Race-start characteristics and risk of catastrophic musculoskeletal injury in Thoroughbred racehorses

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Objective—To identify race-start characteristics associated with catastrophic musculoskeletal (MS) injury in Thoroughbred racehorses at 2 racetracks in Florida during 1995 through 1998.

Design—Matched case-control study.

Animals—97 Thoroughbreds (case horses) that incurred a catastrophic MS injury during racing and 388 Thoroughbreds (control horses) randomly selected from noninjured participants and matched on the basis of racetrack and year.

Procedure—Incidence of MS injury was calculated for all race meets at 2 racetracks in Florida from 1995 through 1998. Race-start characteristics were compared among case and control horses, using conditional logistic regression.

Results—Overall incidence of MS injury was 1.2/1,000 race starts (97/79,416 starts). Incidence of injury was significantly higher for turf races (2.3/1,000 starts) than for dirt races (0.9/1,000 starts). Sex, number of days since last race, and racing surface were associated with risk of injury; geldings, ≥ 33 days since the last race, and turf racing surface were associated with a higher risk of injury.

Conclusions and Clinical Relevance—Incidence of injury among Thoroughbreds in Florida was associated with sex, number of days since last race, and racing surface. Days since last race may have been an indicator of previous health and lameness problems. Racing surface may have been a risk factor for MS injury because turf races tended to be more competitive than dirt races. Horses running in turf races were more likely to participate in races with a large field, handicap races, long races, and races with high purses. (*J Am Vet Med Assoc* 2001;218:83–86)

A high incidence of breakdowns, or **musculoskeletal (MS)** injuries, in racehorses over a short period can raise questions about the safety of training and racing conditions. Several epidemiologic studies have identified risk factors associated with MS injury in Thoroughbred racehorses. In 1 study,[1] racetrack, racing surface, total number of starts, season, number of seasons raced, and age of the horse were significantly associated with risk of MS injury in Thoroughbreds in New York. Barrier position, type of race, and change in distance from previous race were associated with MS injury in Thoroughbreds in Australia.[2] In California, the incidence of catastrophic MS injury has been associated with sex and age of the horse,[3,4] racetrack,[4] horseshoe characteristics,[5] and racing history during the 6 months preceding injury,[6,7] but not with race length or racing surface.[4] In Kentucky, Thoroughbreds found to have a preexisting pathologic condition (eg, injury of the suspensory apparatus or tendon of the superficial digital flexor muscle of the forelimb) during a prerace veterinary inspection were at higher risk of MS injury[8,9]; racetrack, class of race, and race length were also significantly associated with risk of injury.[9]

Risk factors associated with MS injury among Thoroughbreds in Florida have not been investigated. An understanding of the factors influencing risk of injury will aid racetrack administrators, horse owners, trainers, and racetrack veterinarians in making management decisions to help mitigate this risk. The purpose of the study reported here was to identify race-start characteristics associated with catastrophic MS injury in Thoroughbred racehorses at 2 racetracks in Florida from 1995 through 1998.

Materials and Methods

Study population—There are 4 Thoroughbred racetracks in Florida. Study horses were selected from 2 racetracks because veterinary records were available and racetrack administrators were 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 (10 to 20%) races. Some horses had the opportunity to run at both racetracks during the study period.

Selection of cases—Case horses were selected by examining necropsy records kept by the racetrack veterinarian and included all horses reported to have sustained catastrophic MS injuries at the 2 racetracks from 1995 through 1998. Records for 109 horses that died or were euthanatized within 30 days after a race because of a MS injury sustained during racing were examined and considered for inclusion in the study. Horses that had injuries that did not involve MS structures (exercise-induced pulmonary hemorrhage [n = 10]) or in which MS injuries were the result of an accident (jumped turf rail [2], fracture of third tarsal bone while in the gate [1], flipped in paddock [1]) were excluded from the study. Postmortem examinations were performed by 1 of the authors (MCS) at the racetrack and included evaluation of soft tissue and skeletal structures of injured and contralateral limbs. Ninety-seven case horses were included in the study.

Selection of controls—Four control horses were matched to each case horse by randomly selecting from non-

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injured participants racing at the same racetrack during the same year (but not necessarily on the same racing surface) as the case horse. Within each racetrack and year, all noninjured horses were numbered sequentially, and control horses were identified by random numbers, using computer software.[a] Three hundred eighty-eight control horses were included in the study.

Data collection—For each horse, data of epidemiologic interest were obtained from the official race-day program for the racetrack and from a computerized commercial racehorse database.[b] Data collected included sex (female, colt, gelding), age (years), weight carried (pounds), number of days since last race, total number of races and total number of races during the last year, type of race (maiden, allowance, claim, handicap), gate position, season (winter, spring, summer, fall), race length (number of furlongs), field size (number of horses), racing surface (dirt, turf), dirt surface condition (fast, sloppy, good), and turf surface condition (firm, good, yielding).

Statistical analyses—Incidence of MS injury was calculated for all race-meets at the 2 racetracks from 1995 through 1998. Conditional logistic regression[10] was used to model the odds of being a case horse as a function of race-start characteristics evaluated in the study. Initial screening of potential risk factors for MS injury was performed by use of univariable conditional logistic regression. Continuous variables (age, weight carried, number of days since last race, total number of races, total number of races during the last year, race length, and field size) were categorized into 4 groups on the basis of their frequency distribution (quartiles). Adjacent categories of variables with more than 2 categories were collapsed whenever it was biologically feasible and when they had similar stratum-specific odds for MS injury (eg, age). In the multivariable analysis, a first model was used to estimate the effect of sex and age on the risk of MS injury. Sex, age, and the 2-way interactions among the main effects were considered for inclusion in the model. A second model was used to explore and identify potential risk factors associated with MS injury. The level of significance required for potential risk factors to enter a starting model was $P \leq 0.15$. A model with a hierarchical structure was specified by adding terms for biologically plausible interactions between independent variables. Variables for sex, age, and racing surface were forced into the model. A backward model selection procedure was used in a sequential fashion, starting with a full model. The level of significance was $P \leq 0.05$ for the Wald test statistic of each model parameter in the reduction process. Goodness-of-fit was assessed graphically by plotting the diagnostic statistics (standardized delta-betas) versus observation number. Case-control sets that appeared to have horses with extreme values during visual examination of these plots were excluded from the analysis to evaluate their influence on estimated **odds ratios (OR)**. In the final model, adjusted OR and 95% **confidence intervals (CI)** were reported. In this study, the OR was used as an epidemiologic measure of association between a factor (eg, sex) and risk of MS injury. Thus, if a particular factor was not associated with risk of MS 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 MS 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, the precision is low.

Because racing surface is a possible confounder for investigations of the relation between race-start characteristics and risk of MS injury in racehorses, associations between racing surface and field size, type of race, race length, season, sex, and age were evaluated by use of univariable logistic regression. In addition, median race purses were compared between races run on dirt and races run on turf, using the Mann-Whitney *U* test. The level of significance was set at $P \leq 0.05$.

Results

Incidence of MS injury—A total of 97 horses with catastrophic MS injuries during racing were identified by examining necropsy records from 1995 through 1998 for the 2 racetracks (**Table 1**). The forelimb sesamoid bones were most commonly involved (20 horses; 21%). The overall incidence of MS injury was 1.2/1,000 race starts (97/79,416 starts). The incidence of injury was significantly different between racetracks (1.0 vs 1.6/1,000 starts) and significantly higher for turf races (2.3/1,000 starts), compared with dirt races (0.9/1,000 starts). For both racetracks, incidence of injury was significantly higher for turf races (2.1 and 2.8/1,000 starts), compared with dirt races (0.8 and 1.3/1,000 starts, respectively).

Association of race-start characteristics and racing surface—Field size, type of race, and race length were significantly associated with racing surface. Compared with dirt races, turf races were 5 times as likely to be a large field of horses (9 to 13 horses), 7

Table 1—Frequency and distribution of race-start characteristics among Thoroughbred racehorses that suffered a catastrophic musculoskeletal (MS) injury at 2 racetracks in Florida from 1995 through 1998 (case horses) and among matched noninjured participants (control horses)

Variable	Case horses (n = 97)	Control horses (n = 388)
Categorical variables		
Sex		
Female	30	41
Colt	36	33
Gelding	34	26
Type of race		
Maiden	21	33
Allowance	25	25
Claiming	44	36
Handicap	10	6
Gate position		
1 to 4	43	50
5 to 13	57	50
Season		
Winter	42	42
Spring	8	10
Summer	12	24
Fall	37	24
Racing surface		
Dirt	68	83
Turf	32	17
Dirt surface condition		
Fast	90	78
Sloppy	9	14
Good	1	8
Turf surface condition		
Firm	87	79
Good	13	18
Yielding	0	1
Soft	0	1
Continuous variables		
Age (y)	3.8 (3.0 [2–10])	3.6 (3.0 [2–8])
Weight carried (lb)	117.4 (117.0 [110–122])	116.8 (117.0 [107–122])
No. of days since last race	41.3 (22.5 [4–438])	34.2 (20.0 [5–477])
Total No. of races	16.3 (12.0 [1–83])	15.9 (11.0 [1–79])
Total No. of races in past year	9.5 (9.0 [1–25])	9.3 (9.0 [1–30])
Race length (furlongs)	7.6 (8.0 [5–12])	7.2 (7.0 [4.5–12])
Field size (No. of horses)	9.2 (9.0 [5–12])	8.7 (8.0 [4–13])

Values for categorical variables are percentages; values for continuous variables are mean (median [range]).

times as likely to be a handicap race, and 66 times as likely to be a long race (8 to 12 furlongs). Median purse value was significantly higher for turf races ($23,000) than for dirt races ($13,000).

Risk of MS injury—In univariable analyses, factors identified ($P \leq 0.15$) as being associated with risk of MS injury included sex (geldings were at a higher risk), number of days since last race (horses that had last raced ≥ 33 days previously were at higher risk), type of race (horses in claiming and handicap races were at higher risk), race length (horse in races that were 9 to 12 furlongs were at higher risk), field size (horses in races with 9 to 13 horses were at higher risk), and track surface (horses in turf races were at higher risk). In the multivariable analysis, risk of MS injury among geldings was 1.7 times the risk among females when controlling for age only; however, this difference was not significant. In addition, interaction terms between sex and age categories were not significant. The final model included terms for sex, age, days since last race, and racing surface (**Table 2**). Addition of 2-way interaction terms did not contribute to the final model for risk of MS injury, and these terms were removed from the model. Geldings, horses with ≥ 33 days since their last race, and horses running on turf were at higher risk of MS injury. None of the individual case-control sets had a large influence on the delta-beta estimate. The case horse for the case-control set with the largest delta-beta estimate (racing surface) was a 4-year-old colt with a history of 20 races and 4 days since its last race. When this case-control set was removed and the model was refit to the remaining sets, the model parameters (adjusted OR) changed < 10%.

Discussion

The present study was conducted to identify race-start characteristics associated with the risk of catastrophic MS injury among Thoroughbred racehorses in Florida. Case and control horses were matched on the basis of racetrack and year of injury for the case horse because of potential differences between racetracks (eg, racehorse quality, age and sex distributions, and track design and maintenance). Results of this study indicate that sex, number of days since last race, and racing surface were associated with the risk of catastrophic MS injury among Thoroughbreds in Florida from 1995 through 1998. Horses running on turf surfaces were more likely to participate in more competitive events (large fields, handicap races, long races, high purse values).

Table 2—Multivariable conditional logistic regression model for risk of catastrophic MS injury among Thoroughbred racehorses at 2 racetracks in Florida

Variable	Adjusted OR	95% CI	*P* value
Sex			
Female	1.0	NA	NA
Colt	1.4	0.8–2.6	0.22
Gelding	2.0	1.1–3.6	0.02
Age (y)			
2–3	1.0	NA	NA
4–10	0.9	0.5–1.4	0.57
Days since last race			
4–13	1.0	NA	NA
14–20	1.9	0.9–3.9	0.07
21–32	1.6	0.8–3.5	0.21
33–477	2.5	1.2–5.1	0.01
Racing surface			
Dirt	1.0	NA	NA
Turf	1.7	1.1–2.9	0.03

CI = Confidence interval. NA = Not applicable.

In the present study, the overall incidence rate of catastrophic MS injury was 1.2/1,000 race starts. This was similar to the incidence reported for Thoroughbreds in Kentucky (1.4/1,000 starts)[11] and California (1.7/1,000 starts).[3,4] However, comparing incidence of MS injuries among racetracks is difficult because of the different definitions used for MS injury among studies. In addition, differences in horses, training, and race-start and racing-surface characteristics among racetracks may have an effect on the incidence of injury.

The forelimb sesamoid bones were most commonly involved in catastrophic MS injuries in the present study. This is consistent with results of previous studies conducted in California,[3,4] Kentucky,[8] and Texas.[12] Although the exact location of injuries has not always been identified in these studies, the most common type of MS injury during racing is a fracture or dislocation of the component bones of the metacarpophalangeal joint or a failure of the suspensory apparatus.[4]

The effect of sex and age on risk of MS injury in Thoroughbred racehorses was determined by use of conditional logistic regression in the present study. Only sex was significantly associated with risk of MS injury. Consistent with findings from studies in California,[3,4] geldings were at a higher risk of MS injury (OR, 2.0), compared with females in the present study. Because of their potential for breeding or sale purposes, females and colts are likely to run less frequently or to be retired from racing sooner than are geldings. In the present study, median total number of races was significantly higher for geldings (17 races) than for females (10) or colts (9), and median age of the geldings (4 years) was significantly higher than median age of the females and colts (3). Initial assessment of age (2, 3, 4, or 5 to 10 years old) did not reveal a significant linear association with risk of MS injury. Consequently, horses were grouped as 2 to 3 years old and 4 to 10 years old on the basis of the frequency distribution of median age to simplify interpretation of the OR. Because age has been associated with risk of MS injury in previous studies,[1,3,4] and older horses have a greater opportunity to race and, therefore, spend more time at risk, the final logistic regression model for risk of MS injury included age as a dichotomous variable.

Horses with ≥ 33 days since their last race were 2.5 times as likely to have a catastrophic MS injury during racing as were horses with ≤ 13 days since their last race. Horses with a preexisting injury would be more likely to experience periods of reduced activity, have an extended interval between races, and be at a higher risk for bone fracture.[13,14] 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 with exercise; stress fractures may develop as a result of continued repetitive loading.[14] 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 limb had been immobilized for 32 and 39 days for treatment of a large granulating wound and a degloving laceration, respectively.[15] In a study of 5 horses that had a fracture of the humerus during racing,[13] 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). Horses returning to training after a lay-up of ≥ 2 months were at risk for humeral fracture.[14] 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.[8] One limitation of the present study was that information concerning the high-speed exercise histories of study horses was not available. However, we believe that horses with a preexisting injury typically are more likely to have extended periods without racing. Thus, the number of days since the last race may serve as a useful indicator of previous health and lameness problems.

Another risk factor for MS injury in the present study was racing surface. That racing surface was a risk factor could be attributable to the fact that turf races are typically more competitive than dirt races at Florida racetracks. Horses running on turf were more likely to participate in races with large fields, handicap races, long races, and races with high purse values. In studies conducted in California[3,4] and Kentucky,[8,9] racing surface was not found to be a significant risk factor for MS injury. In New York,[1] horses participating in turf races were at lower risk of MS injury, compared with horses participating in dirt races, and the authors speculated that the difference was a result of the softer consistency of turf surfaces. However, data related to race-start characteristics such as type of race, field size, and race length between turf and dirt races were not examined. Results of the present study suggest that in addition to sex and gender, racing surface should be examined as a potential confounder in investigations of race-start characteristics associated with risk of MS injury in Thoroughbred racehorses.

[a]EpiInfo 6, USD Inc, Stone Mountain, Ga.

[b]The Jockey Club Information Systems, Lexington, Ky.

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