Risk Factors for Musculoskeletal Injuries

Susan M. Stover, DVM, PhD, Dipl ACVS
Outline

• Magnitude of the problem
• Nature of injuries
• Injury development
• Key factors that promote injury development
• Risk factors for injury
• Race surface considerations
CHRB Postmortem Program
Since Feb 1991
> 4,000 racehorses have been necropsied

In 2005 …

342 racehorses died at CA racetracks
 – 264 (77%) Thoroughbred horses

266 (78%) deaths were due to injuries
 – 46% racing / 34% training
CA TB Racehorse Fatalities
TB MS Fatal Injuries / Starts by Year

Proportion TB MS Fatal Injuries per TB Starts

Year

TB MS Fatal Injuries / Starters by Year

Proportion TB MS per TB Starters

Year

0.000 0.005 0.010 0.015 0.020 0.025 0.030
Outline

• Magnitude of the problem - HUGE
• Nature of injuries
• Injury development
• Key factors that promote injury development
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Stress Fractures

What about Joint Injuries?
Pre-Existing Damage
Lateral Condylar Fracture

Condylar Fractures &
Traumatic Osteochondrosis
Bone Lesions Precede Arthritis
Proportion Fetlock / MS Fatalities
Limb – System of Levers

Equine Foot Studies- Dr. C.C. Pollitt
University of Queensland
Fetlock Suspensory Apparatus

- Suspensory ligament
- Proximal sesamoid bones
- Distal sesamoidean ligaments
Suspensory Apparatus Injuries
Pre-race Physical Findings

5-18 times increased risk with positive assessment

Low incidence of injury in associated race limits implementation

Cohen, et al. JAVMA 1997;211:454-463
Mild Suspensory Apparatus Injury Leads to Severe Injury

Hill, et al. JAVMA 2001;218:1136-1144
Association between findings on palmarodorsal radiographic images and detection of a fracture in the proximal sesamoid bones of forelimbs obtained from cadavers of racing Thoroughbreds


328 horses

136 horses with a fracture

192 horses without a fracture
PSB Fracture... has a Pre-existing Lesion
Outline

• Magnitude of the problem
• Nature of injuries – PRE-EXISTING DAMAGE
• Injury development
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Injury can induce transient bone loss

2-3 wks
Repair takes TIME

- 2-3 wks
- 3 mos
Early clinical signs 1 month later 3 months later

Courtesy of Dr. Rick Arthur
Catastrophic Fracture

Bone damage exceeds bone repair
Catastrophic Fracture

Bone damage exceeds bone repair
Outline

• Magnitude of the problem
• Nature of injuries
• Injury development – COMPETING RATES
• Key factors that promote injury development
• Risk factors for injury
• Race surface considerations
Injury Development

physical activity

microdamage

bone remodeling and modeling

completion

adaptation

transient osteoporosis + physiologic activity

excessive activity

complete bone fracture
Outline

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Key Factors for Injury

- Physical activity
- Microdamage
- Bone remodeling and modeling
- Bone fracture completion
- Transient osteoporosis + physiologic activity
- Excessive activity
- Load magnitude
Outline

- Magnitude of the problem
- Nature of injuries
- Injury development
- Key factors – CYCLES & LOAD MAGNITUDE
- Risk factors for injury
- Race surface considerations
Key Factors for Injury

- physical activity
  - distance
  - speed, conformation, shoeing, ...
- microdamage
- bone remodeling and modeling
  - completion
- adaptation
  - transient osteoporosis + physiologic activity
- excessive activity
- complete bone fracture
Outline

• Magnitude of the problem
• Nature of injuries
• Injury development
• Key factors
• Risk factors for injury – distance & distance rates
• Race surface considerations
# Proximal Sesamoid Bone Fracture

<table>
<thead>
<tr>
<th></th>
<th>Non-PSB</th>
<th>PSB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Death</td>
<td>Fracture</td>
</tr>
<tr>
<td># Works</td>
<td>21</td>
<td>26</td>
</tr>
<tr>
<td># Races</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Races/yr</td>
<td>4.7</td>
<td>6.4</td>
</tr>
<tr>
<td>Days since layup</td>
<td>46</td>
<td>153</td>
</tr>
</tbody>
</table>

Fatal Musculoskeletal Injuries (FMI) Training Effect

![Graph showing relationship between distance trained (furlongs) and racing career (days). The arrow indicates a breakdown point.]
Rates of Distance Accumulation

## Estimated Odds Ratios for PSB Fracture

<table>
<thead>
<tr>
<th>Exposure</th>
<th>OR*</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>distance 2 mos</td>
<td>1.03</td>
<td>1.01-1.05</td>
</tr>
<tr>
<td>works</td>
<td>1.16</td>
<td>1.01-1.32</td>
</tr>
<tr>
<td>work furlongs</td>
<td>0.97</td>
<td>0.94-0.99</td>
</tr>
<tr>
<td>gender</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Distance and Rate Effects

• Australia


• UK


Outline

• Magnitude of the problem
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• Risk factors for injury – load magnitude
• Race surface considerations
System of Levers

- BW
- $F_{\text{tendons}}$
- Hoof Lever

[Diagram showing a system of levers with forces and body weight (BW).]
Conformation Factors

• Inherent conformation


  – Long pastern increased risk for forelimb fracture
Increased Risk for SAF

High toe grabs
Long toe / under-run heel

Kane, et al. AJVR 1996;57:1147-1152
Balch, et al. AAEP 2002;47:334-338
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Race Surface
Race Surface

• Scapegoat

‘one who is blamed for misfortunes, often as a way of distracting attention from the real causes’

Racetrack ‘Effect’

Month(s) before Death
-12 -10 -8 -6 -4 -2

High Speed Distance (Furlongs)
0 50 100 150 200 250 300 350

Non-PSB Fx (n=148)
PSB Fx (n=121)
Del Mar A
Del Mar B
Del Mar C
Del Mar D
Del Mar E
Del Mar F
Del Mar G
Del Mar H
Del Mar I
Del Mar J
Del Mar K
Other
Del Mar L
Del Mar M
Del Mar N
Del Mar O

Racetrack 'Effect'
Race Surface

• Affects magnitude and character of load transfer between the ground and hoof, and limb mechanics
  – Consistency
  – Compliance, shear
  – Geometry, banking
Race Surfaces

- Epidemiology results are *inconsistent*
  - dirt vs turf
  - soft vs hard
  - all-weather vs other
  - sand
  - fast vs slow

  *Oikawa and Kusunose. Vet J 2005;170;369-374*
  *Hill, et al. JAVMA 2001;218:1136-1144*
  *Hernandez, et al. JAVMA 2001;218:83-86*
Race Surface

• Need for additional approaches to reduce confounding variables
  – direct race surface measurements
  – *in-vitro* studies
  – modeling approaches
  – *in-vivo* studies
Effect of Ground Surface on Suspensory Ligament Strains at 5 kN Load

Doles, et al.
Computer Simulation

\[ m = 345 \text{ kg} \]
\[ I_{zz} = 74.5 \text{ kg} \cdot \text{m}^2 \]

\[ m = 145 \text{ kg} \]
\[ I_{zz} = 14.4 \text{ kg} \cdot \text{m}^2 \]
Influence of Soft Track

$k: 1.84 \cdot 10^9 \rightarrow 6.98 \cdot 10^7$

$b: 69500 \rightarrow 32500$

Pratt (1984)
Compliant Surface: $\varepsilon_{SL}$
Fetlock Joint

Angle (deg)

Stance (%)
Instrumented Shoe

- Instrumented horseshoe
  - track surface
  - shoe appliances (e.g., toe grabs)
Fetlock Angle

p=0.06
Hoof Angle

![Graph showing hoof angles for Dirt, Polytrack, and Turf with a p-value of 0.07.]

- **Dirt**: Hoof Maximum Angle (deg) around 120 degrees
- **Polytrack**: Hoof Maximum Angle (deg) around 170 degrees
- **Turf**: Hoof Maximum Angle (deg) around 100 degrees

The difference in hoof angles between Polytrack and the other surfaces is statistically significant with a p-value of 0.07.
Polytrack
Heel Strike Deceleration

Heel Strike Start Vertical Acceleration

- Dirt
- Polytrack
- Turf

p=0.01
Stride Vibration

- Dirt
- Polytrack
- Turf

p<0.0001
Heel Strike Vibration

- Dirt
- Polytrack
- Turf

Differences are statistically significant at p<0.0001.
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• Race surface considerations - OPTIMISTIC
Increasing race surface compliance …

↓ peak GRFs

↓ fetlock peak hyperextension

↓ coffin peak flexion & ↑ coffin peak extension

↓ SDF and PCL peak strains

↓ DCL peak strain

↓ SL peak strain

↑ SL<sub>nav</sub> peak strain

↓ peak accelerations
TB MS Fatal Injuries / Starts by Year

Proportion TB MS Fatal Injuries per TB Starts


Proportion: 0.000, 0.001, 0.002, 0.003, 0.004, 0.005, 0.006, 0.007
Graduate Students
Ian Campbell
Al Kane
Leah Estberg
Tracy Carrier
Val Gibson
Craig Malik
Luke Hiller
Lanny Griffin
Ashley Hill
Diane Gross

Veterinary Students
Jennifer Reese
Jessica Wade

Collaborators
Bruce Martin
Jeff Gibeling
Mont Hubbard
Dave Hawkins
Scott Hazelwood
Tara Johnson
Alex Ardans
Tanya Garcia
Shrinivasa Upadhyaya
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USDA

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Veterinary Orthopedic Research Laboratory

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