but this association was not significant (95% CI, 0.9 to 4.2; *P* = 0.07). Sample size was small, which may have been a factor regarding the lack of significance of this finding. This result was similar to that of a previous study[2] conducted in Florida in which the odds of catastrophic musculoskeletal injury in horses with 21 to 32 and ≥ 33 days since their last race were 1.6 (95% CI, 0.8 to 3.5) and 2.5 (95% CI, 1.2 to 5.1) times, respectively, the odds in horses with ≤ 14 days since their last race. Although age, sex, track, and track surface were controlled in the previous study,[2] high-speed exercise history was not. Horses with a preexisting injury are more likely to have periods of reduced activity, have an extended interval between races, and be at a higher risk for bone fracture.[12,13] It has been hypothesized that horses that return to training or racing after an extended period of reduced exercise may have insufficient bone mass to prevent microdamage caused by exercise and develop stress fractures as a result of continued repetitive loading.[13] Results of several studies support this hypothesis. Osteoporosis was considered a major factor in the pathogenesis of proximal sesamoid bone fractures that occurred following cast removal in a 2-year-old Thoroughbred filly and a 4-year-old Quarter Horse mare in which the affected hind limbs had been immobilized for 32 and 39 days for treatment of a large granulating wound and a degloving laceration, respectively.[17] In a study[12] of 5 horses that had a fracture of the humerus during racing, the mean interval between races (27 days) was shorter than the interval between the last successfully completed race and the race during which the fracture occurred (169 days). Horses that return to training after a lay-up of ≥ 2 months are at risk for humeral fracture.[13] Injuries of the superficial digital flexor tendon have been related to an interval of > 60 days between the race in which the horse was injured and the previous race among Thoroughbreds in Kentucky.[9] Horses with a preexisting injury typically are more likely to have extended periods without racing.

In this study, horses with ≤ 19 cumulative furlongs during the 30 days preceding injury had increased risk of musculoskeletal injury (OR, 2.5; 95% CI, 1.1 to 5.7). In addition, regarding the relationship between the cumulative number of furlongs during the last 60 days preceding injury, the results were consistent with a previous finding[11] in which decreased exercise was a risk factor for catastrophic musculoskeletal injury. Injured horses had significantly less cumulative high-speed exercise distance than did control horses during the month preceding injury; a difference of 10 furlongs was associated with an approximately 2-fold greater risk of musculoskeletal injury during racing.[11] One explanation for the observed association between decreased exercise and risk of injury is that horses with preexisting injury are more likely to have periods of reduced activity, have an extended interval between races, and have higher risk for bone fracture.[12,13] However, findings of the present study and the study[11] conducted in Kentucky are not consistent with those of 3 previous studies[7,8,15] in California. In 1 study,[7] the risk of catastrophic musculoskeletal injury was 3 times as great in horses that ran 2-month cumulative racing and timed-workout distances in excess of the expected median distance (the expected median cumulative distance for 3-year-old horses for any 2-month period is 40 furlongs). In a second study,[8] horses that had accumulated 35 furlongs of race and timed-workout distance in 2 months, compared with horses with 25 furlongs, had an estimated 3.9-times increase in risk for catastrophic musculoskeletal injury. Results from the first 2 studies[7,8] in California support the hypothesis that many racehorse injuries are the result of long-term insidious skeletal and soft tissue damage that results from repeated loads during high-speed exercise.[18,19] Living tissues can repair damage, but the rate of repair is probably limited.[8] It is possible that exercise-related damage accumulated at a rate exceeding that of damage repair.[8,12,19] In the third study[15] conducted in California, the association between greater distance the week preceding injury and risk of subclinical to mild suspensory apparatus failure was not significant (OR, 2.0; 95% CI, 0.6 to 6.4), after controlling for age and use of toe grabs. Regional differences in racing surfaces, equine populations, racing and training customs, timed-workout record keeping, and time of exposure (7-day vs 30-day period for cumulative distance) were recognized as possible explanations for discrepancies found in the previous studies conducted in Kentucky[11] and California.[7,8,15] Specific differences between the third study[15] conducted in California and the present study include the time of exposure (7-day vs 30- and 60-day period) and injury outcomes (subclinical to mild suspensory apparatus failure during training or racing vs catastrophic injury during racing). Finally, in the present study, a high number of days since last race and a low cumulative number of furlongs during the 30 or 60 days preceding injury fit separately into the statistical model. It is possible that days since last race and cumulative number of furlongs during the 30 or 60 days preceding injury interact with each other to affect the risk of injury, but sample size was too low in the present study to adequately assess such an interaction. That is, horses with a preexisting injury have an extended interval between their last 2 races, they accumulate less high-speed distance during the 30 or 60 days preceding injury, and they are at high risk for bone fracture[12,13] because they may have insufficient bone mass to prevent microdamage with exercise. More knowledge on training patterns that cause horses with a preexisting injury to have periods of reduced activity, an extended interval between races, and higher risk for musculoskeletal injury is needed to assist trainers and horse owners in preventing catastrophic musculoskeletal injuries in Thoroughbred racehorses.

a. Queens Plate XT, Thoro'Bred Inc, Anaheim, Calif.
b. Queens XLT, The Victory Racing Plate Co, Baltimore, Md.
c. The Jockey Club Information Systems, Lexington, Ky.

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