Review of Risk Factors Associated with Racing Injuries

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Racing injuries are a rare occurrence and causes, if identifiable, are multifactorial. However, regulatory veterinarians and racetrack practitioners should be aware of risk factors identified that are potentially under their control. Pre-existing conditions, exercise intensity, shoe type, and results of prerace inspections performed on race day by regulatory veterinarians are examples of potential risk factors identified to date in epidemiological studies that may be influenced by veterinarians. Author's address: Kentucky Racing Commission, 4063 Iron Works Pike, Lexington, KY 40511.

1. Introduction

Racetrack regulatory veterinarians play an integral role in ensuring the safety of participants. Musculoskeletal injuries sustained during the running of races are a major concern to the industry. Practically, severe racing injuries are a rare occurrence in Thoroughbred racing. However, when injuries occur, awareness and interest about causes and subsequent preventative strategies are heightened within the racing industry and among the general population. This discussion reviews published information detailing incidence and descriptive data, approaches employed to identify risk factors, reports of identified risk factors, and strategies implemented to reduce the incidence and severity of racing injuries.

2. Incidence of Racing Injuries

Numerous reports describing the incidence of racing injuries exist. Incidence information is available from North America,[1–5] the United Kingdom,[6] Australia,[7,8] South Africa,[9] and Japan.[10,11] However, as a result of survey design and variation in definitions, it is difficult to compare the reported frequencies. To confound matters, there are marked differences in racing between countries, making a direct comparison of incidence figures impossible. For example, there are differing surfaces, differing directions of racing, and a great variability in racecourse design throughout the world.

Formats used to assess racing injury frequency include questionnaires,[12] racing chart analyses,[13] and official regulatory records.[1] Questionnaires are subjective and information is dependent on the rate of return, limiting their accuracy. Race chart analyses, although objective and readily available for all sanctioned races, are limited because of the individual chart caller's interpretation of a particular racing incident and when during the race the injury was (or wasn't) noticed. "Returned lame, did not finish, eased, pulled up, pulled up lame, broke down, and broke down badly" are terms commonly seen in official race charts that may or may not indicate musculoskeletal injury. Regulatory veterinarians are employed by racing commissions or racetracks to

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Table 1. Incidence of Racing Injuries from Various Sources

Source and Year	RMI Rate/ 1000 Starts	CMI Rate/ 1000 Starts
New York (NYRA) 1983–1985[3]	7.3 (placed on vet's list due to lameness)[3]	1.1 (1992)[16]
Great Britain 1987–1993[6]	NA	0.8 (Flat) 5 (National Hunt)
Minnesota 1987–1992[14]	5.3	1.8
Illinois 1986–1992[14]	NA	1.8
California Necropsy Program 1991[2]	NA	1.7
Japan (JRA) 1990,[10] 1985–1994[11]	21 (accidents)[10]	3.2 (race deaths or euthanasia from fracture/dislocations)[11]
South Africa 1988–1993[4]	NA	1.4 (broke down)
Australia 1986–1993[8]	NA	0.3 (FMI)
U. S. National (ERIRS) 1992[4]	3.8	1.6
Kentucky 1992–1993[1]	3.3	1.4

attend the running of races, maintain the veterinarian's list of horses ineligible to race as a result of unsoundness, and ensure that all horses competing are racing sound.[14] Their official reports of injuries observed during races would appear to be an accurate source of information on injured horses. Regulatory veterinary records have been used to produce many descriptive and epidemiological studies.[1,15] A record of injury is generally completed when a horse requires veterinary attention on the racetrack during or shortly after the running of a race. In Kentucky, when a noticeable change in gait is observed or the equine ambulance responds to aid a horse, a report form is completed. Then if a musculoskeletal structure is identified, the incident is termed a racing injury (racing musculoskeletal injury, or RMI). When the horse's injury is such that euthanasia is performed, the injury is termed catastrophic (catastrophic musculoskeletal injury, or CMI). Fatal injury or racing fatality also describes horses euthanized as a result of a musculoskeletal injury but may include horses with nonmusculoskeletal injuries. Nonmusculoskeletal causes of racing fatalities include collapse, pulmonary hemorrhage, cardiac failure, massive disseminated hemorrhage, and unspecified cause.

Table 1 outlines incidence figures of RMI and CMI rates from North America (a national survey and five individual jurisdictions) and four countries. Incidence rates or frequencies are commonly expressed per 1000 starts. For instance, the RMI rate in Kentucky for a 17-month period representing 35,484 starts was 3.3 per 1000 starts.[1] Although the overall rates show marked variation, likely as a result of case definition and extent of follow-up, the fatal or catastrophic rates from North American sources are similar. A uniform reporting system covering racetracks in major racing jurisdictions would provide useful information regarding injury rates and risk factors for injury.

Few studies have described injury rates during training. Training populations in North America are widely distributed and highly transient, making injury assessment difficult. In Japan, all horses are housed in Japan Racing Association (JRA) facilities and veterinary records are centrally maintained. Therefore, information from Japan provides the most accurate information on training injuries. However, it is difficult to extrapolate that information to North American racehorses. Limited studies in North America suggest an attrition rate of 50%,[17] with the fatal fracture incidence being similar to incidences described for racing.[5] According to JRA information for the period from 1985 to 1994, a greater number of fractures occurred during training than during racing each year.[11] It appears that training injuries are at least as significant as racing injuries as a cause of wastage in Thoroughbred horses.[18]

3. Description of Injured Horses

The distribution of injuries commonly observed may be useful to identify possible risk factors associated with racing injuries (Table 2). Similar distributions of injuries have been recorded in North American studies.[1,2,4,5,15] In a representative descriptive study, 86% of all racing injuries involved structures at or below the carpus.[1]

The Equine Racing Injury Reporting System (ERIRS) study in 1992 reported that 86% of fatal fractures sustained during dirt races involved the forelimbs, with 90.3% of the fractures involving the carpus or distal structures. The distribution of injuries occurring during turf races was proportionately similar, with 88.8% of fatal fractures occurring in the forelimbs and all of the forelimb fractures

Table 2. Distribution and Involvement of Forelimb Structures Commonly Involved in Racing Injuries

Forelimb Structure	% Involvement: Racing Injuries[1]	% Involvement: Catastrophic Injuries[19]
Carpus	12	9
3rd metacarpus	13	30
SAF[a]	45	50
SDF	11	NA

[a]SAF includes the following structures: proximal sesamoid bones, suspensory (interosseous) ligaments, and distal sesamoidean ligaments.

involving the carpus or distal structures.[4] The forelimbs were involved in 90.2% of racing injuries in the Kentucky study.[1]

The suspensory apparatus, including the proximal sesamoid bones and the suspensory ligament, accounted for 47.6% of all injuries in the ERIRS study and 44.7% in the Kentucky descriptive study. It appears, then, that the Thoroughbred racehorse's forelimbs are at particular risk to racing injury and the suspensory apparatus is the structure most often injured.

The Kentucky descriptive study analyzed race charts from races in which injuries occurred. That analysis revealed that the proportion of horses with catastrophic injuries positioned in the last half of the field at the first quarter fraction was significantly greater than that expected by chance alone.[1] This finding led to further epidemiological studies designed to verify and attempt to explain this observation.

The Kentucky descriptive study also recorded locations on the race track where specific injuries occurred. Injuries of the sesamoid bones were significantly more common in the stretch turn than at other locations on the track. Injuries of the third metacarpal condyle were significantly more likely to be detected after the race than during the race.[1] This information has aided track veterinarians in developing emergency procedures for dealing with acutely injured racehorses.

4. Approaches To Identifying Risk Factors

With racing injuries being a rare event, there are challenges in designing studies to identify factors that are associated with injuries. Additionally, racing injuries are multifactorial, that is, there is no simple cause-and-effect relationship between injury and a single factor. By a simple collection of information on injuries when they occur, a description of the injured population of horses can be developed. Most of the studies to date have been descriptive studies, and some inferences about factors predisposing to injury, such as age and sex, have been made.

More information can be obtained from a case-control study design. In a case-control study, when an injury occurs (case), the injured horse is compared with one or more individuals that do not get injured (controls) selected from the same population of interest. In the California necropsy program, controls have been selected by using race charts and published workouts obtained from commercial performance databases (Daily Racing Form or Equibase) and by analyzing exercise intensity patterns as risk factors for the development of FMI (fatal musculoskeletal injuries).[20] More recently, controls (nonracing fatalities) were used to assess types of shoes and their role in FMI.[21] In Kentucky, a case-control study was used during a 2-year period to identify risk factors for injury.[22] The study utilized past performance information, race chart analysis, prerace inspection findings performed by a Commission veterinarian on race day, and video analysis from the injury race. Controls were selected randomly from the race in which the injury occurred and information was collected and analyzed from the injured horse (case) and two noninjured horses (controls).

Cohort studies are prospective in that a study population is identified and characterized for the presence or absence of risk factors of interest and then followed for a specified period to determine which individuals develop disease. At the conclusion of the study, incidence rates can be calculated and the relative risk of disease in individuals with a given risk factor determined by comparing the rate of disease in individuals with that risk factor and the rate of disease in individuals without that risk factor. Although the results of these types of studies do not prove a cause-and-effect relationship, cohort studies provide a stronger association between a risk factor and a disease. For prediction, cohort studies allow development of models whereby the probability of an outcome (e.g., FMI) can be estimated. Such models can be used in programs to prevent diseases.

5. Risk Factors Identified

Relatively few controlled studies have been conducted on the potential causes of racing injuries. Descriptive studies predominate, followed by case-control studies, and only one published report of a cohort study in North America. If a risk factor is alterable, then modifying behavior or procedures should decrease the probability of injury. For instance, smoking has been identified as a risk factor for heart disease. Individuals that smoke can decrease their probability of contracting heart disease by modifying their behavior, specifically quitting smoking. Much progress has been made recently by using case-control studies on horse populations to identify risk factors. In California, the statewide necropsy program has led to a number of studies using horses that died or were euthanized at California race tracks. Controls have been the rest of the racing–training population,[2] matched controls from races in which horses were injured,[20] and necropsied control horses whose cause of death was not related to musculoskeletal injury.[21] A 2-year cohort study is underway in Kentucky, specifically investigating the summary risk assessment evaluation of prerace inspection findings in relation to injury. Results from this and other studies should identify and further elucidate alterable risk factors. To date, several factors have been shown to be associated with injury. Table 3 outlines the type of study, year, and possible risk factor(s) identified.

A. Age

Several descriptive studies showed increased numbers of injuries in certain age groups, suggesting an age predilection.[15,23] Case-control studies further characterized the age relationship.[2] Generally, the older the horse, the higher the risk of injury. The

Table 3. Type of Study, Year, and Possible Risk Factor(s) Identified

Risk Factor	Details and Type of Study
Age	Older horses at higher risk—case-control (CA) 1996, case-control (MN) 1988, case-control (NY) 1991
Sex	Males at higher risk—case-control (CA) 1996
Class/Caliber of race	Higher quality horses, fewer injuries—cohort (MN) 1990
	More injuries in claiming vs. nonclaiming—case-control (MN) 1988
	Stakes caliber, more injuries—case-control (Aust) 1996
Jockey	Amateur jockeys, higher injury rates in flat races—descriptive (UK) 1995
Racing surface	Racetrack—case-control (NY) 1991
	Racetrack higher incidence—descriptive (JP) 1994
	Turf lower risk—case-control (NY) 1991
Surface condition	Soft base/loose cushion—descriptive (CA) 1973
	Muddy track, fewer injuries—case-control (NY) 1991
	Compaction—descriptive (MN) 1991
Exercise intensity	Days between races—case-control (MN) 1990
	Cumulative exercise distance—case-control (CA) 1994
	Trainer—cohort (MN) 1990
Pre-existing conditions	Long bone microfractures—descriptive (CA) 1992
	Condyle microfractures—descriptive (CA) 1994
	Recurrence of injury—descriptive (NY) 1992
	Prerace inspection findings—case-control (KY) 1997
Shoeing	Toe grabs increased risk of CMI, SAF, and CDY—case-control (CA) 1996
Summary assessment of risk	Horses identified on prerace inspection at higher risk—case-control (KY) 1997
Interaction/stumbling	Physical interaction and stumbling during race—case-control (KY) 1997
Barrier position (post position)	Outside starters at higher risk—case-control (Aust) 1996

explanation for this is uncertain, but older horses have more exposure to racing, perhaps indicating a cumulative effect. Irrespective of the explanation, it becomes necessary to adjust incidence rates by taking age into consideration.

B. Sex

Similarly, a case-control study[2] concluded that males were at twice the risk of injury as females.

C. Class/Caliber of Race

Studies conducted at Canterbury Downs in 1987 suggested that higher quality horses sustained fewer injuries[17] and that claiming horses had more injuries than nonclaiming horses.[23] Populations of races horses have to be stratified to address class, age, and sex before incidence rates can be compared. For example, a racetrack with predominantly older male claiming horses would be expected to have a higher incidence of injury than a racetrack with predominantly young female nonclaiming horses. An Australian case-control study found that horses running in a Stakes race (group and listed races) were 2.3 times more likely to suffer a musculoskeletal breakdown than horses in a nonstakes race.[7]

D. Jockey

Based on the higher incidence of fatalities to National Hunt Flat racehorses in the UK[6] when ridden by amateurs, professional jockeys are now allowed to compete. This change was instituted with the hope of reducing injuries. There are no reports in North America that the status (apprentice versus journeyman) of the jockey is associated with injury.

E. Racing Surface

A case-control study in New York identified a particular racetrack with a lower incidence of injury.[15] The ERIRS study identified a marked variation in injury among participating racetracks.[24] In a California case-control study,[2] the differences in risk for injury among racetracks might be attributable in part to underlying differences in age and sex distribution of the entrants in the race meets held at those racetracks. In a case study from Japan, a particular racetrack was identified with an increased incidence of injury compared with other tracks operated by the JRA.[25] Several changes to the racing surface were implemented and the injury rate was affected. The New York study also correlated a decreased risk of injury with racing on turf courses.[15] However, no subsequent study in North America has corroborated this finding. Information from countries conducting turf racing exclusively is extremely variable, with some reports as low as 0.3 catastrophic injuries per 1000 starters,[8] an incidence rate significantly lower than those described in North America.

F. Surface Condition

Most studies have investigated the role of track condition because that information is carried routinely by commercial performance databases (for example, the Daily Racing Form or Equibase). The track condition is listed for each race and assessed by the trackman, i.e., the individual responsible for generating the race information at the racetrack. Usually, the official condition of the track surface is posted to the public. For dirt surfaces, the terms fast, good, muddy, and sloppy are used; for turf surfaces, firm, good, or yielding are common. A case-control study from New York identified fast and sloppy tracks as carrying higher risk, and muddy tracks as carrying lower risk.[15] However, no subsequent studies have corroborated these findings. In California, a questionnaire associated loose cushion and soft base with decreased lameness.[12] A descriptive study in Minnesota collected information on surface parameters and determined that areas with higher traffic (around the chutes) were associated with the location on the track where 50% of injuries occurred.[26] There appears to be merit in developing systems to measure track surface parameters (for example, material compaction and moisture content) to correlate the incidence, types, and location on the surface where injuries occur. Then surface conditions that correlate with injuries could be avoided.

G. Exercise Intensity

In a case-control study from Minnesota, horses with bony lesions were seven times more likely to have raced within the previous 12 days.[27] The Minnesota cohort study also reported that injury rates varied significantly by trainer,[23] with a possible explanation being the exercise regime utilized by individual trainers. In an effort to investigate the role of exercise prior to injury, a case-control study conducted using exercise histories obtained from commercial performance databases found that horses with an excessive 2-month exercise density cluster were at 15.5 times higher risk of sustaining a fatal injury.[20] It was further estimated that horses that have accumulated 35 racing-speed furlongs within a 2-month period are at two to seven times greater risk of catastrophic bone fracture compared with horses that have accumulated 25 racing-speed furlongs in 2 months. In the Kentucky case-control study, horses with an interval exceeding 60 days between the injury race and the previous race compared with noninjured controls in the same race were at 7.9 times greater odds of sustaining an injury to the superficial digital flexor (SDF) tendon.[28]

H. Pre-Existing Conditions

The California Post-Mortem Program has reported the majority of catastrophic fractures to the humerus, tibia, scapula, and pelvic bones occur at sites of pre-existing incomplete stress fractures,[29,30] and many of the lateral condylar fractures of the cannon bones occur at the sites of similar pre-existing injury.[31] A New York descriptive study reported that 11% of injured horses had a history of previous injury.[16] A descriptive study in Kentucky theorized that pre-existing conditions would be a possible explanation for 70% of the catastrophically injured horses being in the back half of the pack at the first quarter call.[1] In the Kentucky case-control study, horses with abnormalities of the suspensory ligament and metacarpalphalangeal joint noted on prerace inspection performed on race day by regulatory veterinarians were 3.4 and 2.4 times greater odds of injury respectively to the suspensory apparatus of the forelimb (SAF) than horses with no noted abnormalities.[28] Additionally, horses with an abnormality of the SDF tendon noted on prerace inspection were at 15.2 times greater odds of injury to the SDF than horses without detectable abnormalities to the SDF on prerace veterinary inspection.[28]

I. Shoeing

Recently, a case-control study published from the California Post-Mortem Program reported an association between toe grabs and the increased risk of catastrophic musculoskeletal injuries, suspensory apparatus failure, and condylar fractures.[8] There is an association between the height of toe grabs and an increased risk of catastrophic injury: the higher the toe grab, the greater the risk. Additionally, rim shoes were found to be associated with decreased risk of catastrophic injury, including fatal suspensory apparatus failure.

J. Summary Assessment of Risk

Further investigation of the role of prerace inspection findings (performed by regulatory veterinarians on race day) and subsequent racing injuries was the focus of a case-control study in Kentucky.[22] Results of prerace inspection by regulatory veterinarians were significantly associated with injury; the odds of musculoskeletal injury, injury of the SAF, and injury of the SDF were from 5.5 to 13.5 times greater among horses assessed to be at increased risk of injury by regulatory veterinarians based on findings of prerace inspection than for horses not considered to be at increased risk of injury.[28]

K. Physical Interaction–Stumbling

A descriptive study from the JRA, utilizing patrol video recordings of races in which injuries occurred, inferred that a change of lane, oblique movement, or some action that upsets the center of gravity of the jockey or horse is the factor that leads to the fracture.[32] In the Kentucky case-control study,[28] a race video analysis found horses were at 2.5 greater odds of injury if there was physical interaction during the race. Additionally, horses were at 4.2 times greater odds of injury if they stumbled during the race and 7.7 times greater odds of catastrophic injury if stumbling occurred.

L. Barrier Position (Post Position)

A case-control study selecting injured horses at two Australian racetracks over a 10-year time period found that horses with outside barrier positions (seven from the rail or greater) were twice as likely to suffer an injury as those starting closest to the rail.[7] No other studies have corroborated this finding to date.

6. Practical Implications In Preventing Injuries

As a direct result of the information revealed about the higher incidence of injuries in National Hunt Flat races, professional jockeys have been allowed to compete in these races since 1995. It is hoped that the inclusion of professional jockeys will decrease the incidence of fatalities in National Hunt Flat races in the UK. No association of injuries with jockey status has been established in North America; however, the JRA, as part of their comprehensive accident prevention measures, has implemented guidance aimed at improving training and riding techniques.[10]

The value of accurate records documenting racing injuries has led to injury monitoring systems being established in racing jurisdictions. As mentioned previously, fatalities are recorded in all racing jurisdictions, but other injury monitoring systems vary. Most major racing jurisdictions record information from horses injured while racing and returning lame from racing, but few have systems in place to document training injuries. A national monitoring system implemented in 1992 by the American Association of Equine Practitioners and the Racing Commissioner's International (AAEP/RCI) provides a common format for regulatory veterinarians to record injury information and accumulate data on a larger scale. Some states have databases to access and analyze the information and have been the basis of some of the studies cited, for example, California, Kentucky, and New York. A uniform injury reporting format and subsequent database for all participating racing jurisdictions would provide accurate, timely information to the industry with adequate statistical power. Likely, major racing jurisdictions will adopt uniform reporting formats and networked databases to collaboratively develop such an injury monitoring system.

Racing surface monitoring systems are currently being developed and utilized worldwide. Routine surface monitoring includes cushion depth measurements and material composition analyses. Racecourses in Japan are monitored intermittently with a track hardness measuring device, i.e., a drop hammer apparatus connected to a computer. A histogram of the entire track is prepared that illustrates the recorded track hardness values.[33] Regular evaluation of racecourse surfaces can identify tracks or areas of tracks that vary from the desired hardness values. Other parameters can be measured simultaneously and included in the analysis. These include base sensors, cushion depth sensors, and slope and pitch sensors. One company is developing a harrow-type apparatus that will eventually include data on moisture, impact, and metal (identify horse shoes).[a] All these devices are utilized to maintain track parameters within desired guidelines and to possibly correlate surface condition parameters with the occurrence of injuries.

The California findings of pre-existing microfractures in the majority of long bone fractures has lead to the routine application of nuclear scintigraphy in equine lameness diagnostics.[34] The presence of pre-existing conditions in race horses is also the focus of studies in Kentucky that utilize the findings of pre-race inspections performed by regulatory veterinarians. Strategies are being investigated to identify horses at higher risk of injury based on inspection findings and to develop preventative measures. Findings to date substantiate the role of the race day veterinary inspection as a useful tool to identify horses at higher risk.[22,28] This preliminary information should lead to an increased emphasis on the inspection and implementation of the procedure in jurisdictions where it is not routinely performed. For a number of years now, major racing events have instituted a veterinary surveillance program to monitor the racing soundness of participants well in advance of race day.[35]

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