Risk Factors for Musculoskeletal Injuries

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UC DAVIS School of Veterinary Medicine

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 …

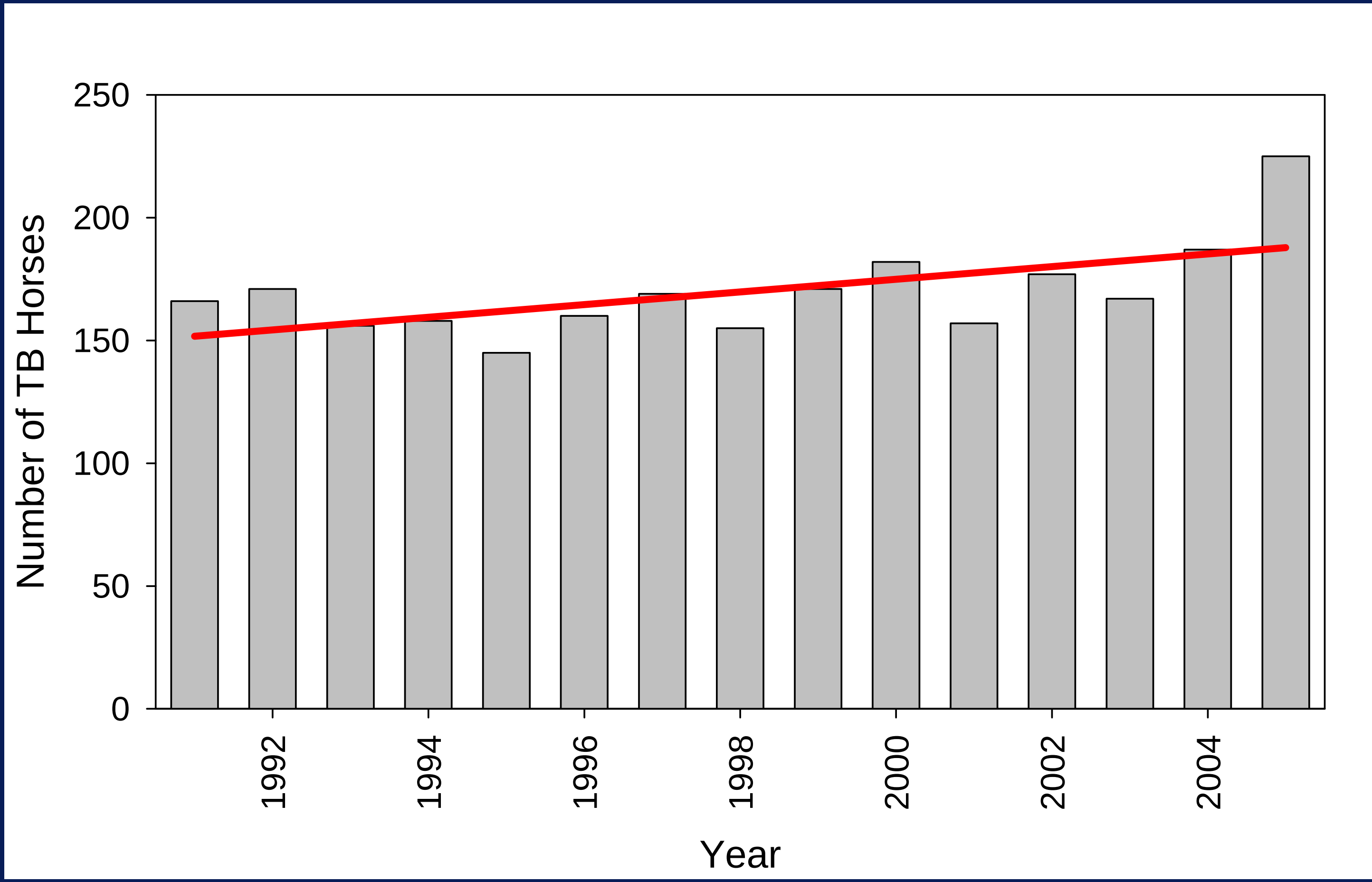
342 racehorses died at CA racetracks

– 264 (77%) Thoroughbred horses

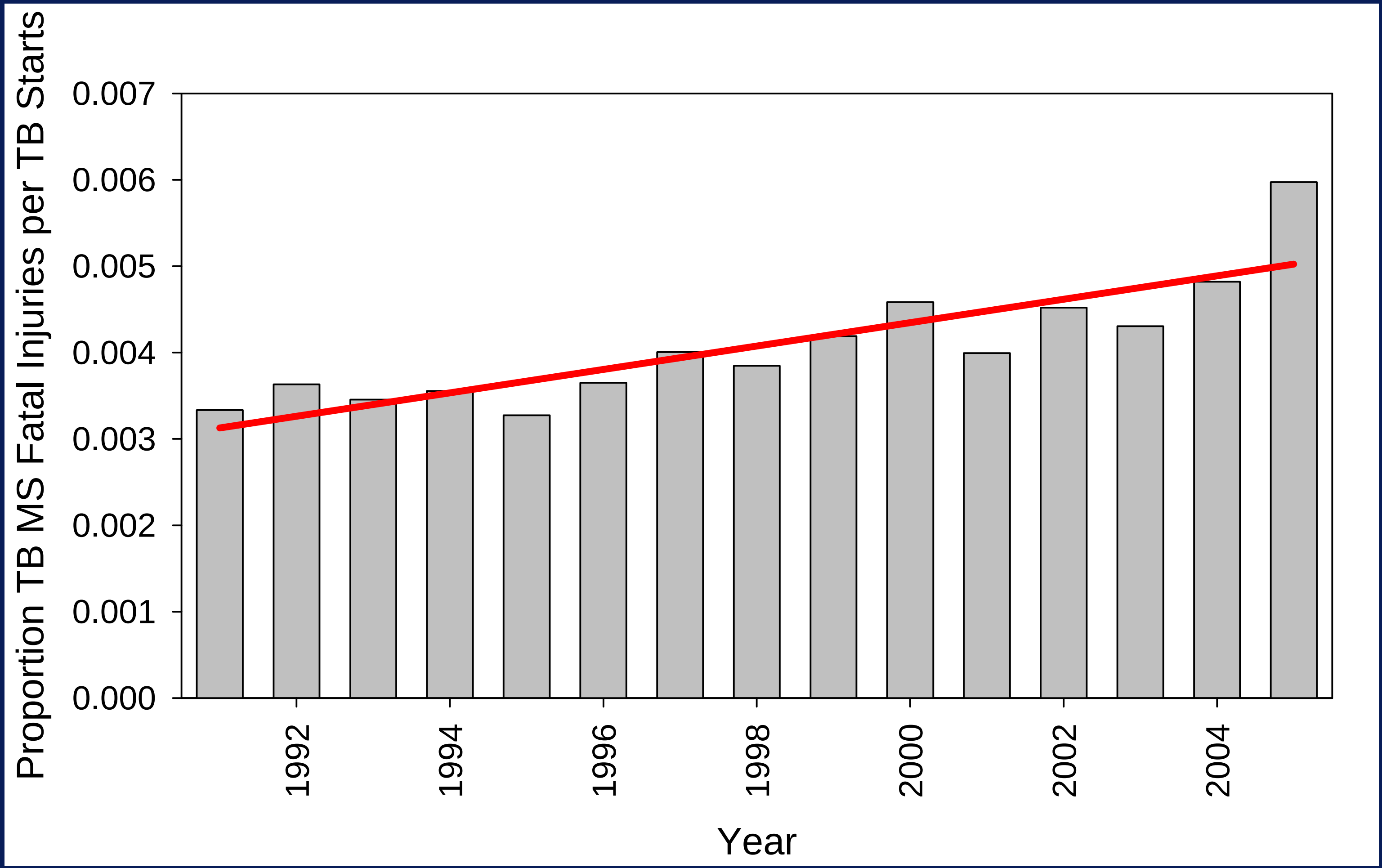
266 (78%) deaths were due to injuries

– 46% racing / 34% training

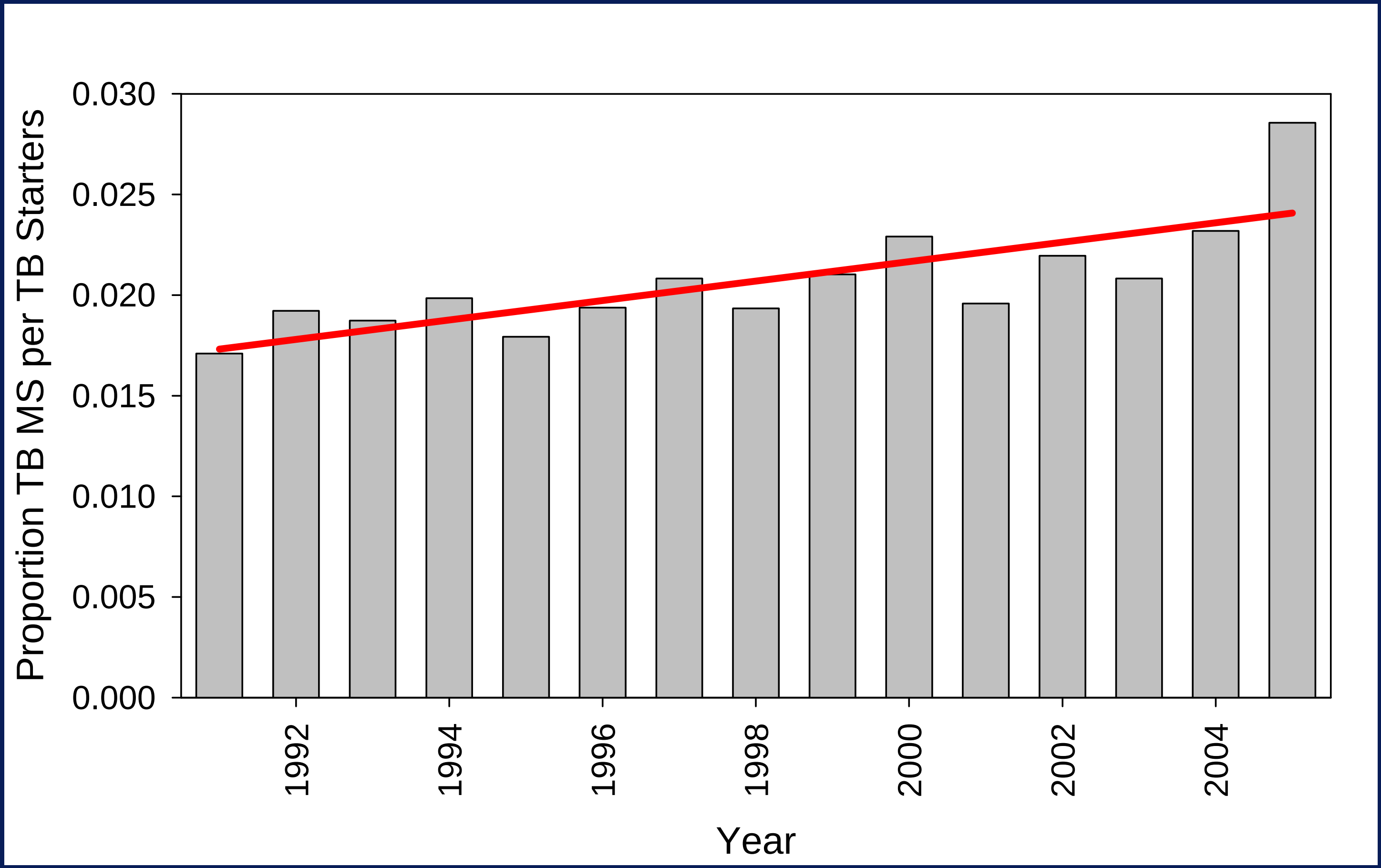
CA TB Racehorse Fatalities



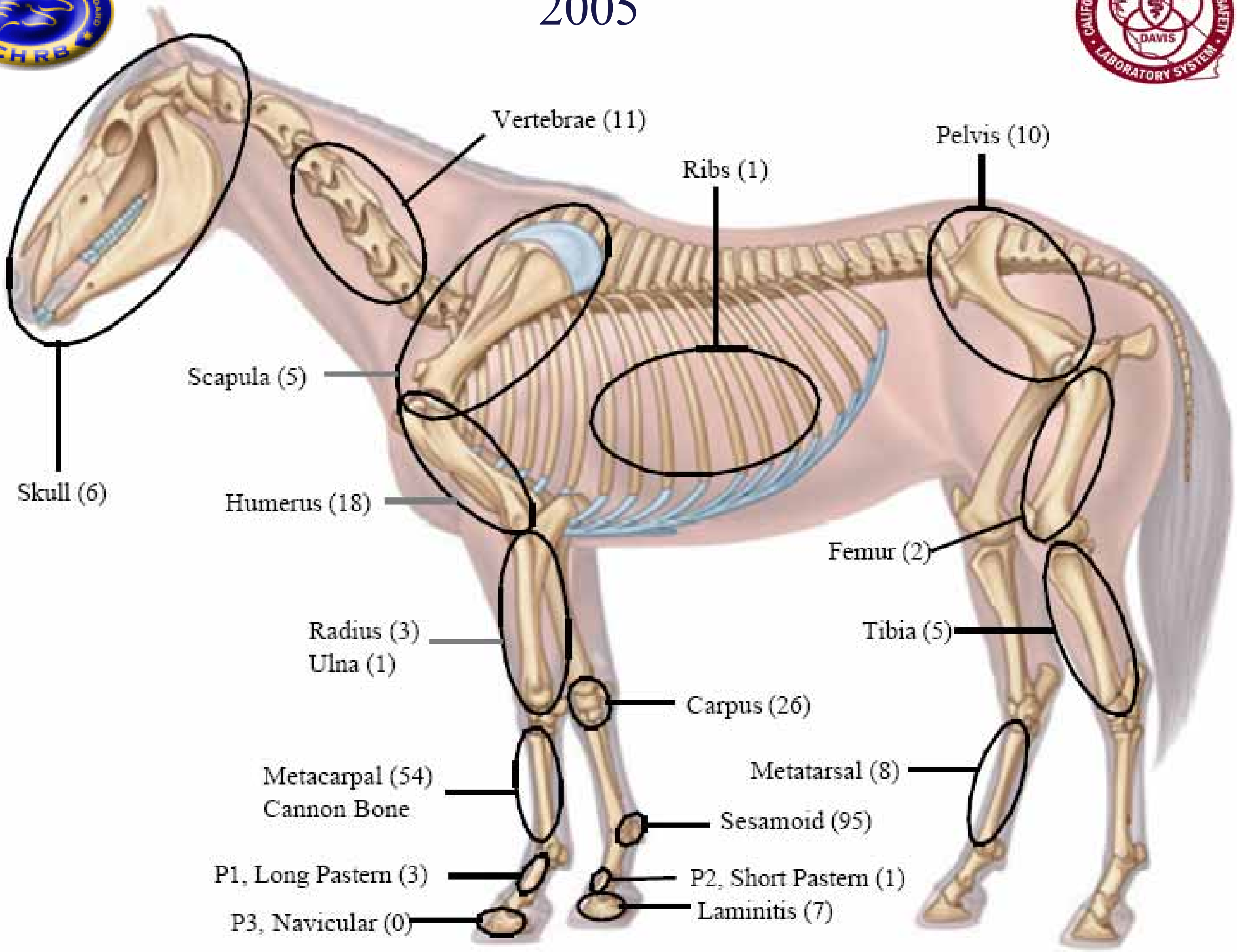
TB MS Fatal Injuries / Starts by Year



TB MS Fatal Injuries / Starters by Year



2005



Vertebrae (11)
Pelvis (10)
Ribs (1)
Scapula (5)
Skull (6)
Humerus (18)
Femur (2)
Radius (3)
Ulna (1)
Tibia (5)
Carpus (26)
Metacarpal (54)
Cannon Bone
Metatarsal (8)
Sesamoid (95)
P1, Long Pastern (3)
P2, Short Pastern (1)
P3, Navicular (0)
Laminitis (7)

Outline

- Magnitude of the problem - HUGE
- Nature of injuries
- Injury development
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Outline

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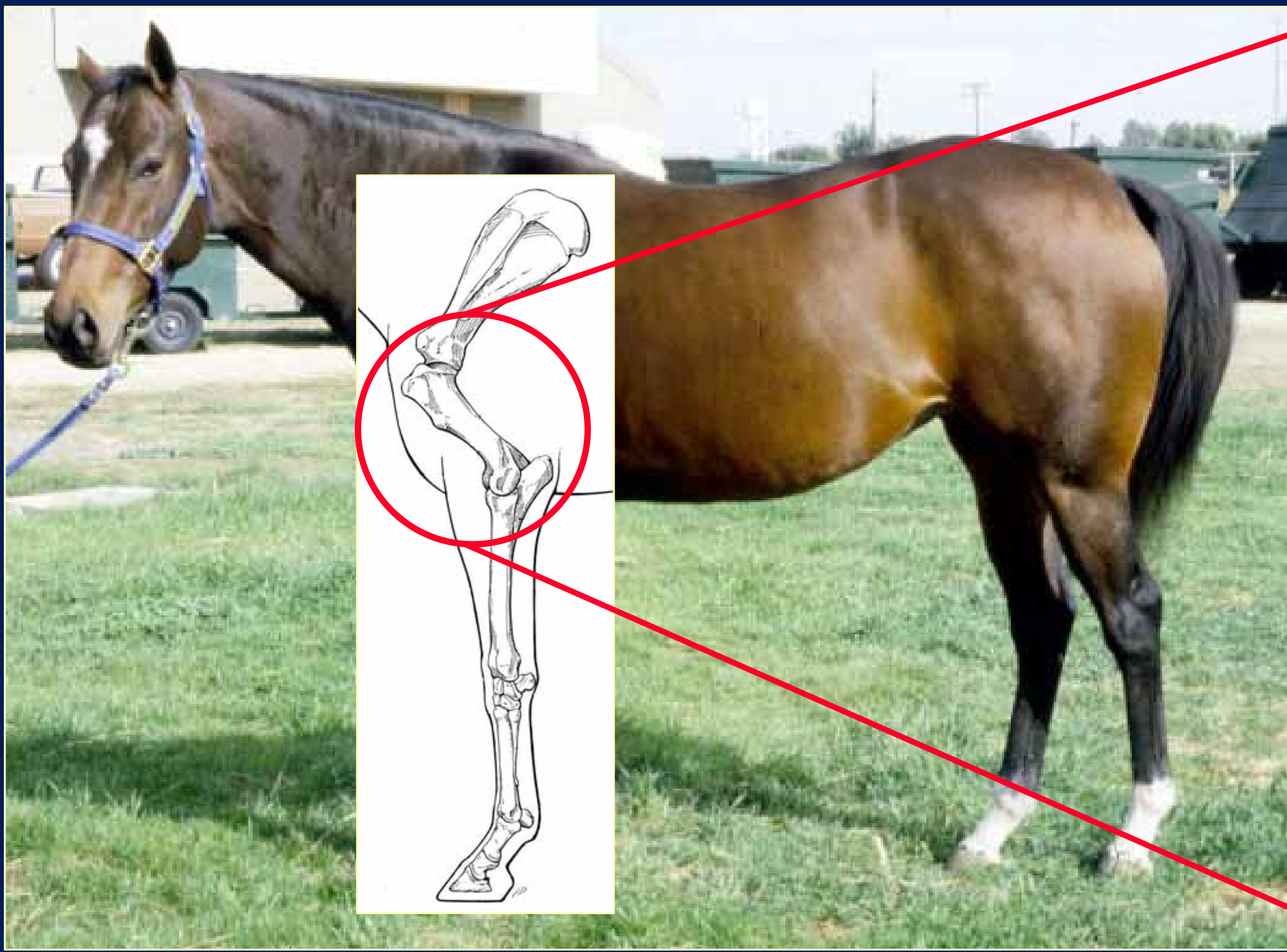
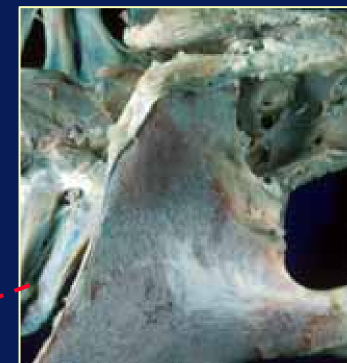
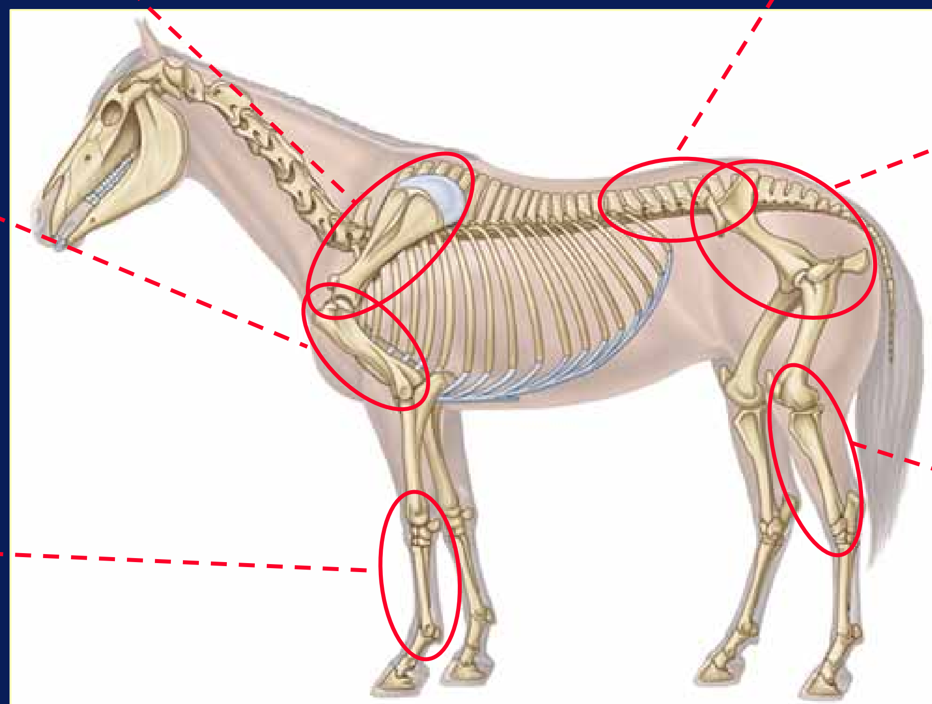
Humeral Fractures



Stover, Johnson, Daft, et al Equine Vet J 1992;24:260-263


Stress Fractures



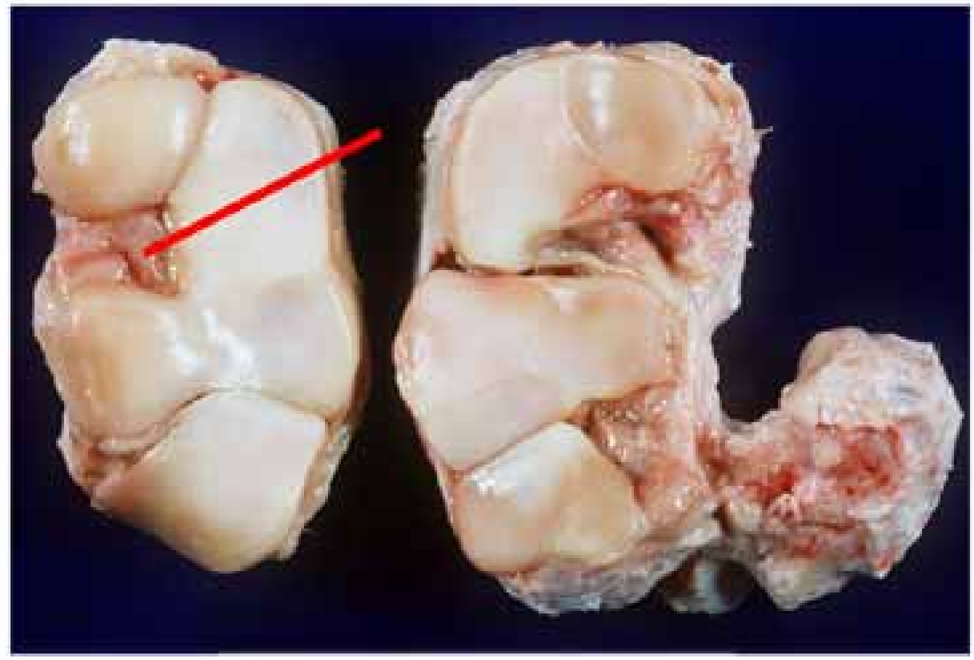


Haussler, Stover. Equine Vet J 1998;30:374-381

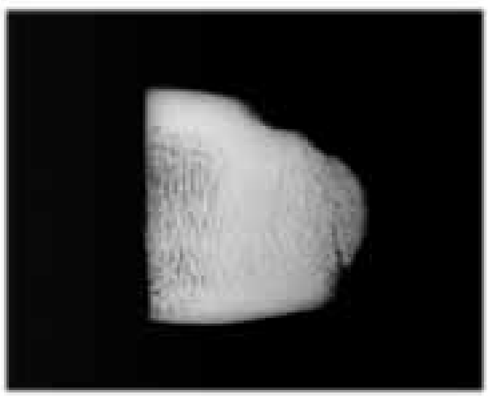
Stover. Current Tech, Equine Surg Lameness 1998:451-459

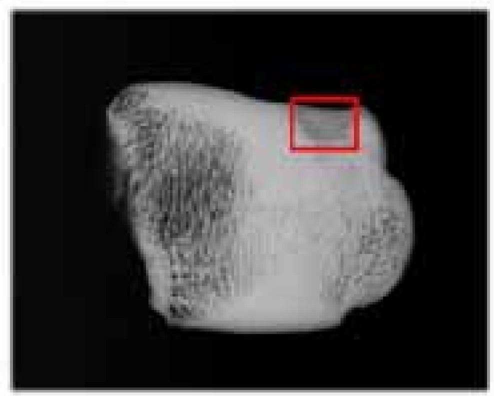
What about Joint Injuries?

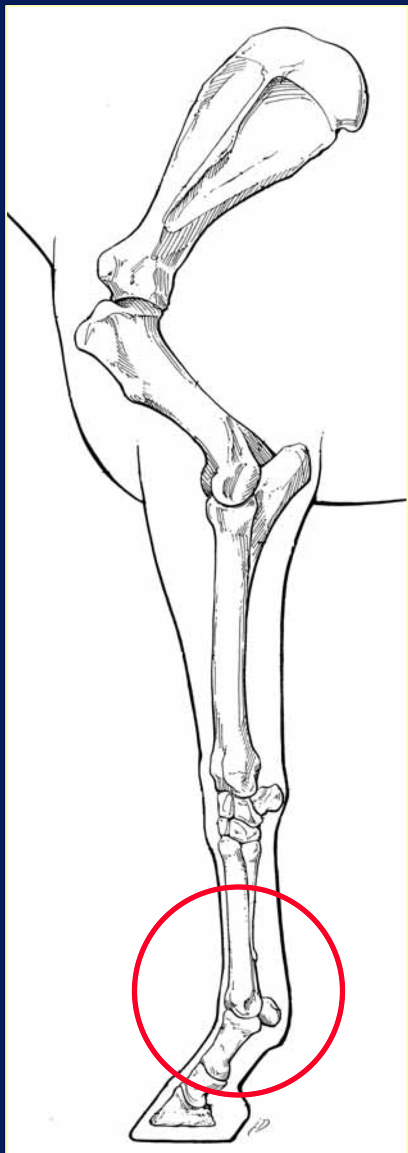
Left Carpus

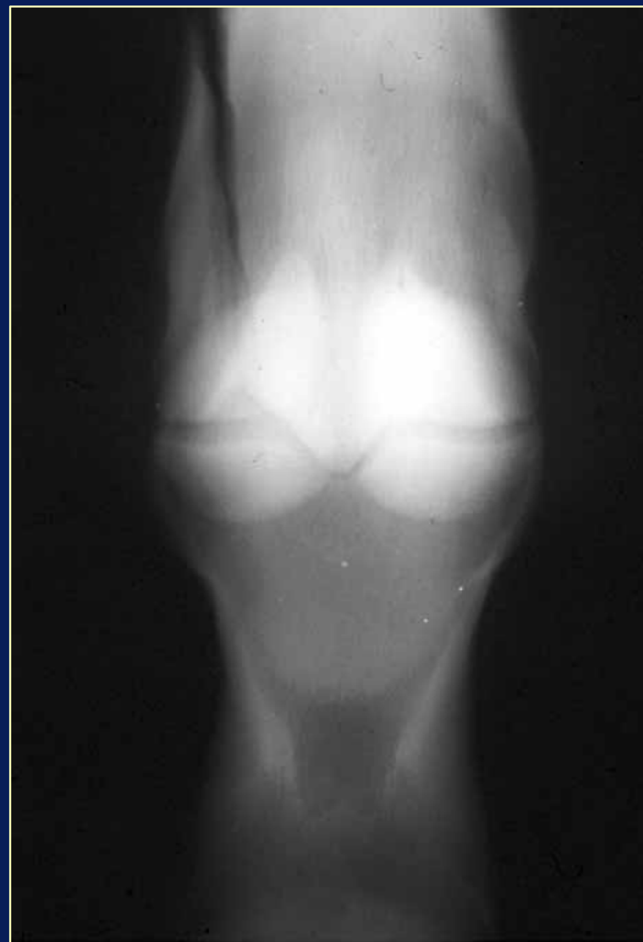


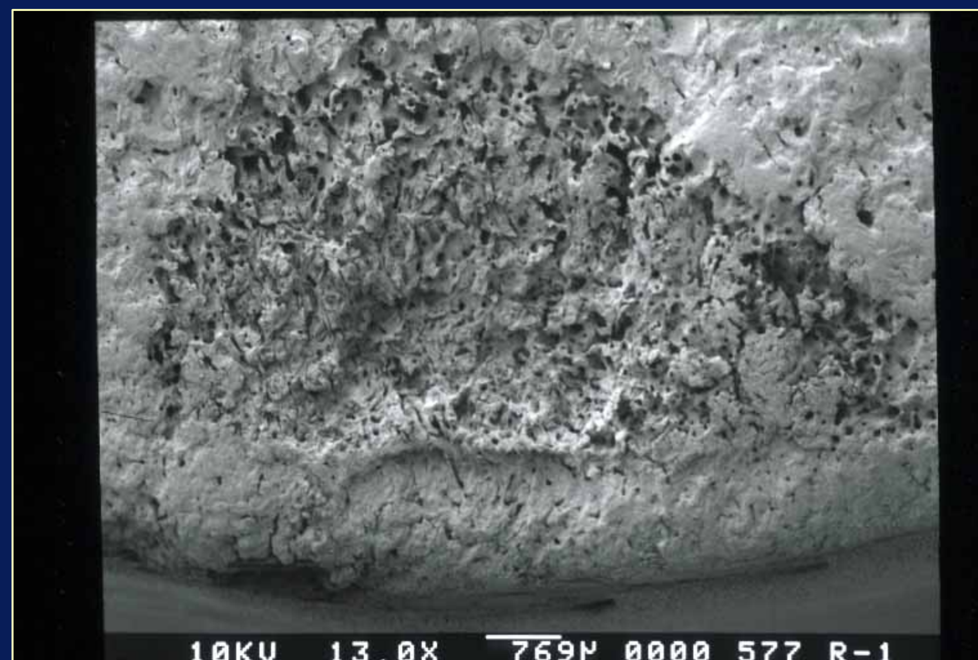
Right Carpus







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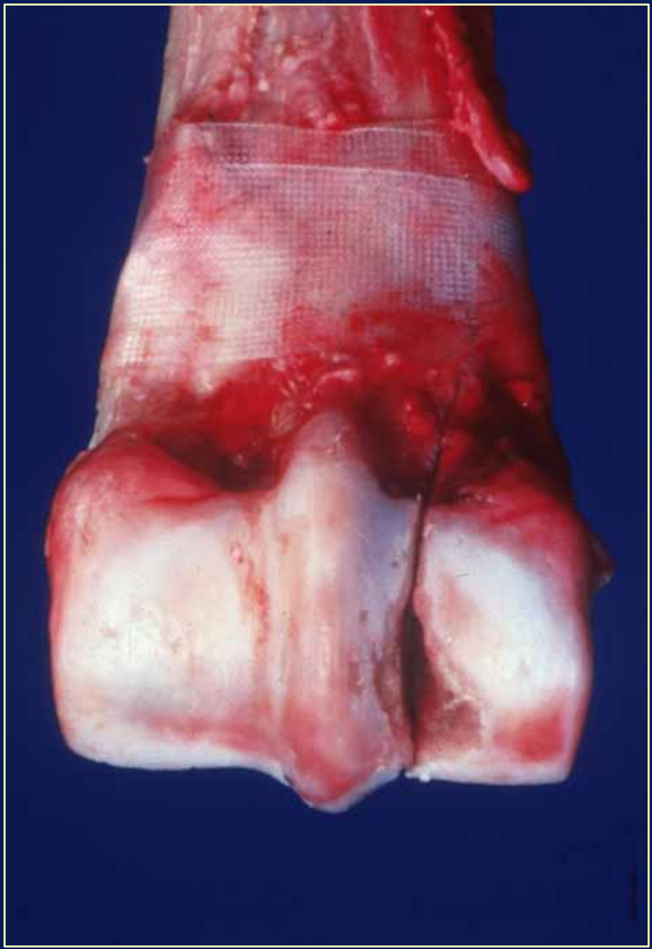
EAGLE
BALLPARK
STYLE
PEANUTS

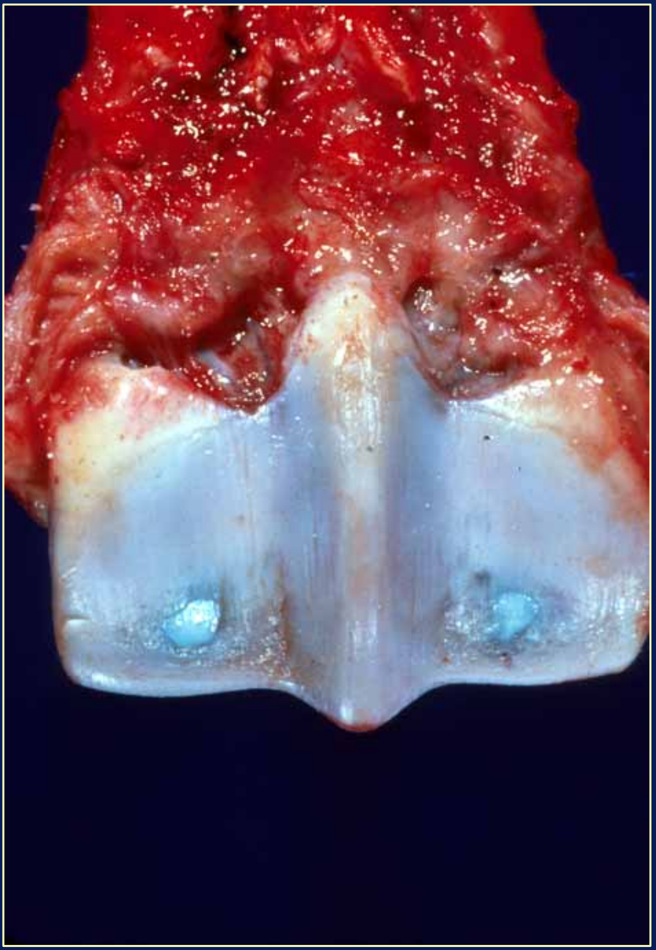

EAGLE
BALLPARK
STYLE
PEANUTS

Pre-Existing Damage
Lateral Condylar Fracture

Parkin, et al. Vet J 2006;171:157-165

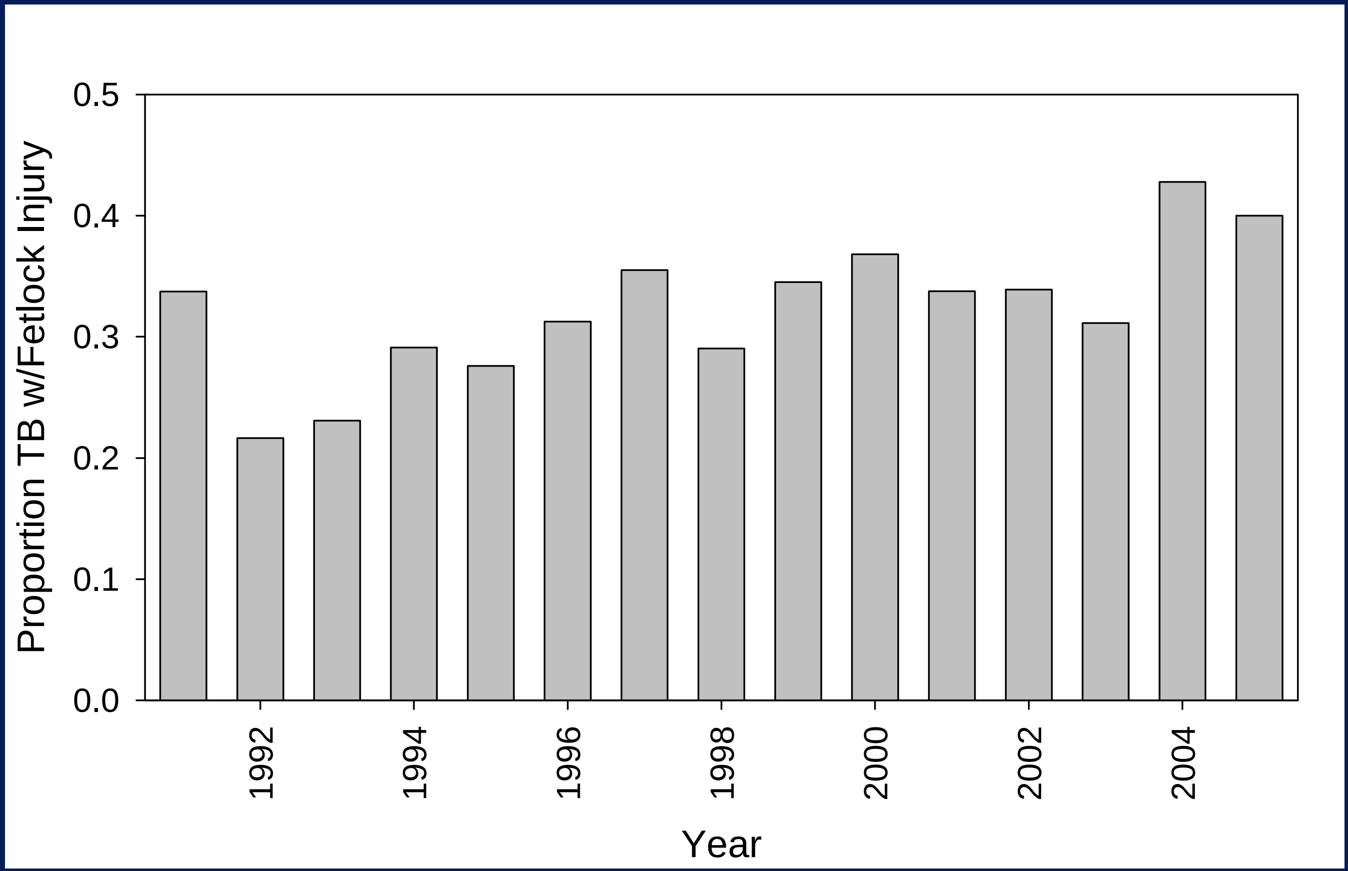
Condylar Fractures & Traumatic Osteochondrosis





Bone Lesions Precede Arthritis

Proportion Fetlock / MS Fatalities



Limb – System of Levers

Equine Foot Studies- Dr. C.C. Pollitt
University of Queensland

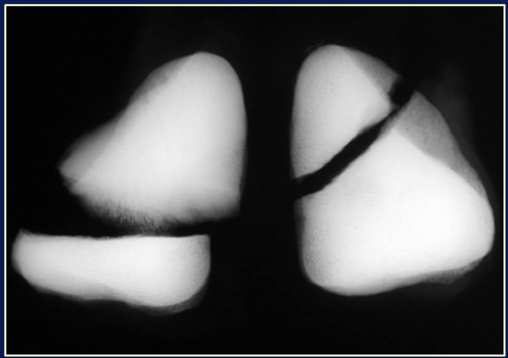
Fetlock Suspensory Apparatus

Suspensory ligament

Proximal sesamoid bones

Distal sesamoidean ligaments

Suspensory Apparatus Injuries

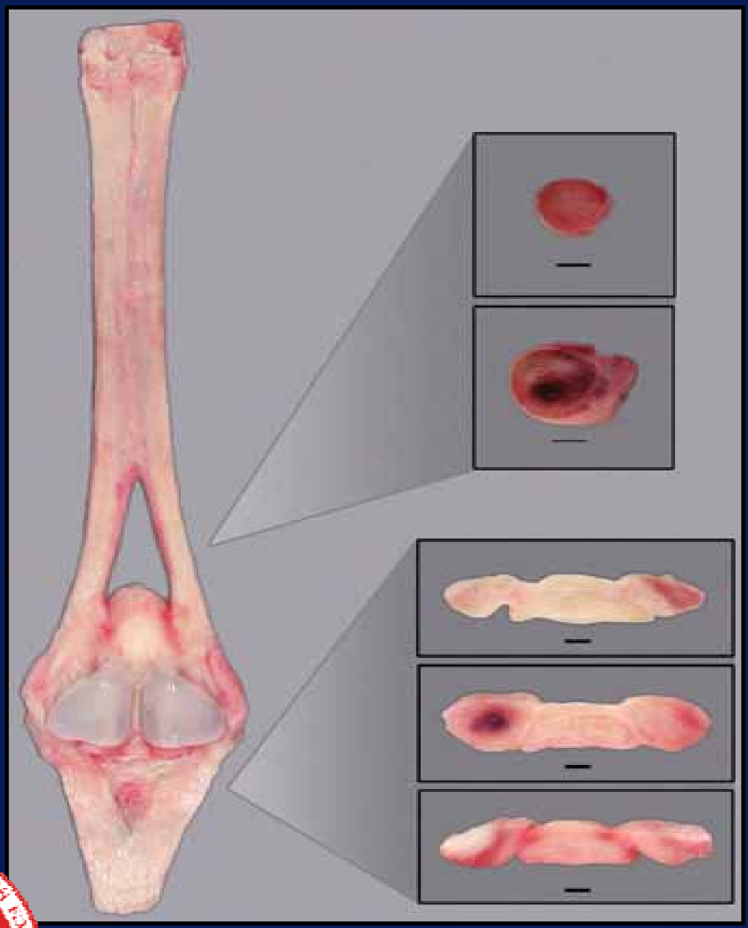


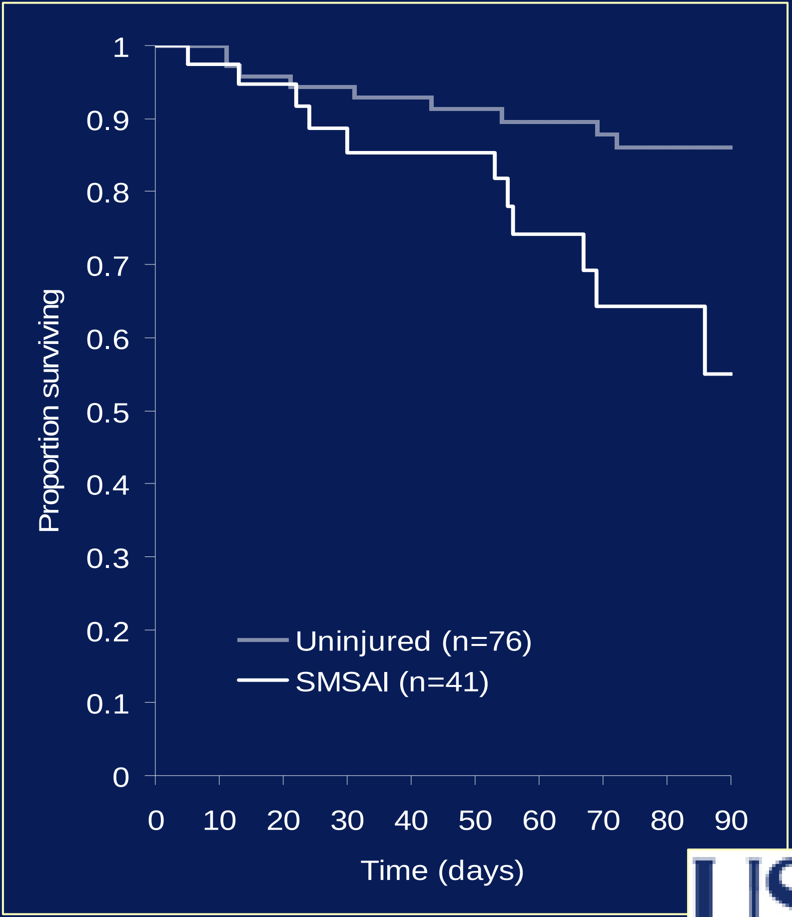
Pre-race Physical Findings

- 5-18 times increased risk with positive assessment
  - Low incidence of injury in associated race limits implementation

Cohen, et al. JAVMA 2000;216:1273-1278
Cohen, et al. JAVMA 1997;211:454-463

Mild Suspensory Apparatus Injury Leads to Severe Injury





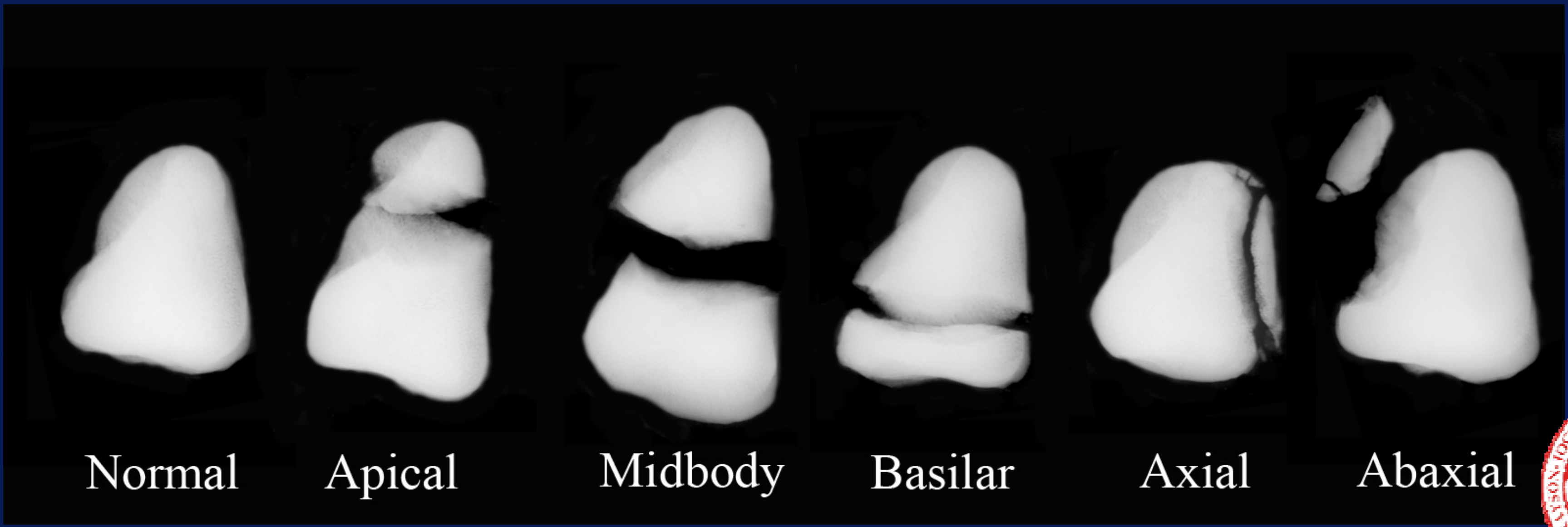
Hill, et al. JAVMA 2001;218:1136-1144

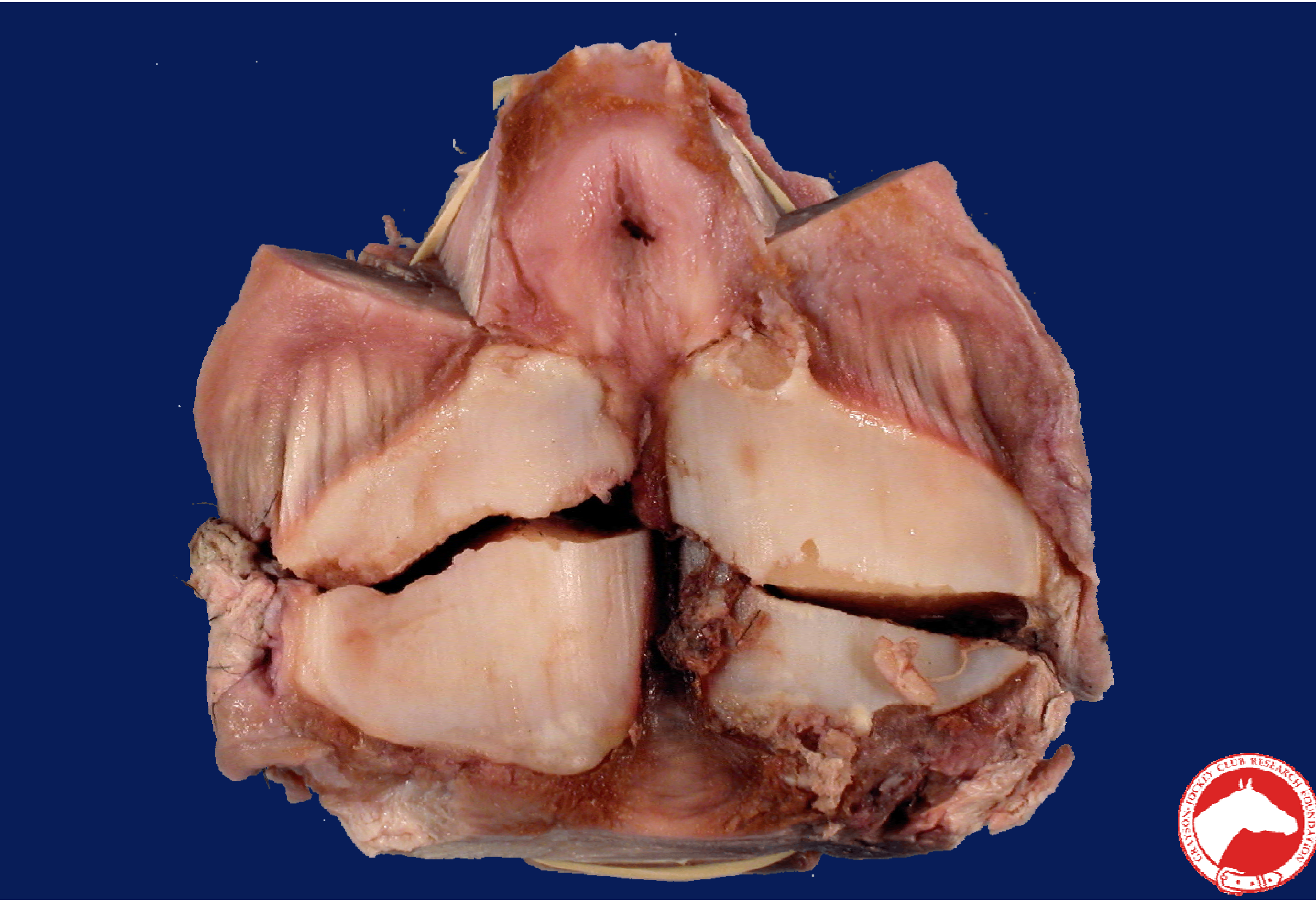
Association between findings on palmarodorsal radiographic images and detection of a fracture in the proximal sesamoid bones of forelimbs obtained from cadavers of racing Thoroughbreds

Anthenill LA, Stover SM, Gardner IA, et al. *Am J Vet Res* 2006;67:858-868

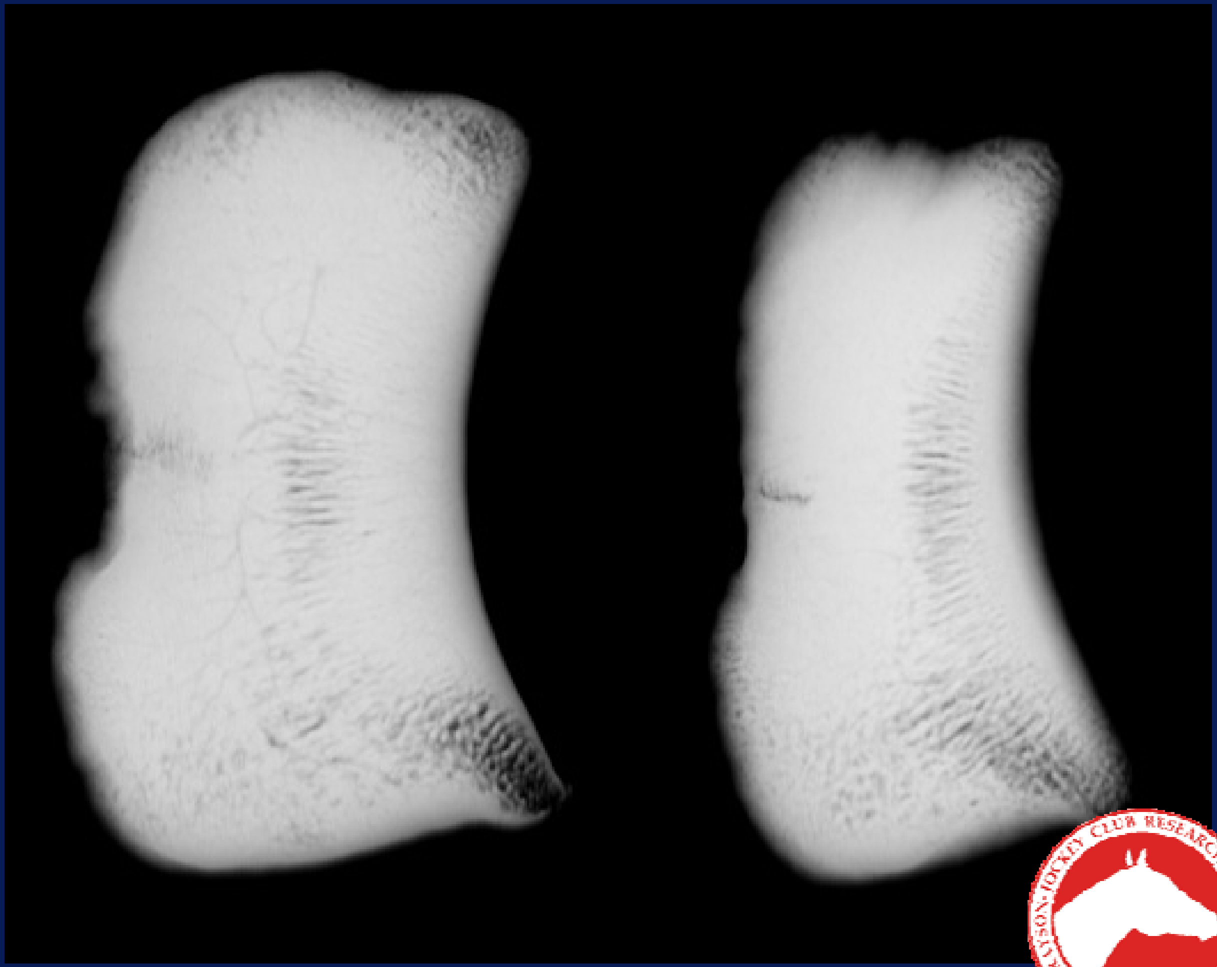
328 horses

- 136 horses with a fracture
- 192 horses without a fracture




GRAYSON-JOCKEY CLUB RESEARCH FOUNDATION

PSB Fracture



Outline

- Magnitude of the problem
- Nature of injuries – PRE-EXISTING DAMAGE
- Injury development
- Key factors that promote injury development
- Risk factors for injury
- Race surface considerations

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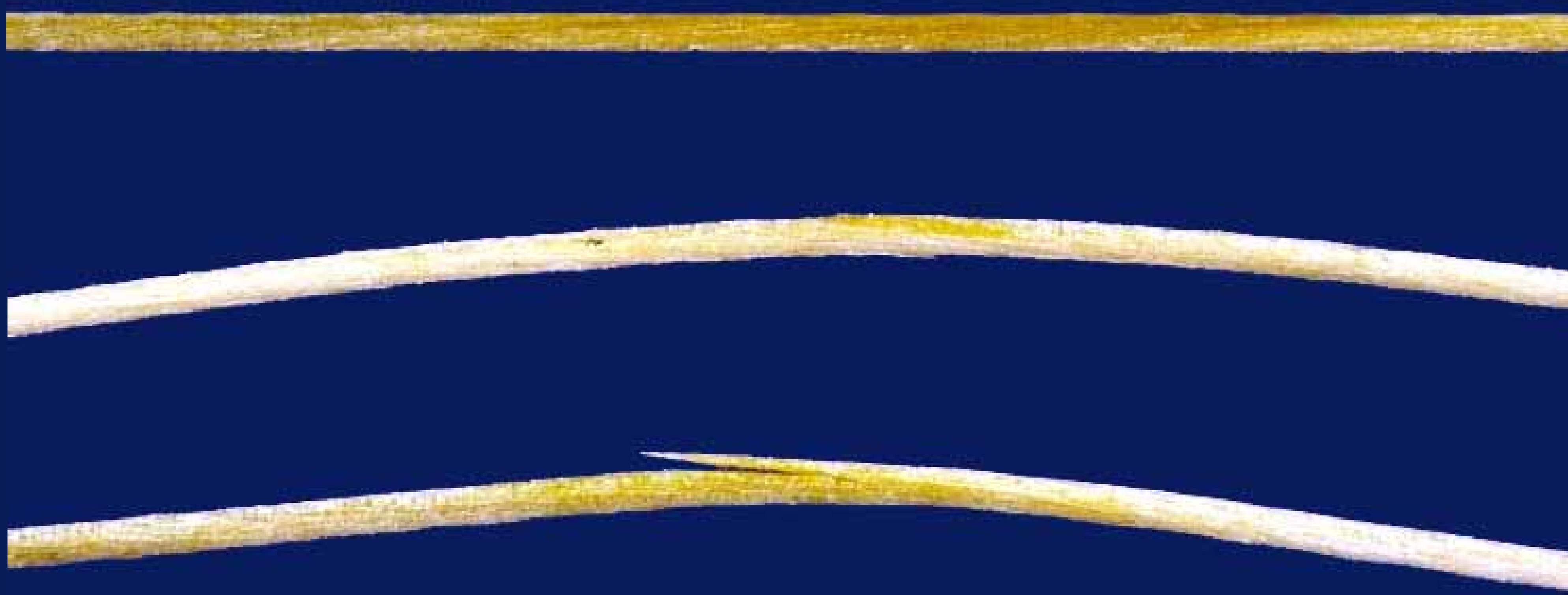
Fatigue Damage

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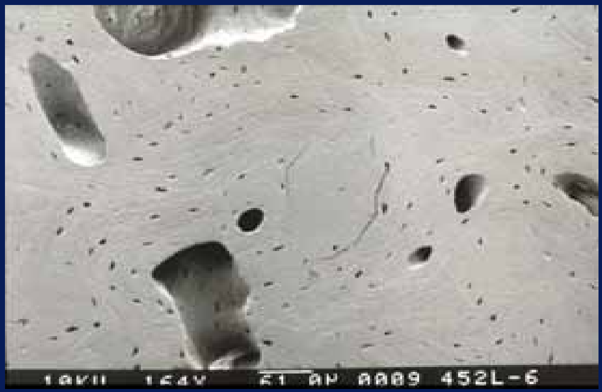
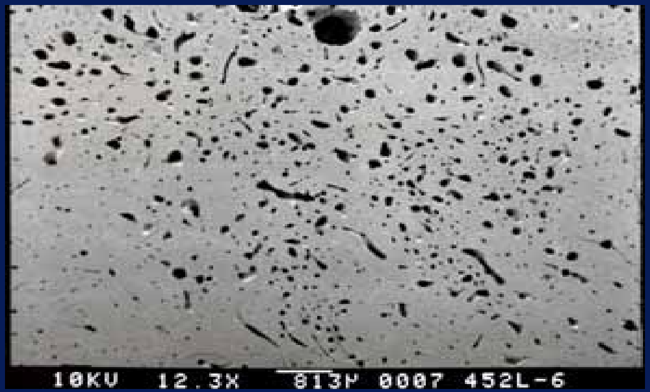
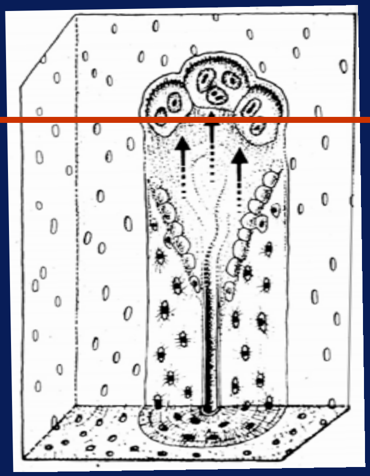
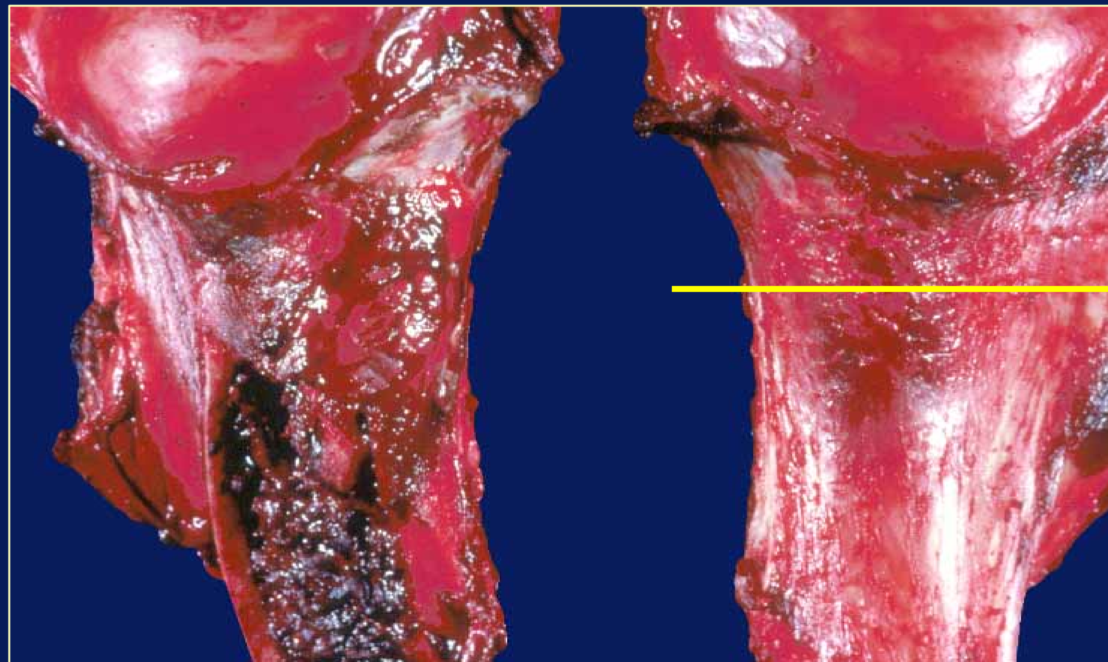
Injury can induce transient bone loss

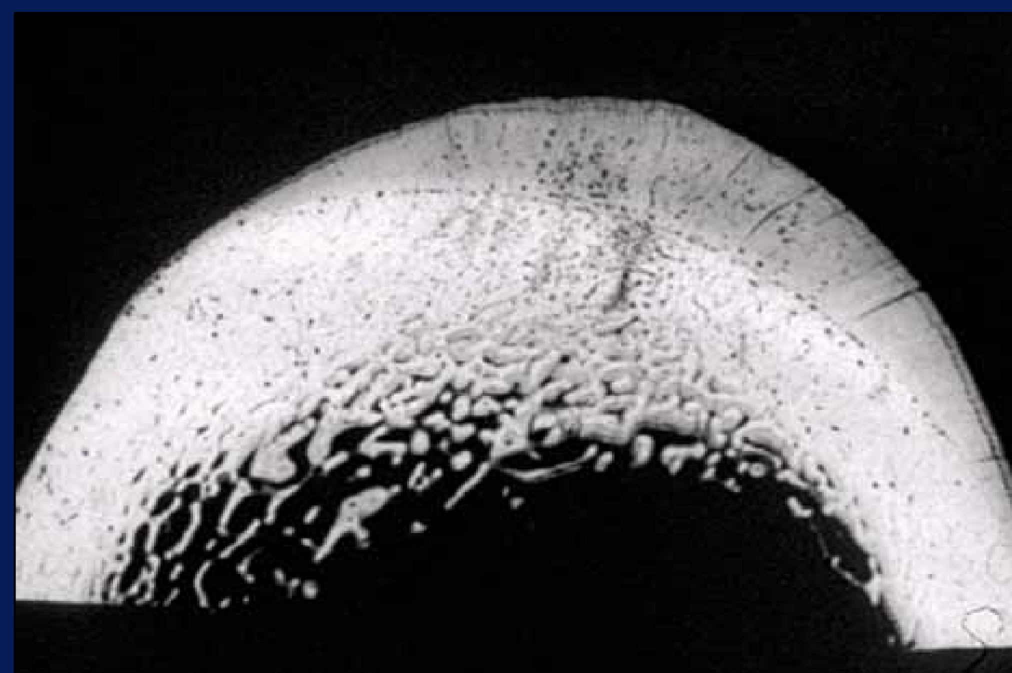




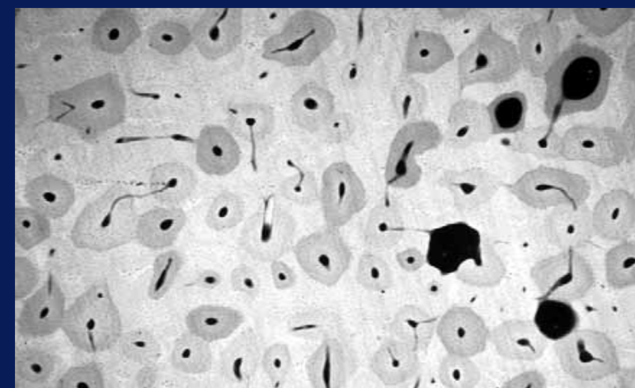
2-3 wks





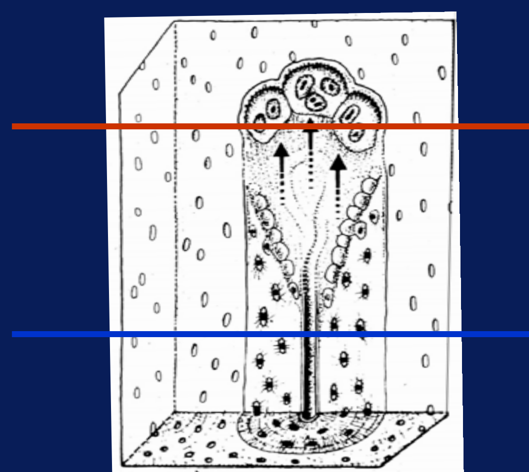


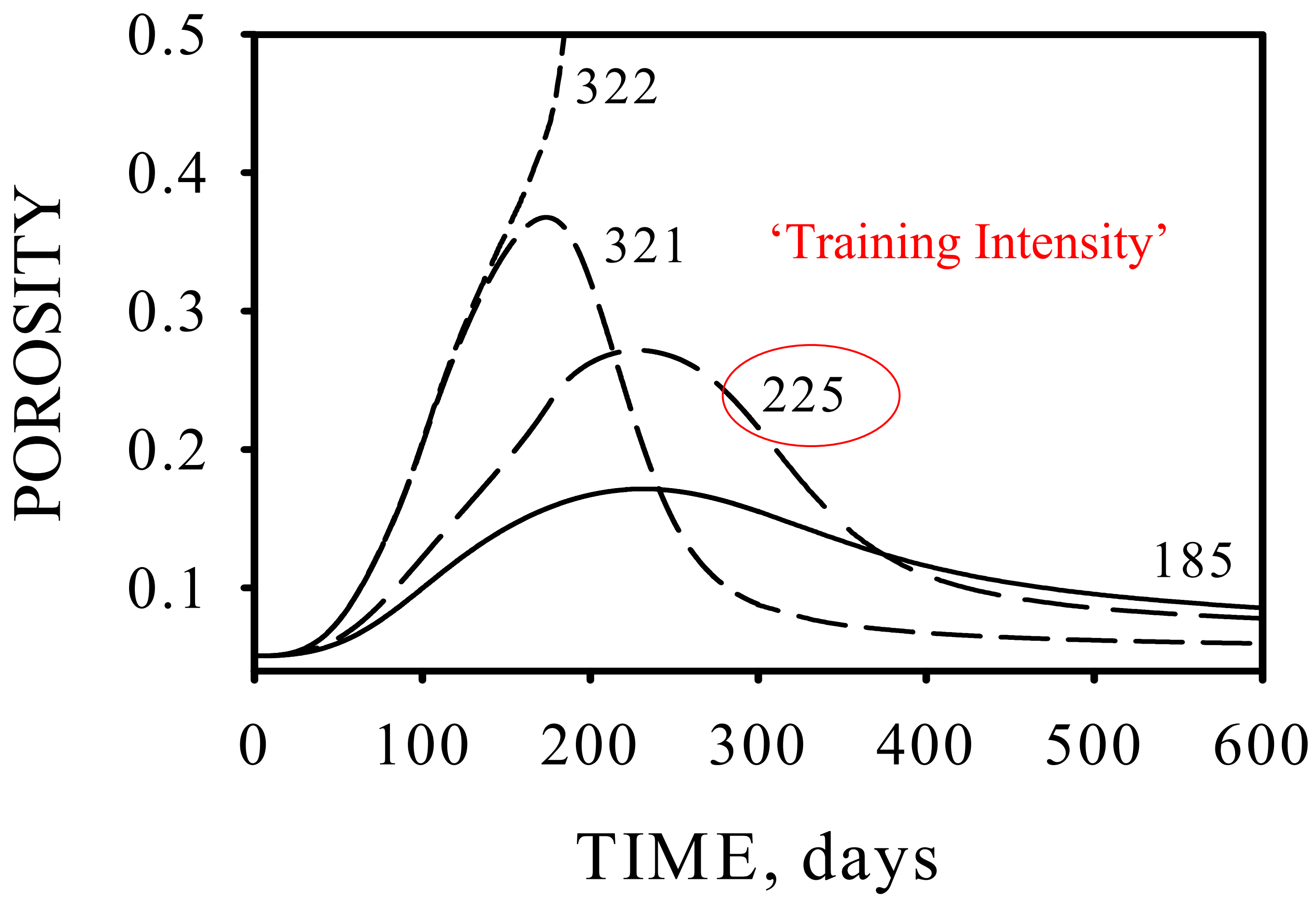
Repair takes TIME



2-3 wks

3 mos

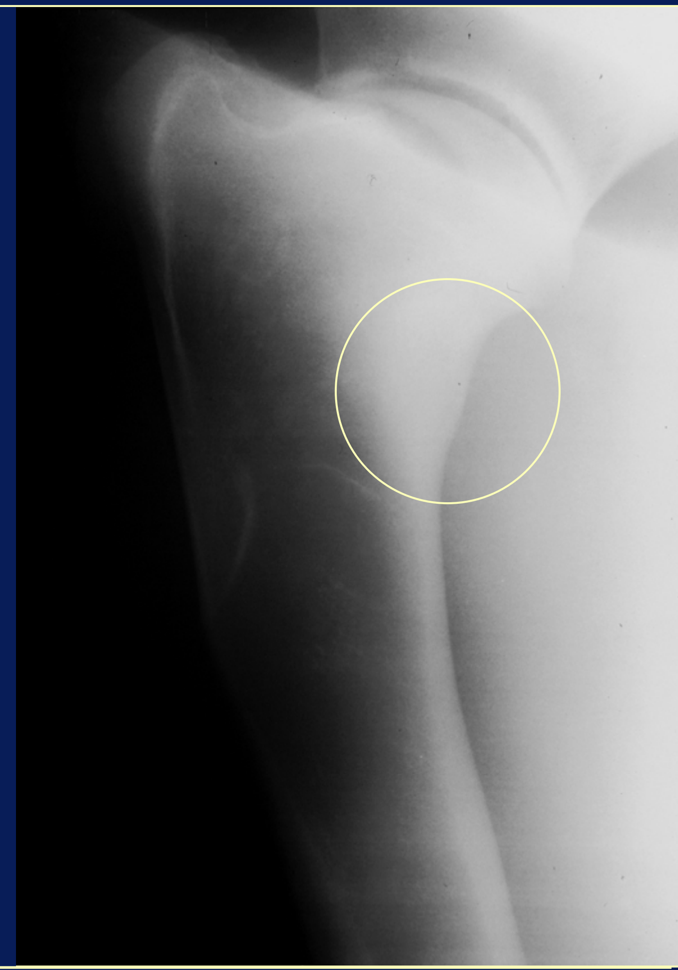




2001 <u>Martin, R.B.</u>: The Role of Bone Remodeling in Preventing or Promoting Stress Fractures. In <u>Musculoskeletal Fatigue and Stress Fractures</u>, D.B. Burr and C. Milgrom, eds., CRC Press, Boca Raton, FL

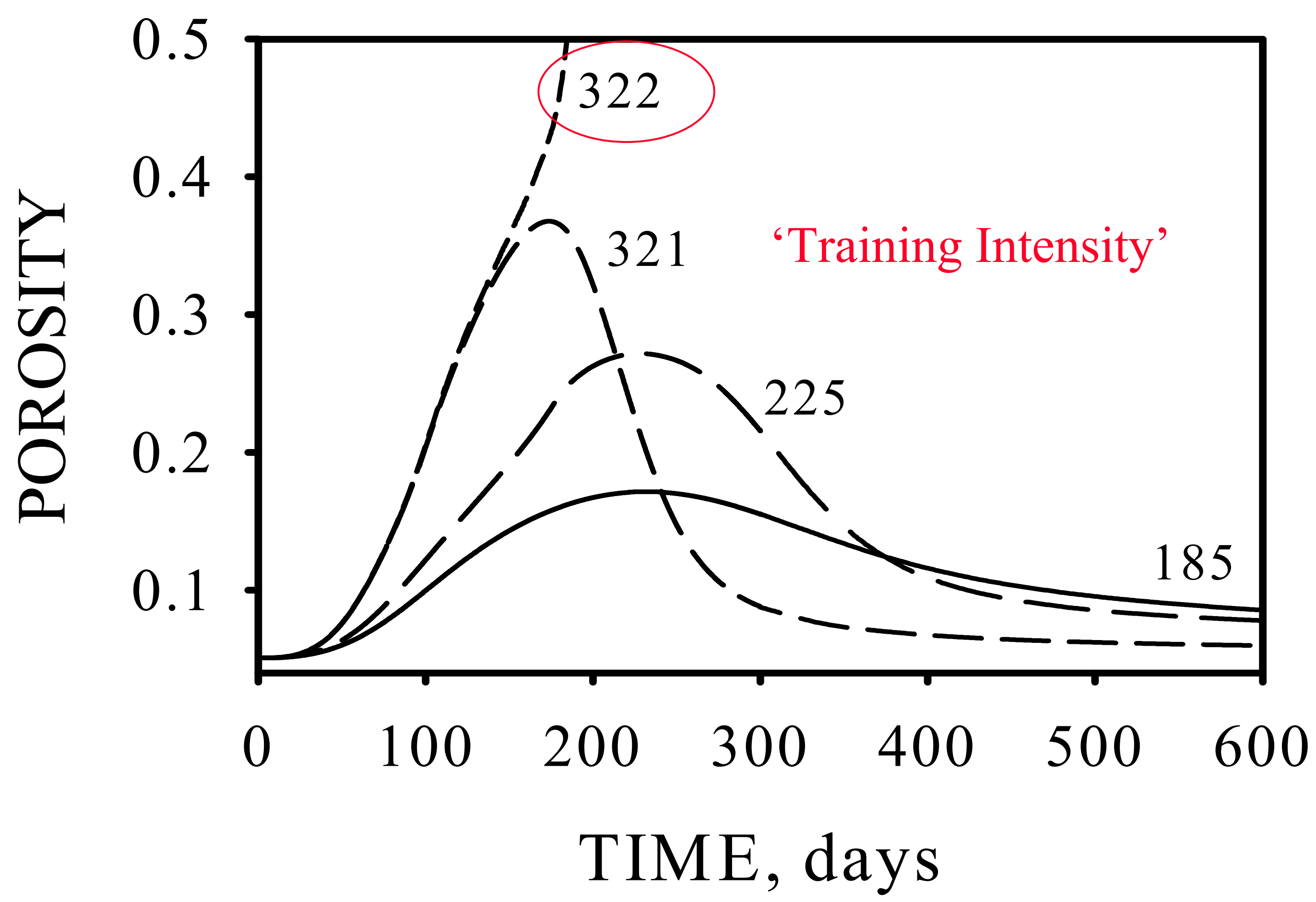
Early clinical signs

1 month later



3 months later

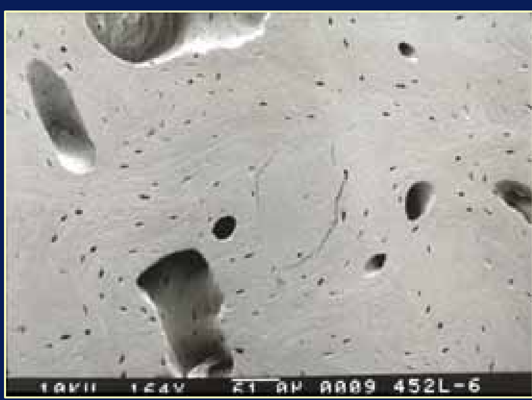
Courtesy of Dr. Rick Arthur

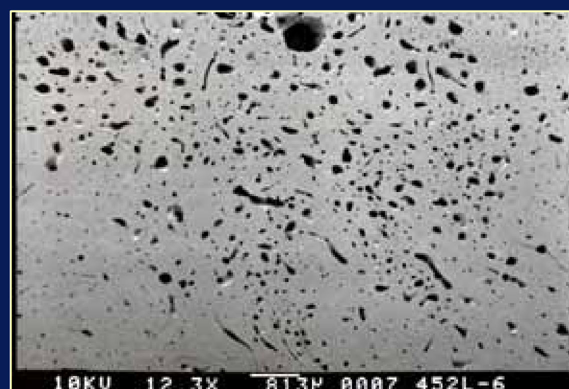


2001 Martin, R.B.: The Role of Bone Remodeling in Preventing or Promoting Stress Fractures. In Musculoskeletal Fatigue and Stress Fractures, D.B. Burr and C. Milgrom, eds., CRC Press, Boca Raton, FL

Catastrophic Fracture

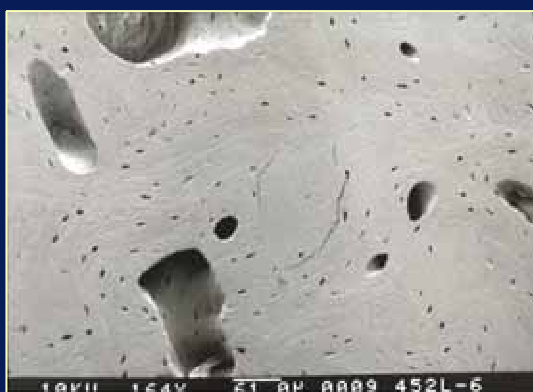
Bone damage exceeds bone repair





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

excessive activity

completion

adaptation

transient osteoporosis

+

physiologic activity

complete bone fracture

Outline

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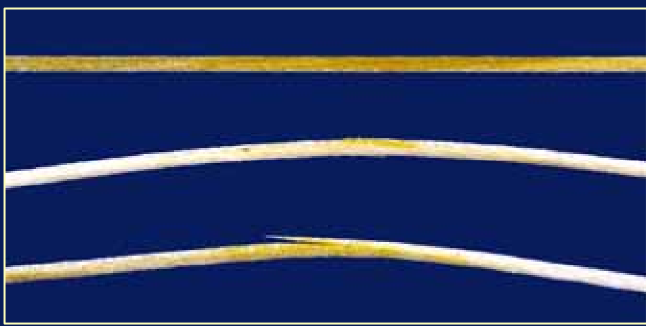
Key Factors for Injury



physical activity

 # cycles ⇩ *load magnitude*

microdamage

bone remodeling
and modeling

completion

adaptation

excessive activity

transient osteoporosis
+
physiologic activity

complete bone fracture

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

excessive activity

completion

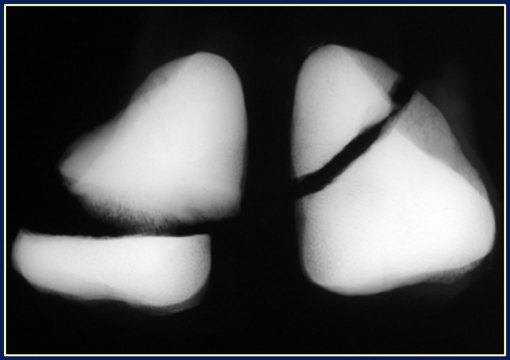
adaptation

transient osteoporosis + *physiologic activity*

complete bone fracture

Outline

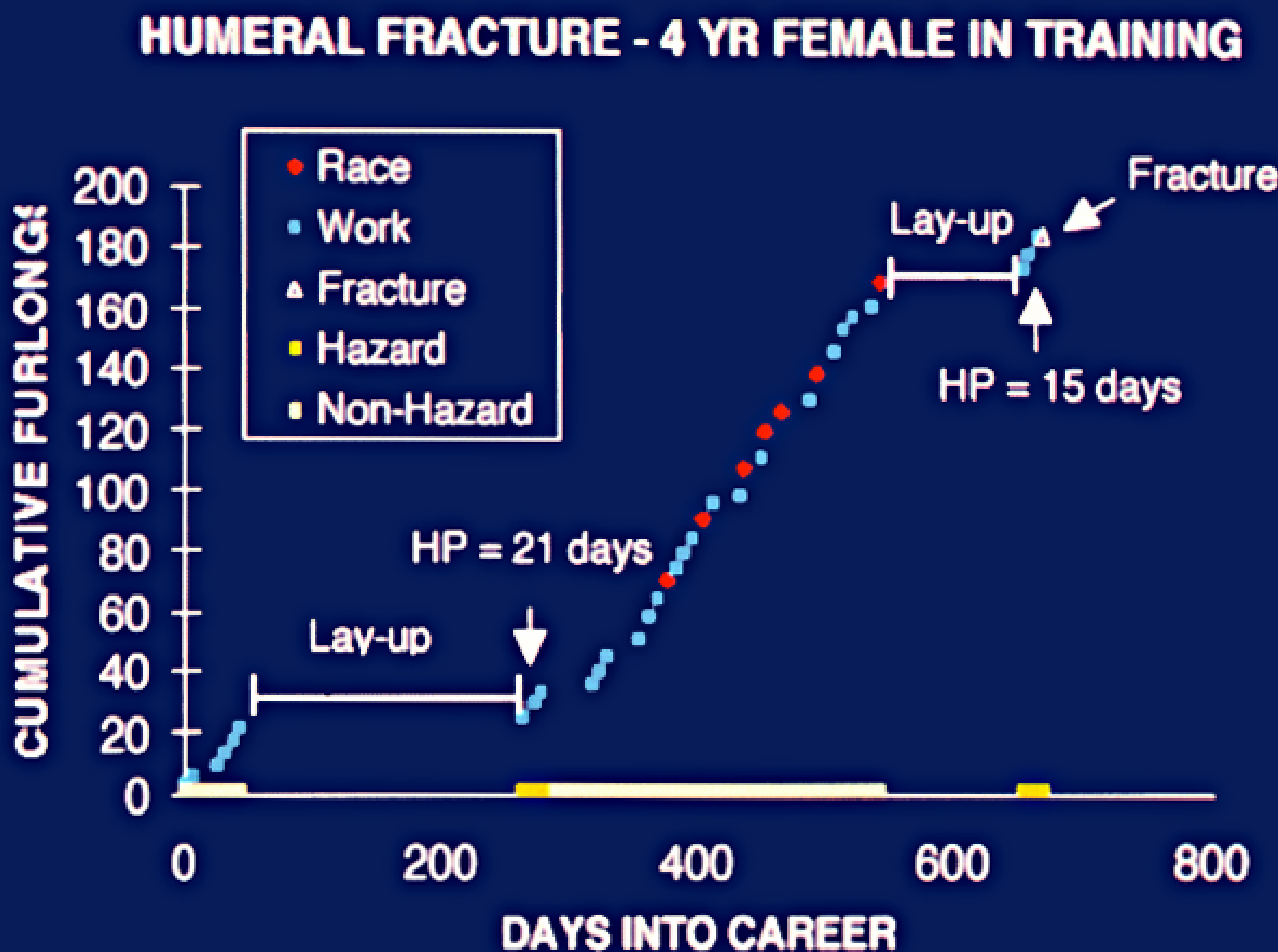
- Magnitude of the problem
- Nature of injuries
- Injury development
- Key factors
- Risk factors for injury – distance & distance rates
- Race surface considerations



Proximal Sesamoid Bone Fracture

	Non-PSB Death	PSB Fracture
# Works	21	26
# Races	6	8
Races/yr	4.7	6.4
Days since layup	46	153

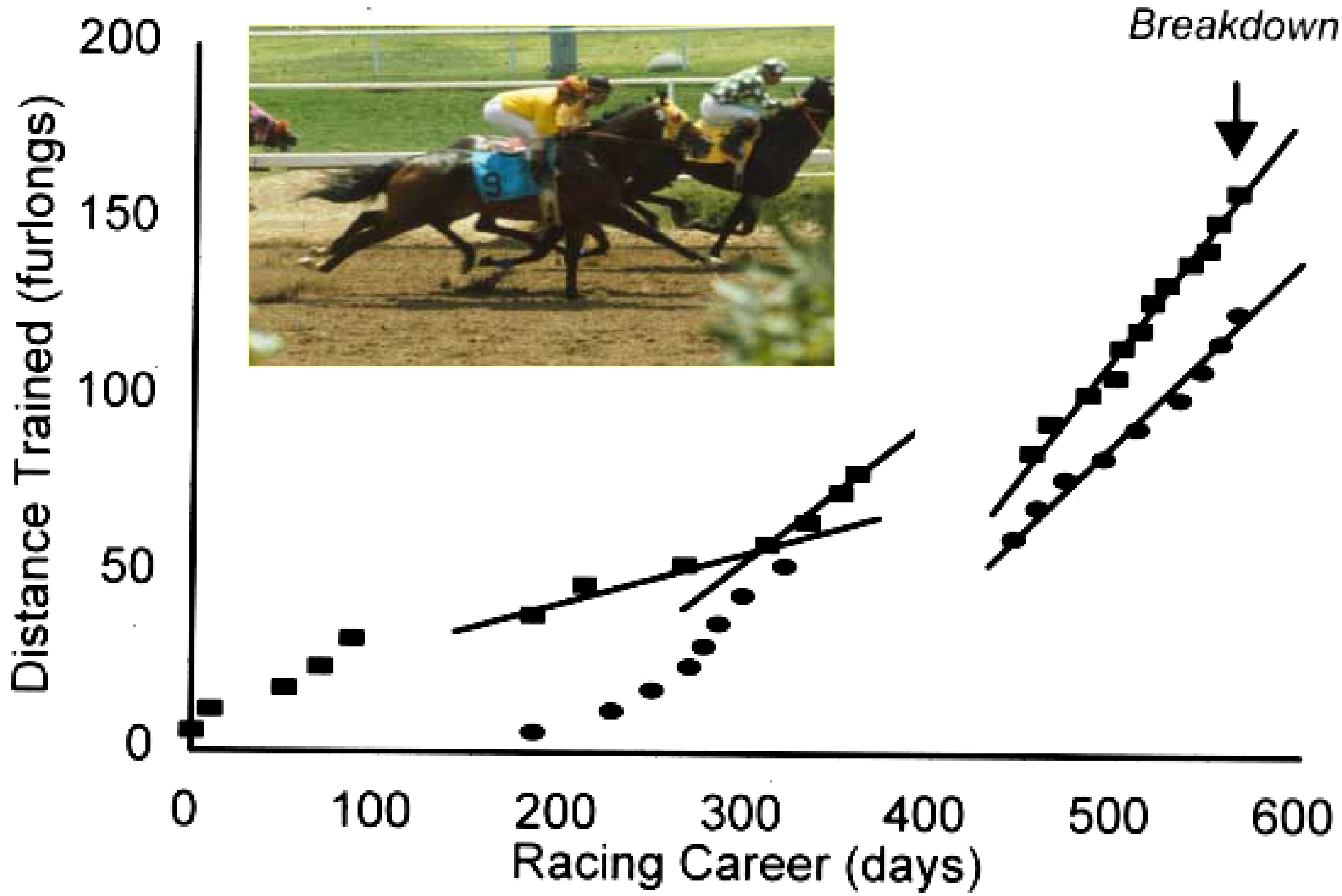
Anthenill, et al. Am J Vet Res submitted 2006

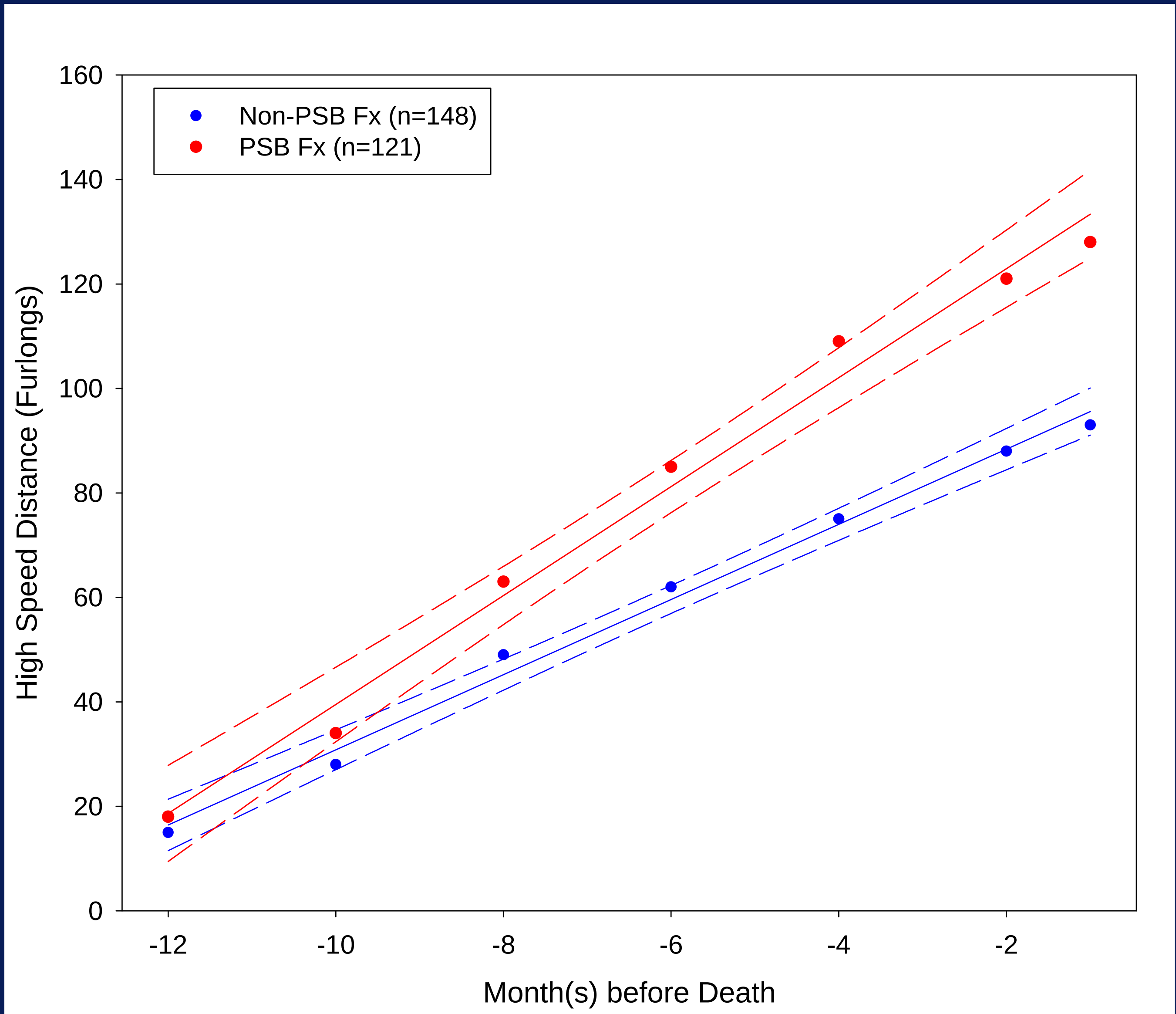


Carrier, et al. J Am Vet Med Assoc 1998;212:1582-1587

Fatal Musculoskeletal Injuries (FMI)

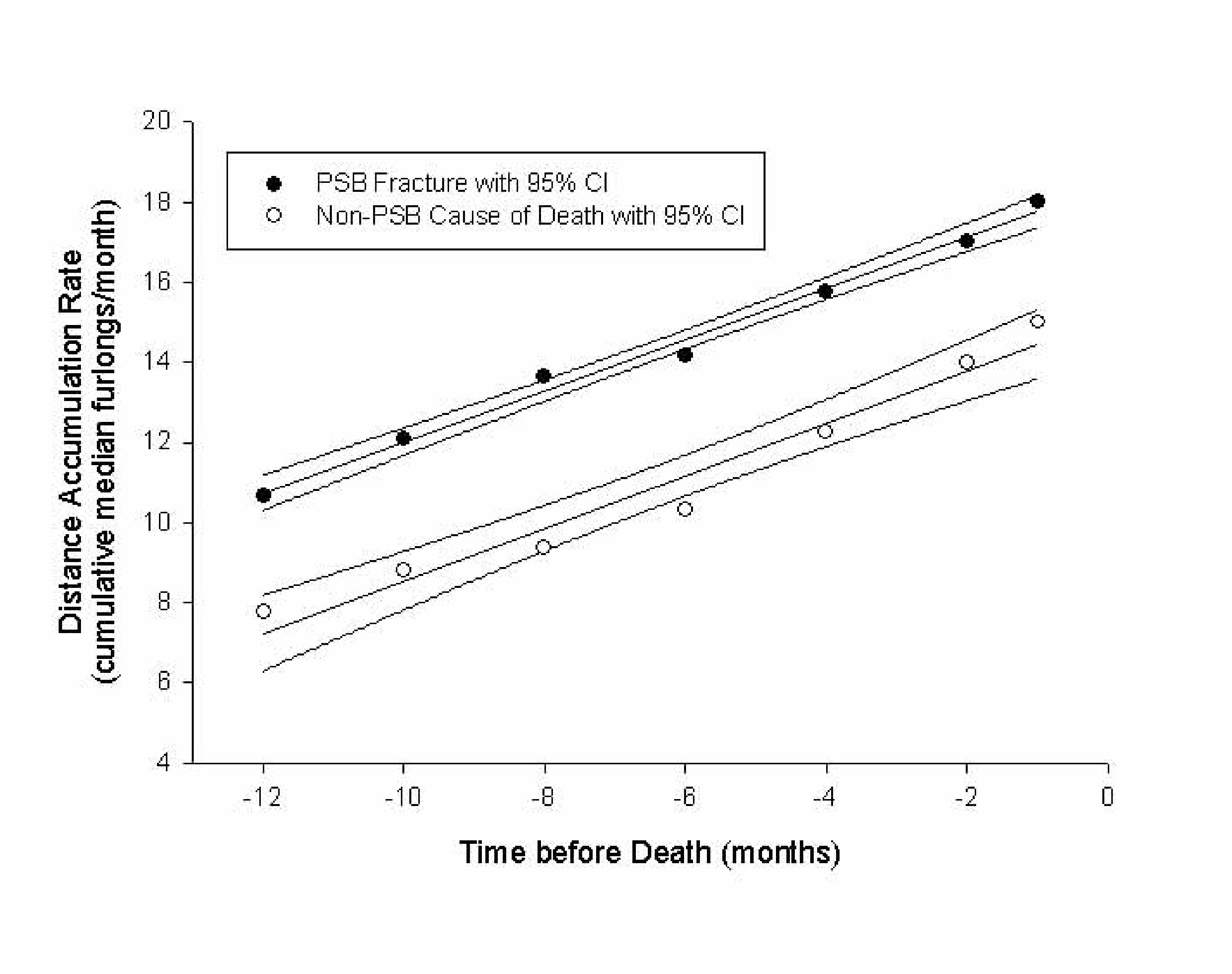
Training Effect



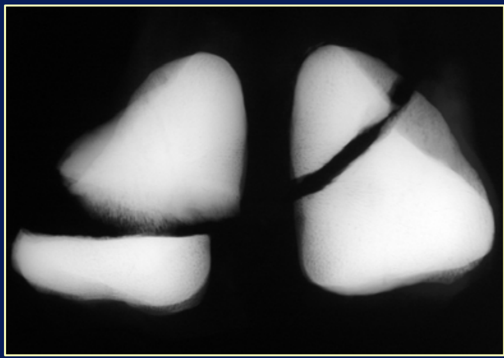


Anthenill, et al. Am J Vet Res submitted 2006

Rates of Distance Accumulation



Anthenill, et al. Am J Vet Res submitted 2006



Estimated Odds Ratios for PSB Fracture

Exposure	OR*	95% CI
distance 2 mos	1.03	1.01-1.05
works	1.16	1.01-1.32
work furlongs	0.97	0.94-0.99
gender		

Anthenill, et al. Am J Vet Res submitted 2006

Distance and Rate Effects

- Australia

  Cogger, et al. Prev Vet Med 2006;74:36-43

- UK

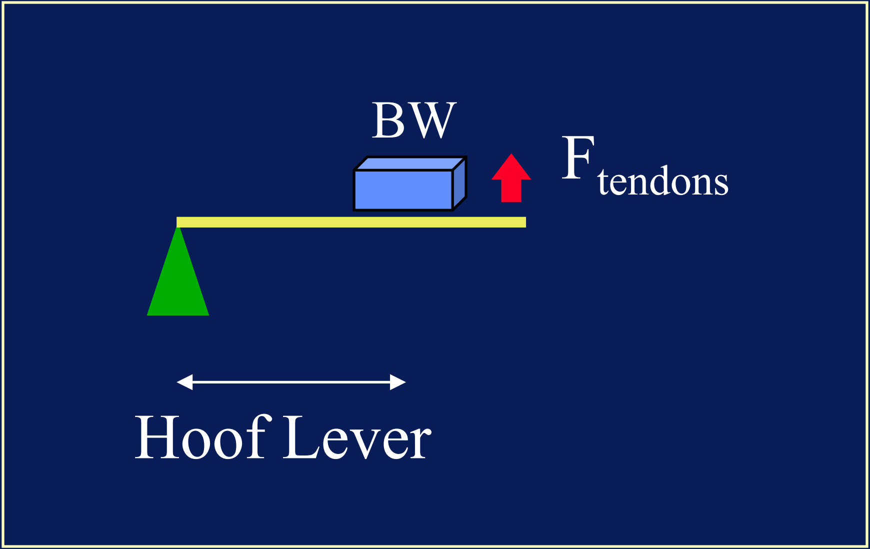
  Verheyen, et al. Prev Vet Med 2006;74:21-35

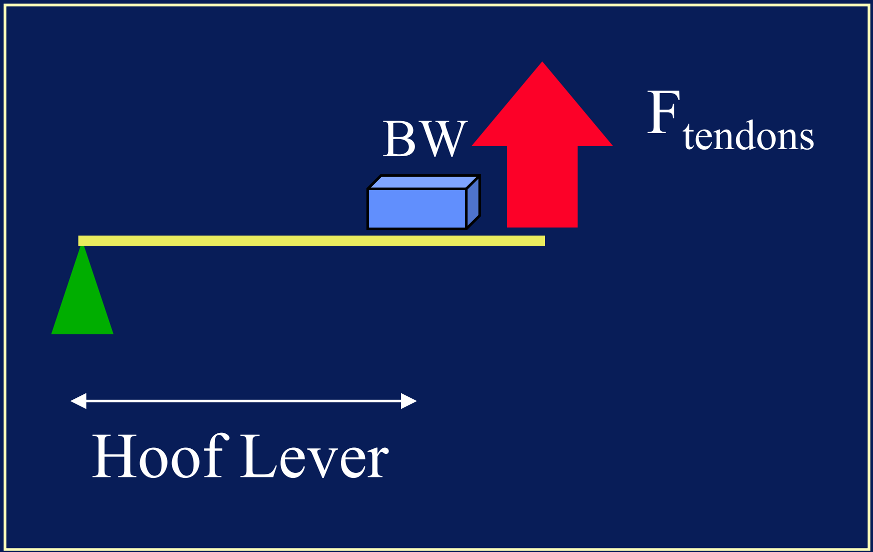
  Henley, et al. Prev Vet Med 2006;74:3-20

Outline

- Magnitude of the problem
- Nature of injuries
- Injury development
- Key factors
- Risk factors for injury – load magnitude
- Race surface considerations

System of Levers





Conformation Factors

- Inherent conformation

  Anderson, et al. Eq Vet J 2004

  – 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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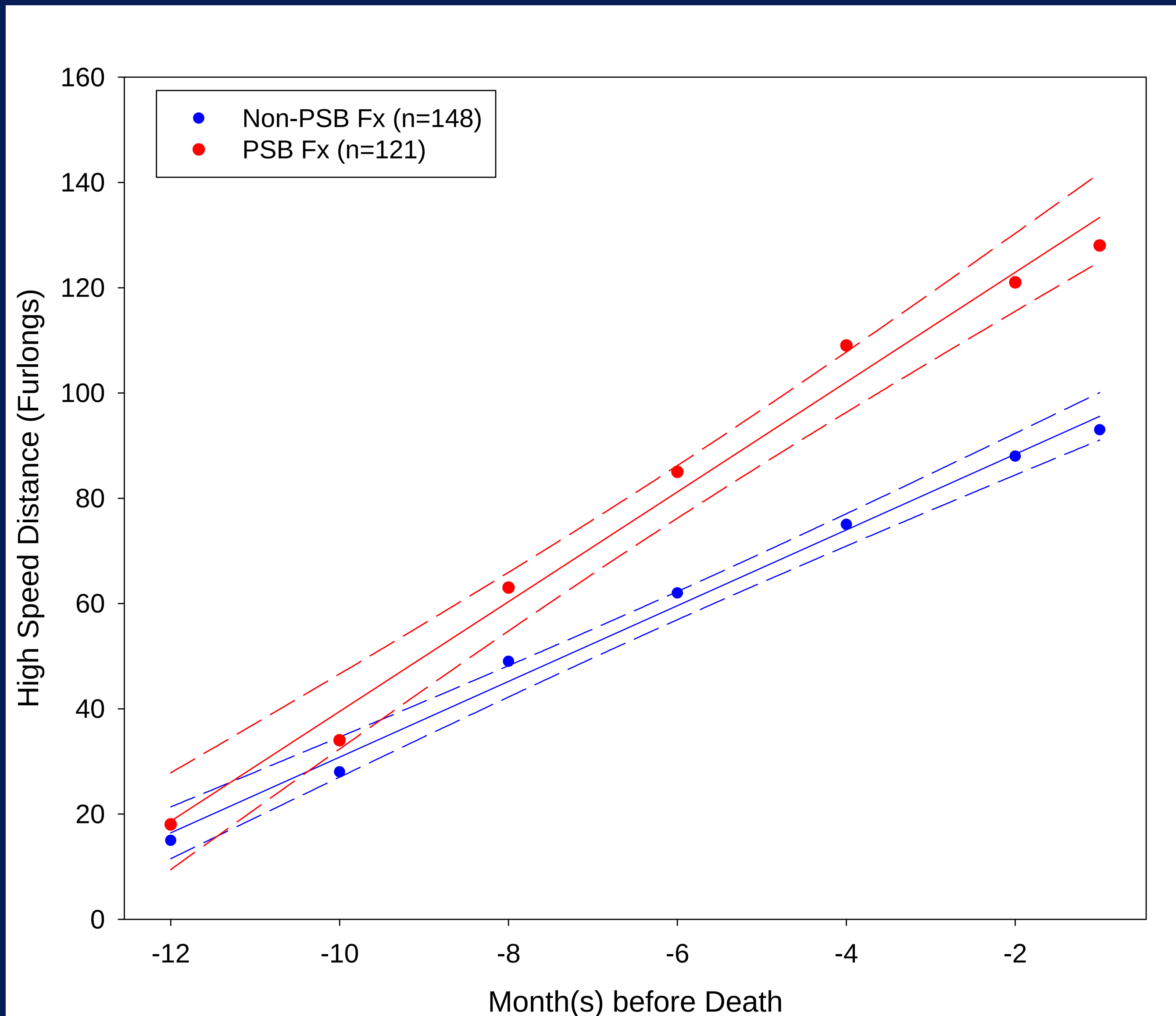
Race Surface

Race Surface

- Scapegoat

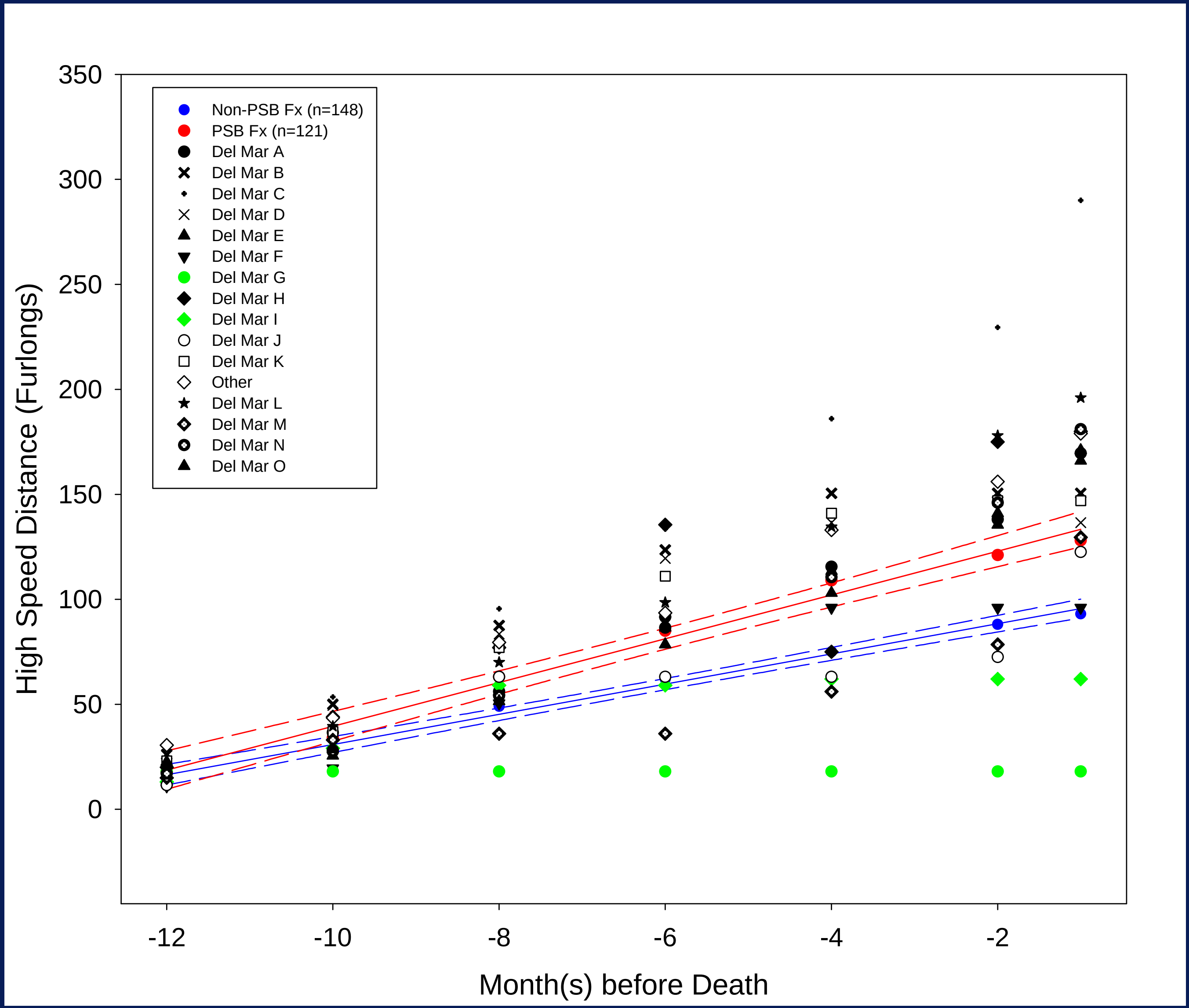
  ‘ one who is blamed for misfortunes, often as a way of distracting attention from the real causes’

(http://en.wikipedia.org/wiki/Scapegoats, 2006)



Anthenill, et al. Am J Vet Res submitted 2006

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

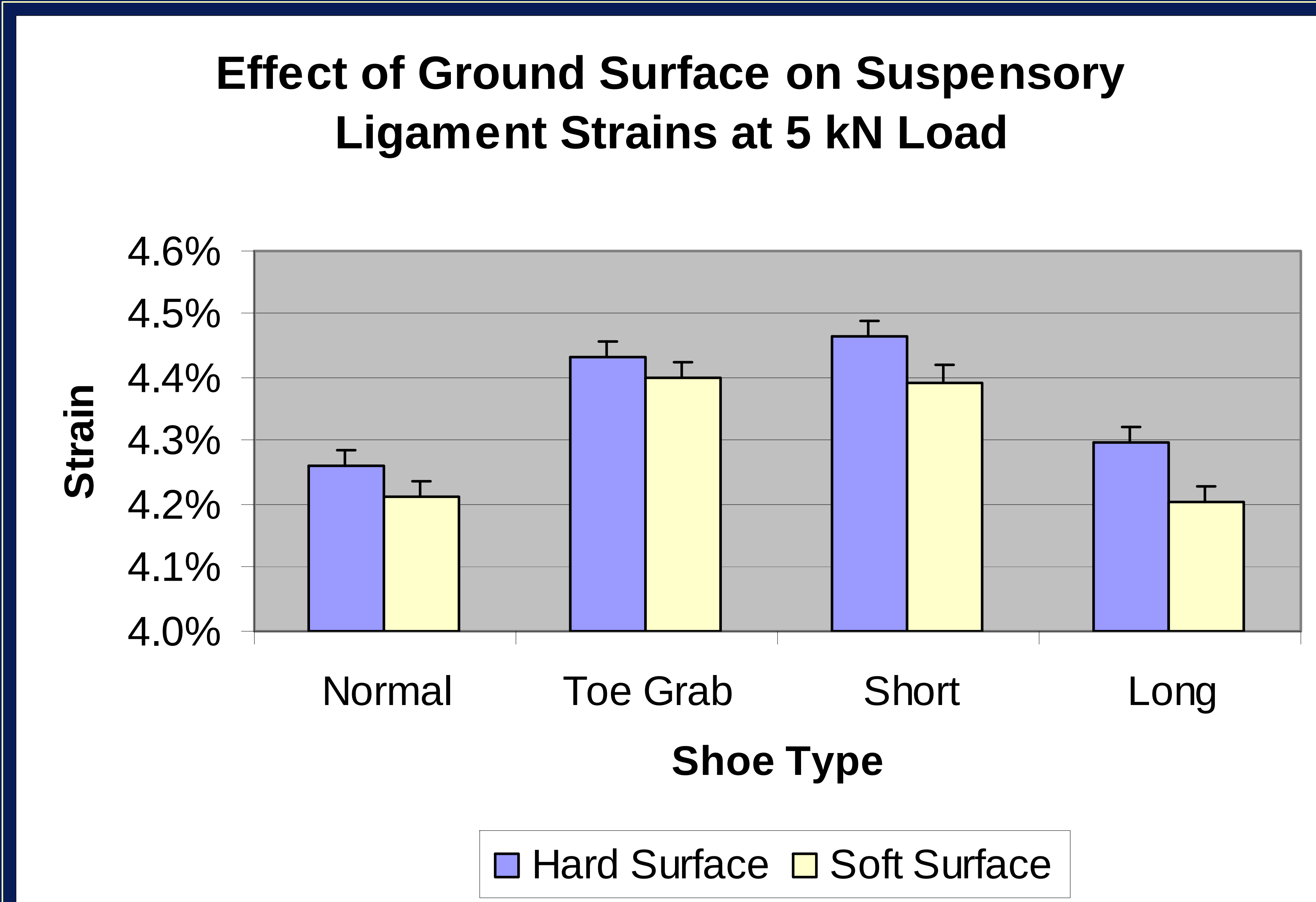
- Epidemiology results are *inconsistent*
  - dirt vs turf
  - soft vs hard
  - all-weather vs other
  - sand
  - fast vs slow

Parkin, et al. Equine Vet J 2004;36:513-519
Oikawa and Kusunose. Vet J 2005;170;369-374
Henley, et al. Prev Vet Med 2006;74:3-20
Hill, et al. Cornell Vet 1986;76:361-369
Hill, et al. JAVMA 2001;218:1136-1144
Mohammed, et al. Equine Vet J 1991;23:445-448
Hernandez, et al. JAVMA 2001;218:83-86
Moyer, et al. Equine Vet J. 1991;23:166-168

Race Surface

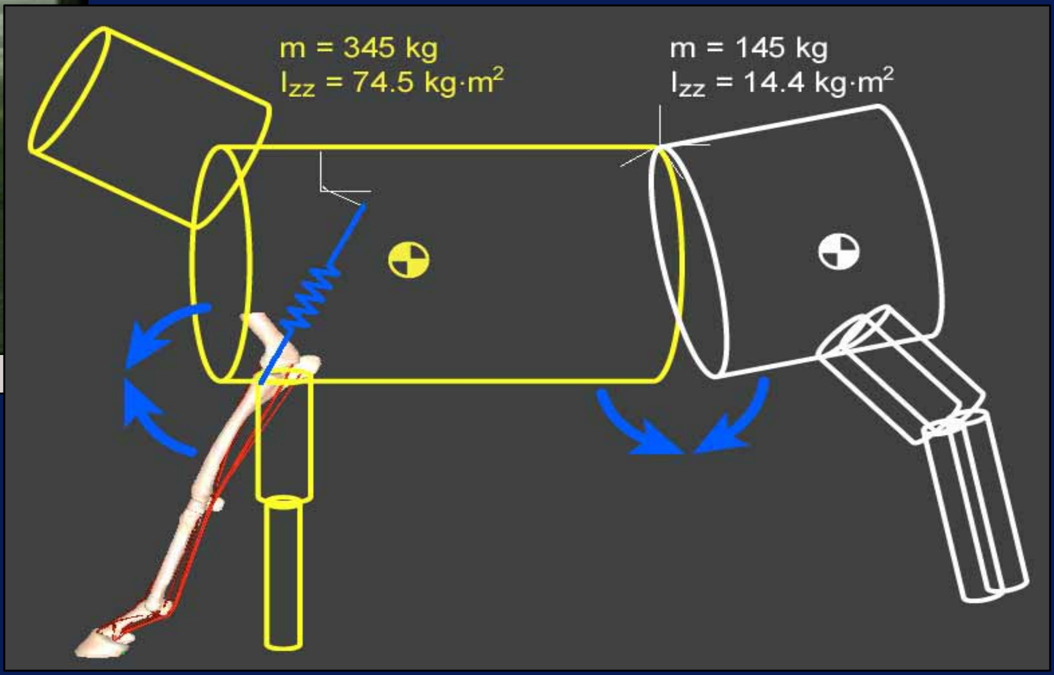
- Need for additional approaches to reduce confounding variables
  - direct race surface measurements
  - *in-vitro* studies
  - modeling approaches
  - *in-vivo* studies

Le Jeune, et al.


Effect of Ground Surface on Suspensory Ligament Strains at 5 kN Load
Strain
4.6%
4.5%
4.4%
4.3%
4.2%
4.1%
4.0%
Normal
Toe Grab
Short
Long
Shoe Type
Hard Surface
Soft Surface

Doles, et al.

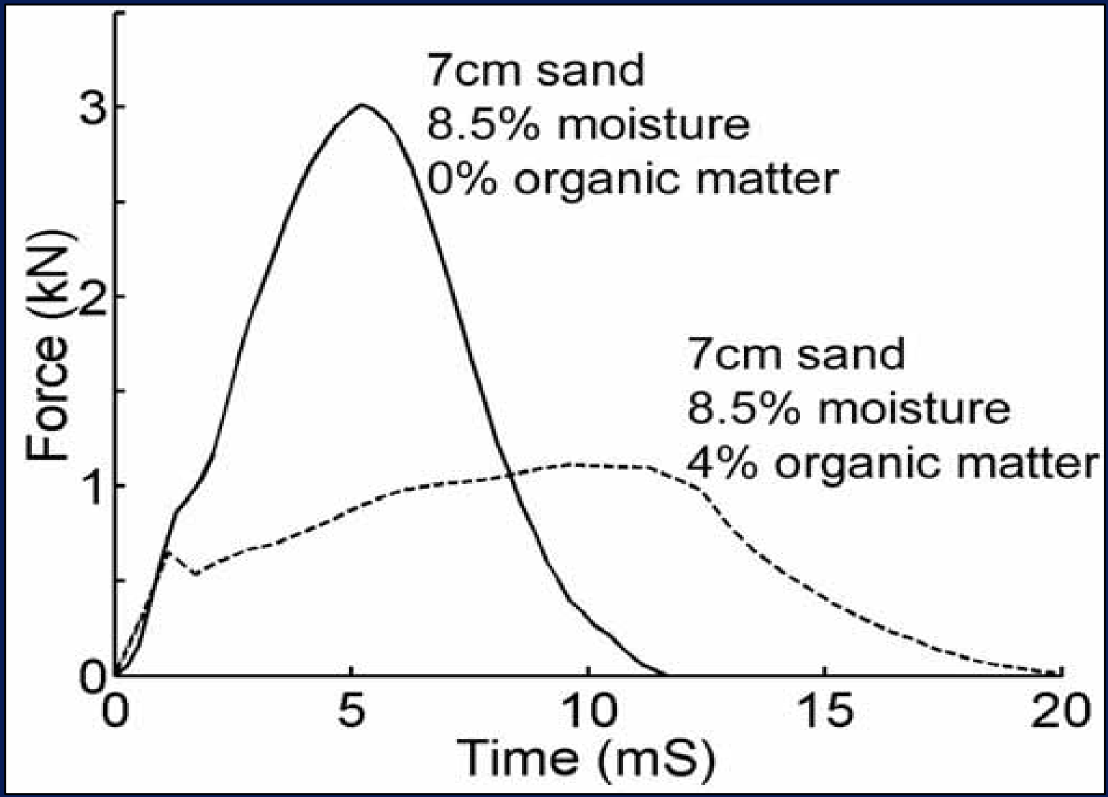
Computer Simulation



Influence of Soft Track

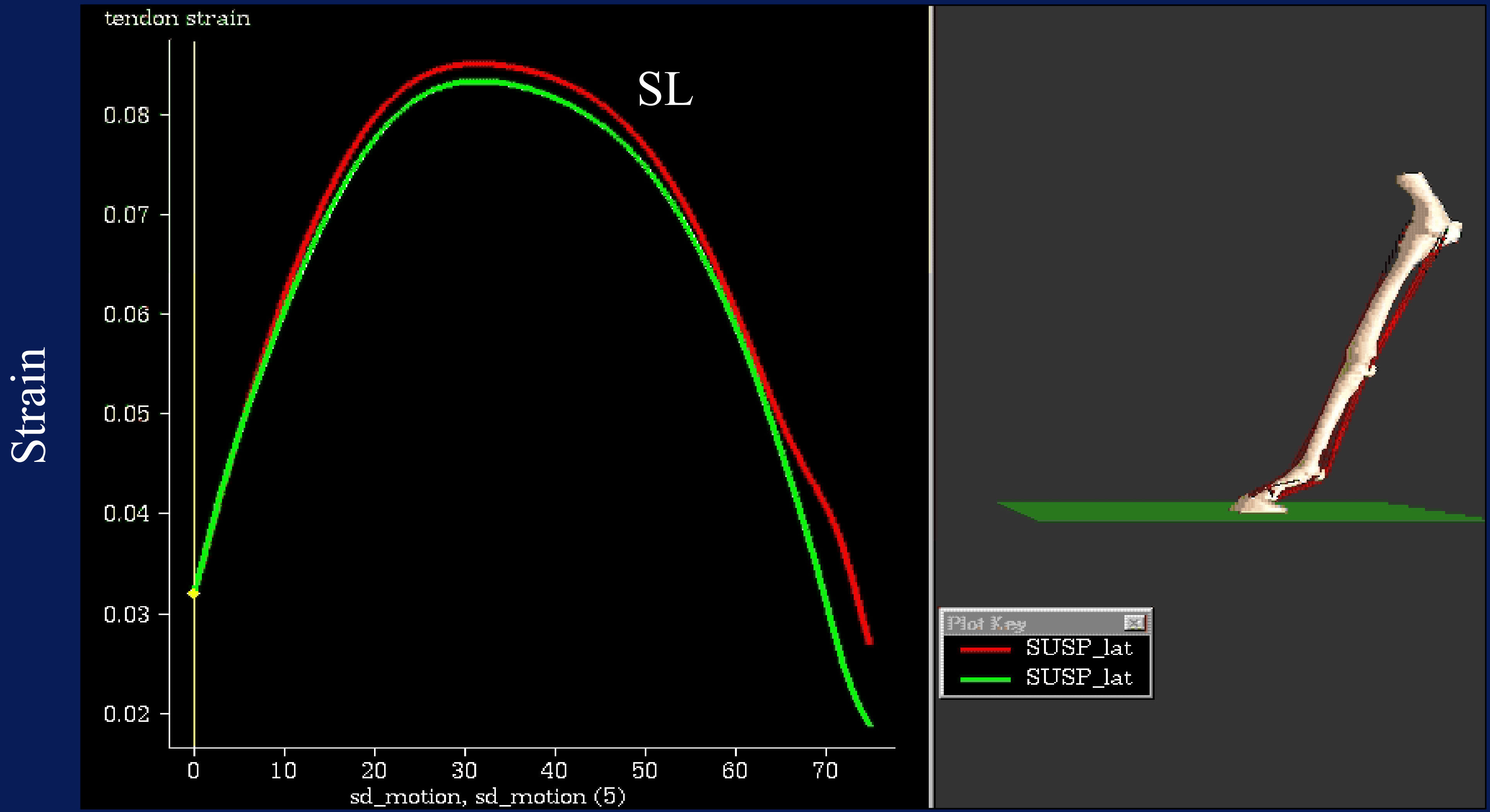
k: $1.84 \cdot 10^9 \rightarrow 6.98 \cdot 10^7$

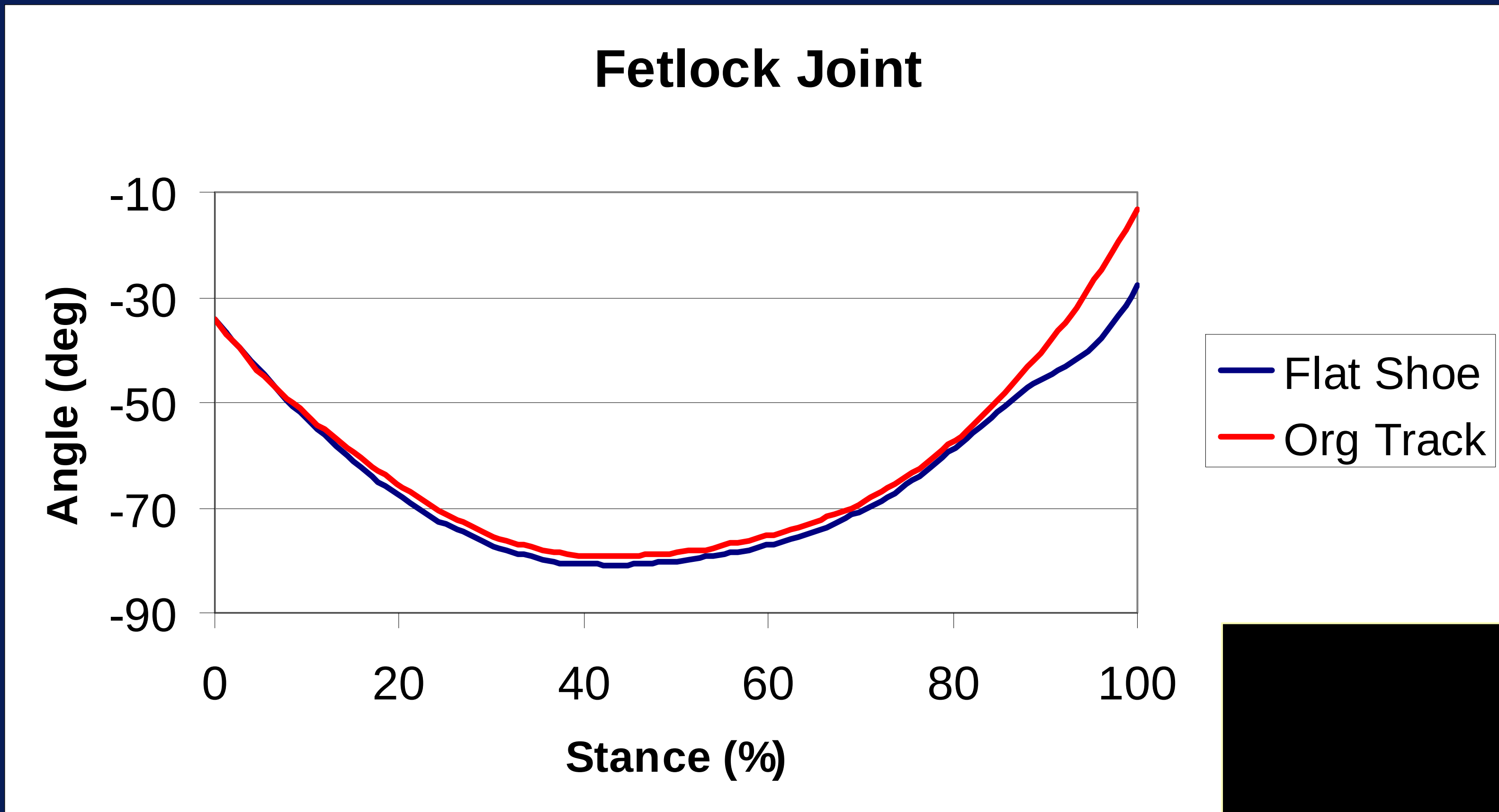
b: $69500 \rightarrow 32500$



Pratt (1984)

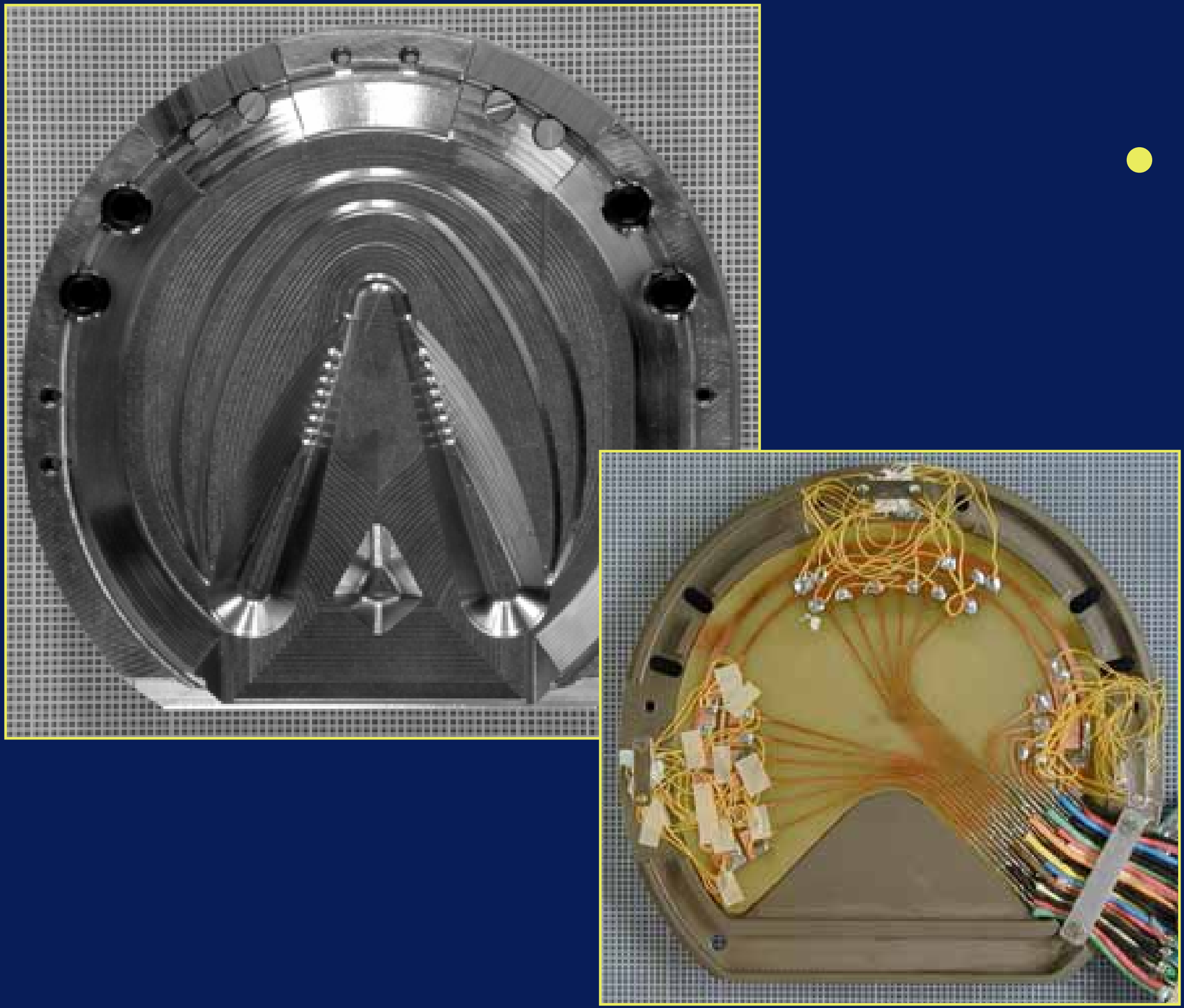
Compliant Surface: ε_{SL}





Fetlock Joint
-10
-30
-50
-70
-90
Angle (deg)
0
20
40
60
80
100
Stance (%)
Flat Shoe
Org Track

Instrumented Shoe



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

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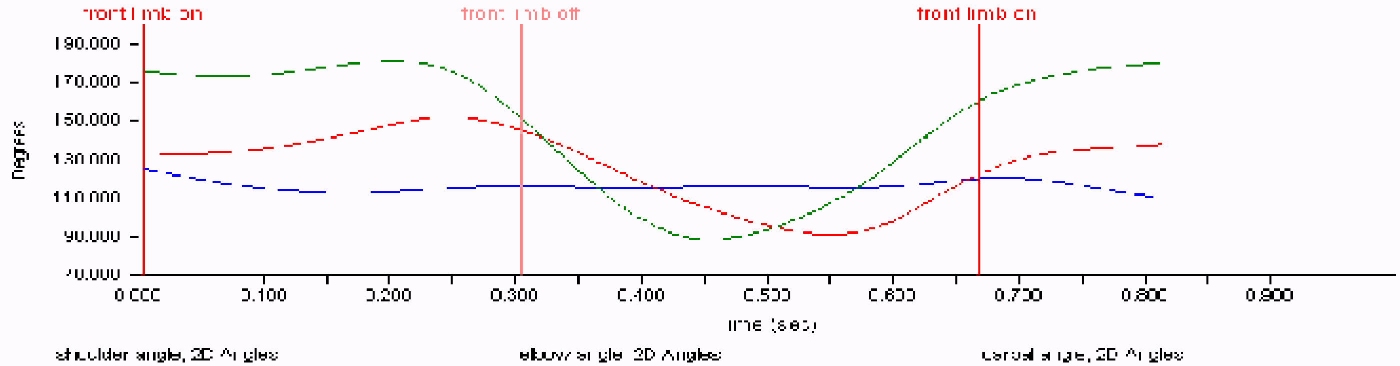
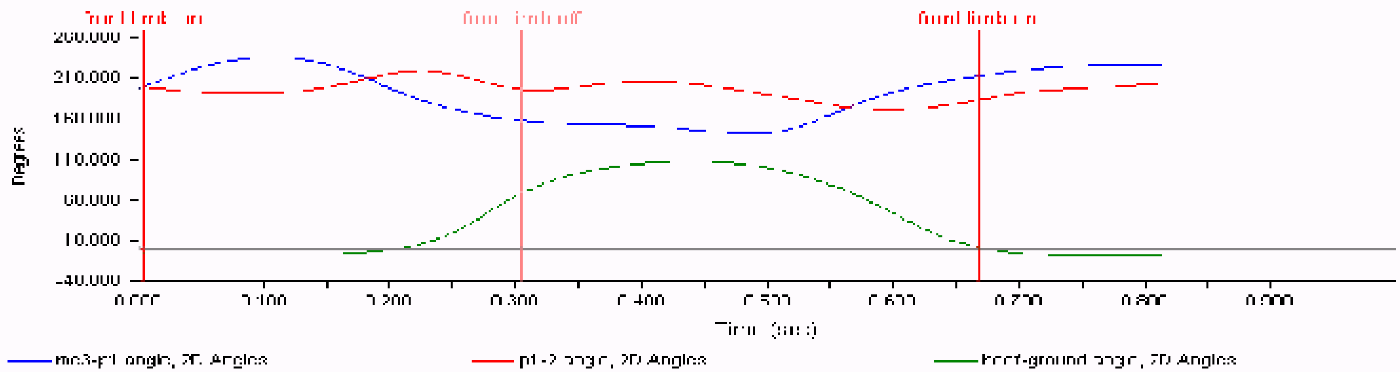
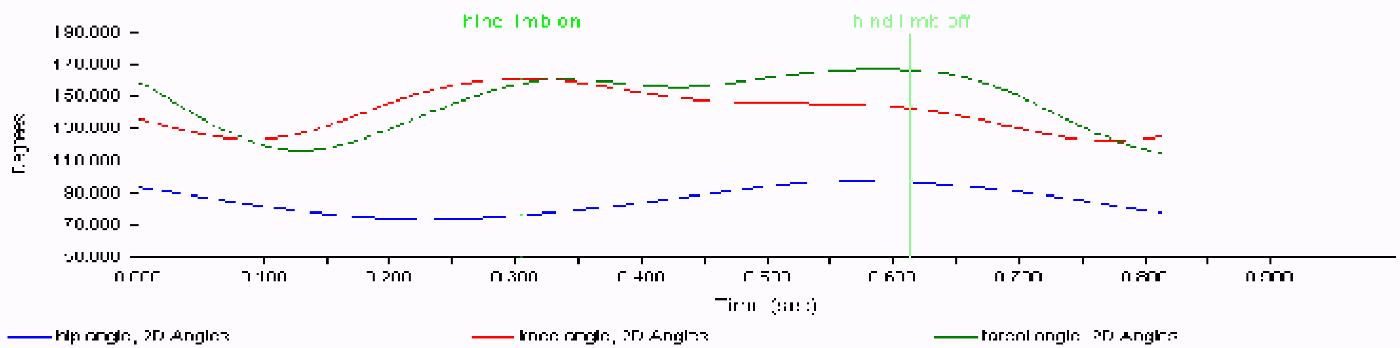
Trot - Polytrack

Sample
1 / 106

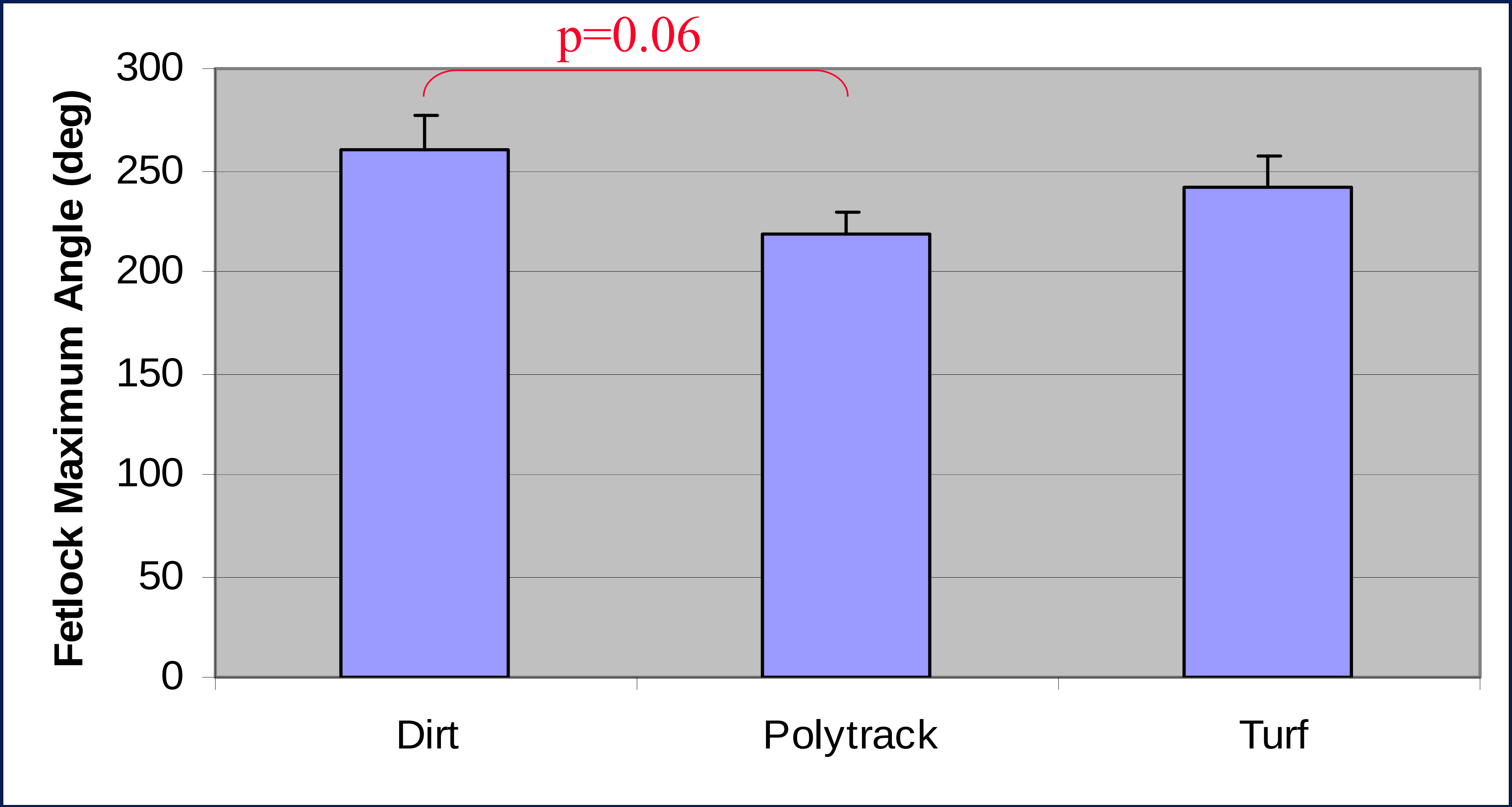




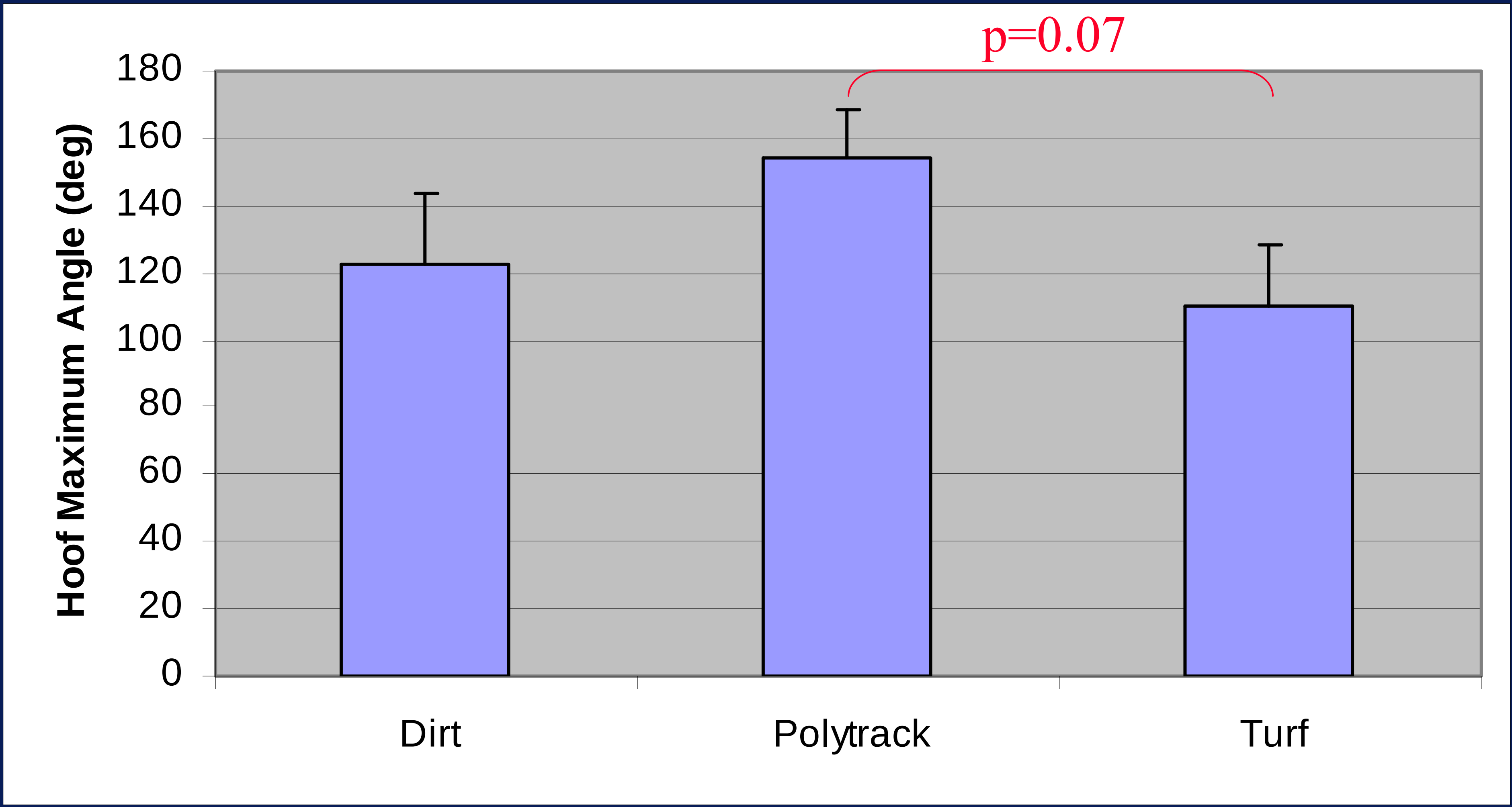


sample trot polytrack.avi

Fetlock Angle

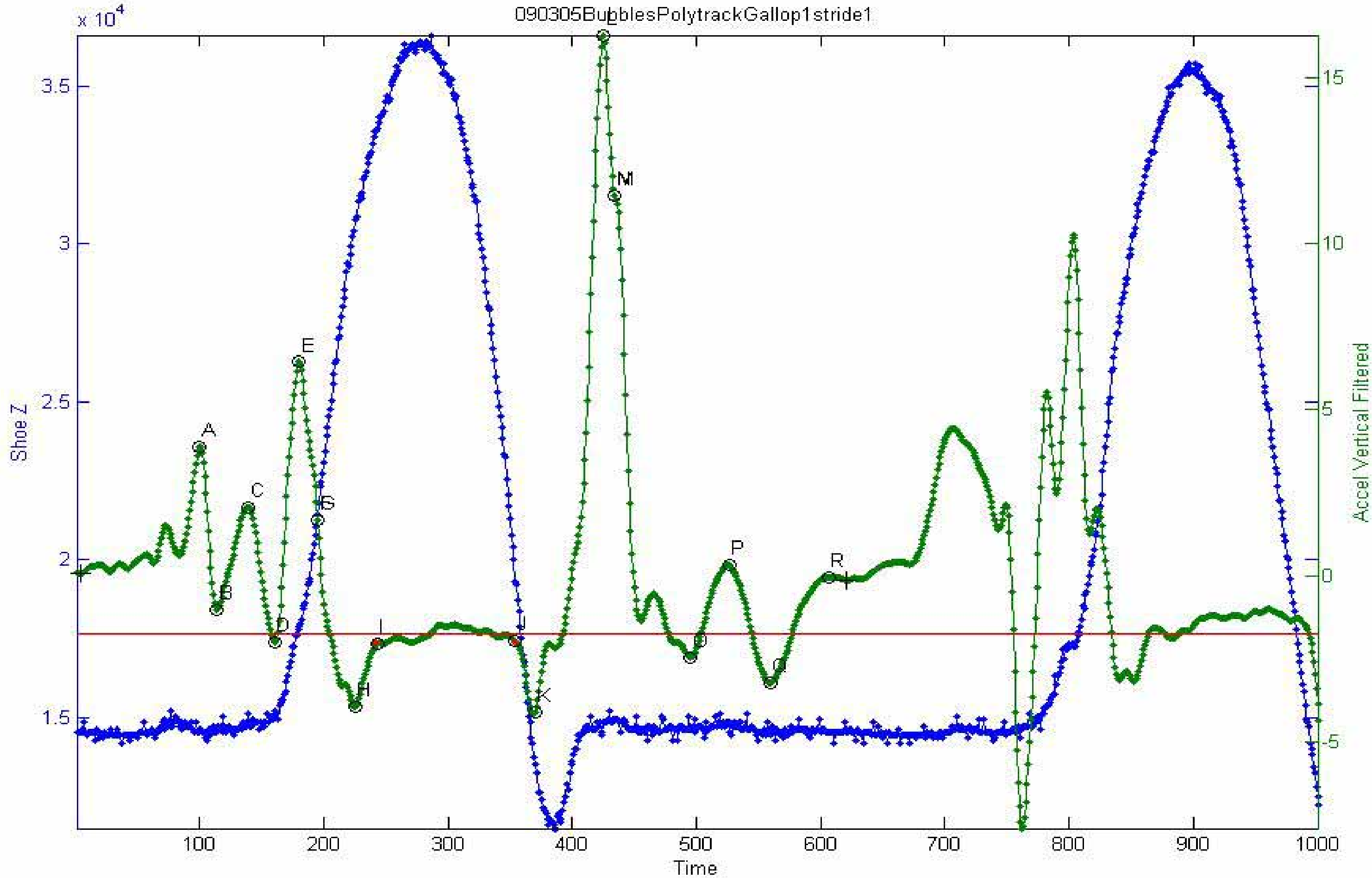


Hoof Angle



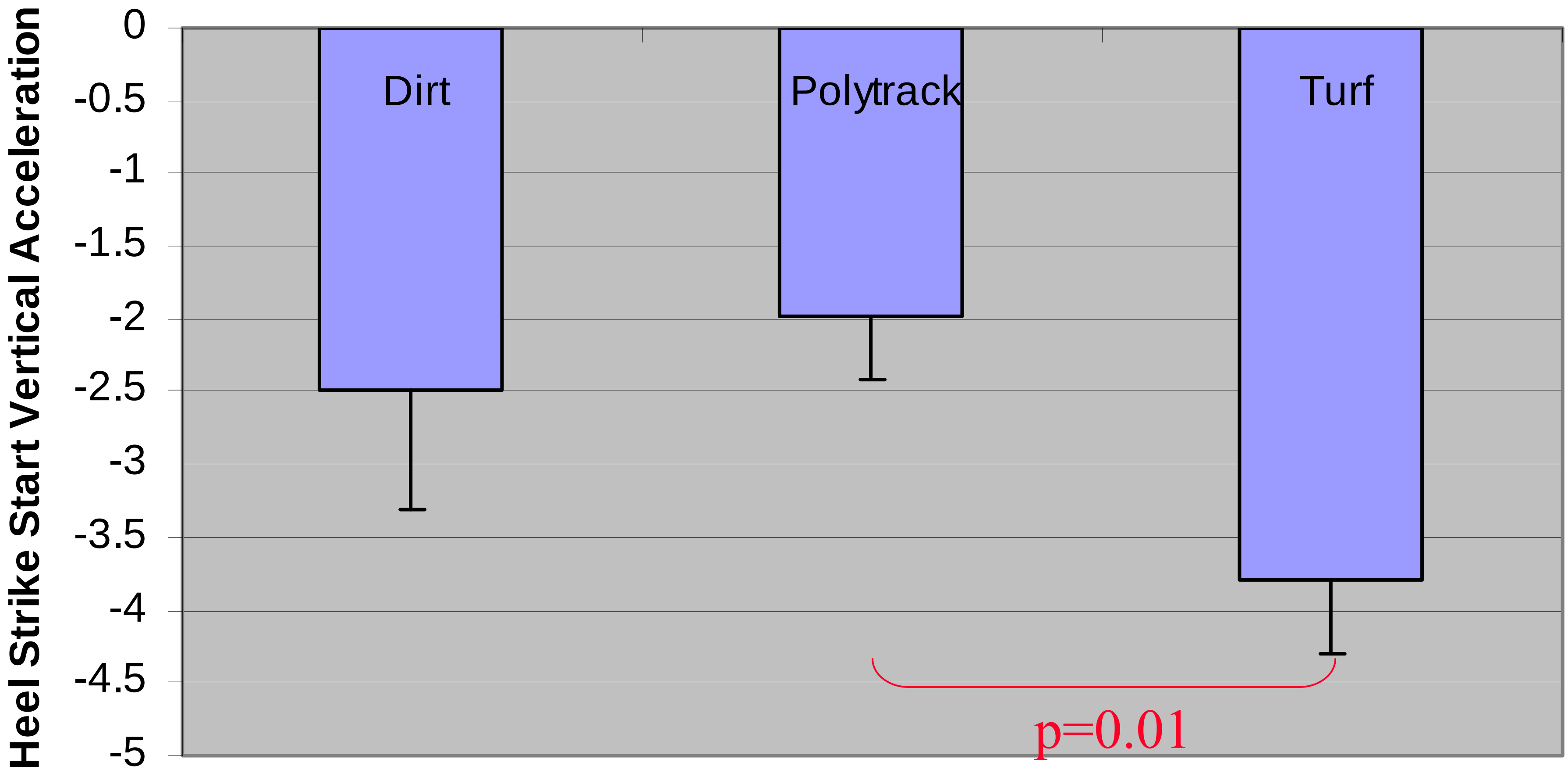
p=0.07
Hoof Maximum Angle (deg)
180
160
140
120
100
80
60
40
20
0
Dirt
Polytrack
Turf

Polytrack

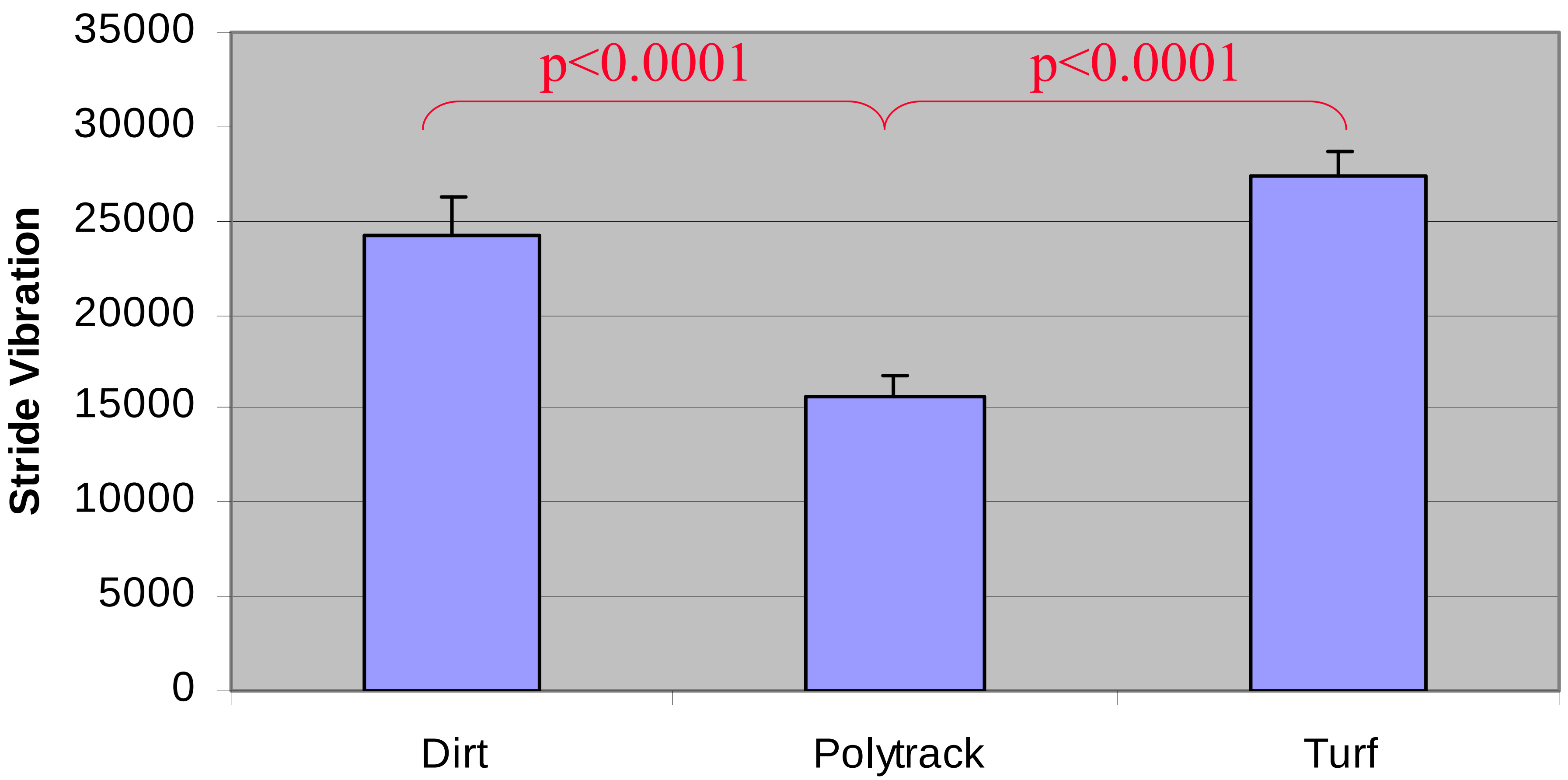


090305BubblesPolytrackGallop1stride1
x 10^4
3.5
3
2.5
2
1.5
Shoe Z
A
B
C
D
E
G
H
I
J
K
L
M
O
P
Q
R
15
10
5
0
-5
Accel Vertical Filtered
100
200
300
400
500
600
700
800
900
1000
Time

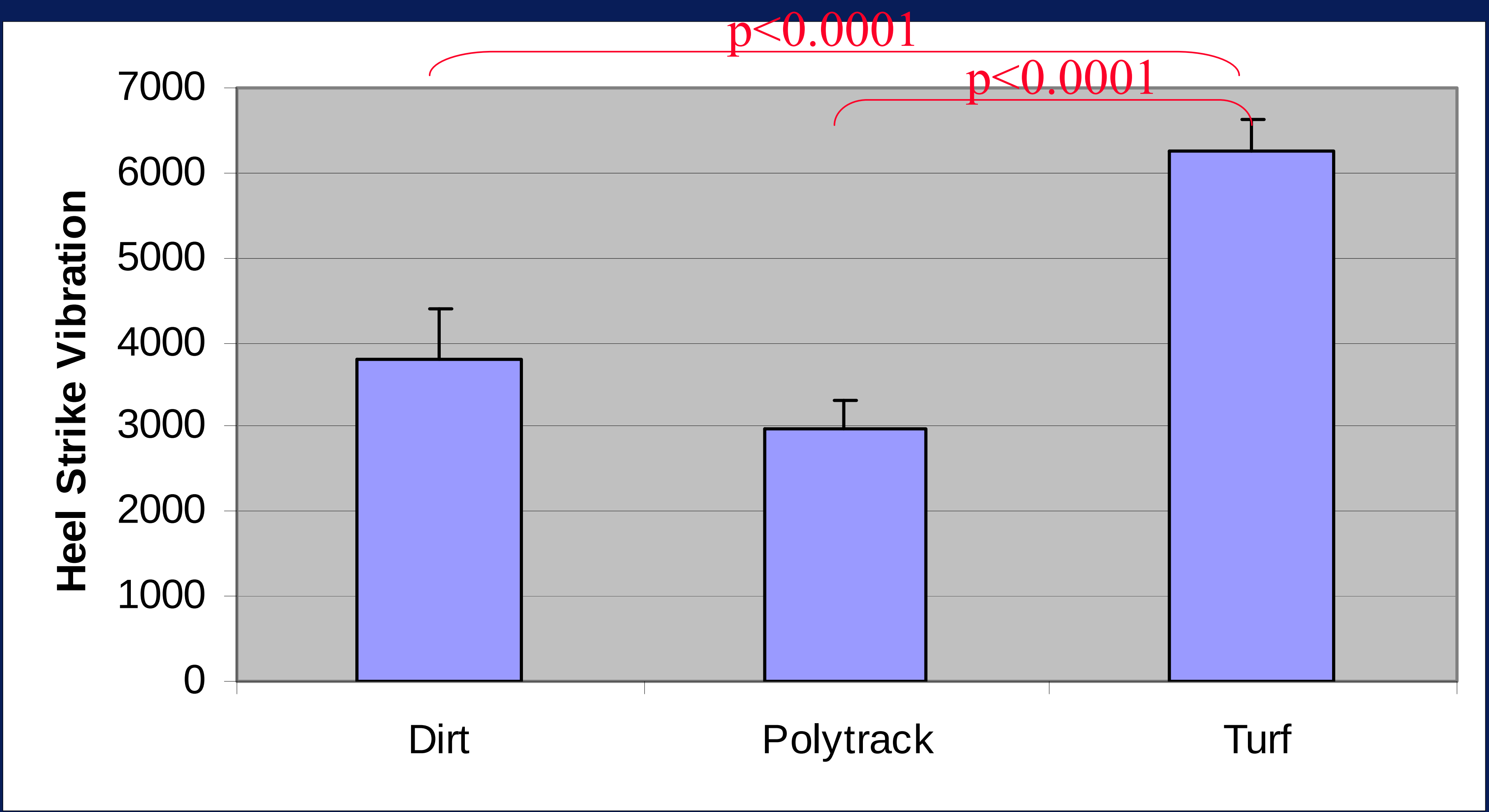
Heel Strike Deceleration



Stride Vibration



Heel Strike Vibration



Outline

- Magnitude of the problem
- Nature of injuries
- Injury development
- Key factors
- Risk factors for injury

- Race surface considerations - OPTIMISTIC

Increasing race surface compliance …

↓ peak GRFs

↓ fetlock peak hyperextension

↓ coffin peak flexion & ↑ coffin peak extension

↓ SDF and PCL peak strains

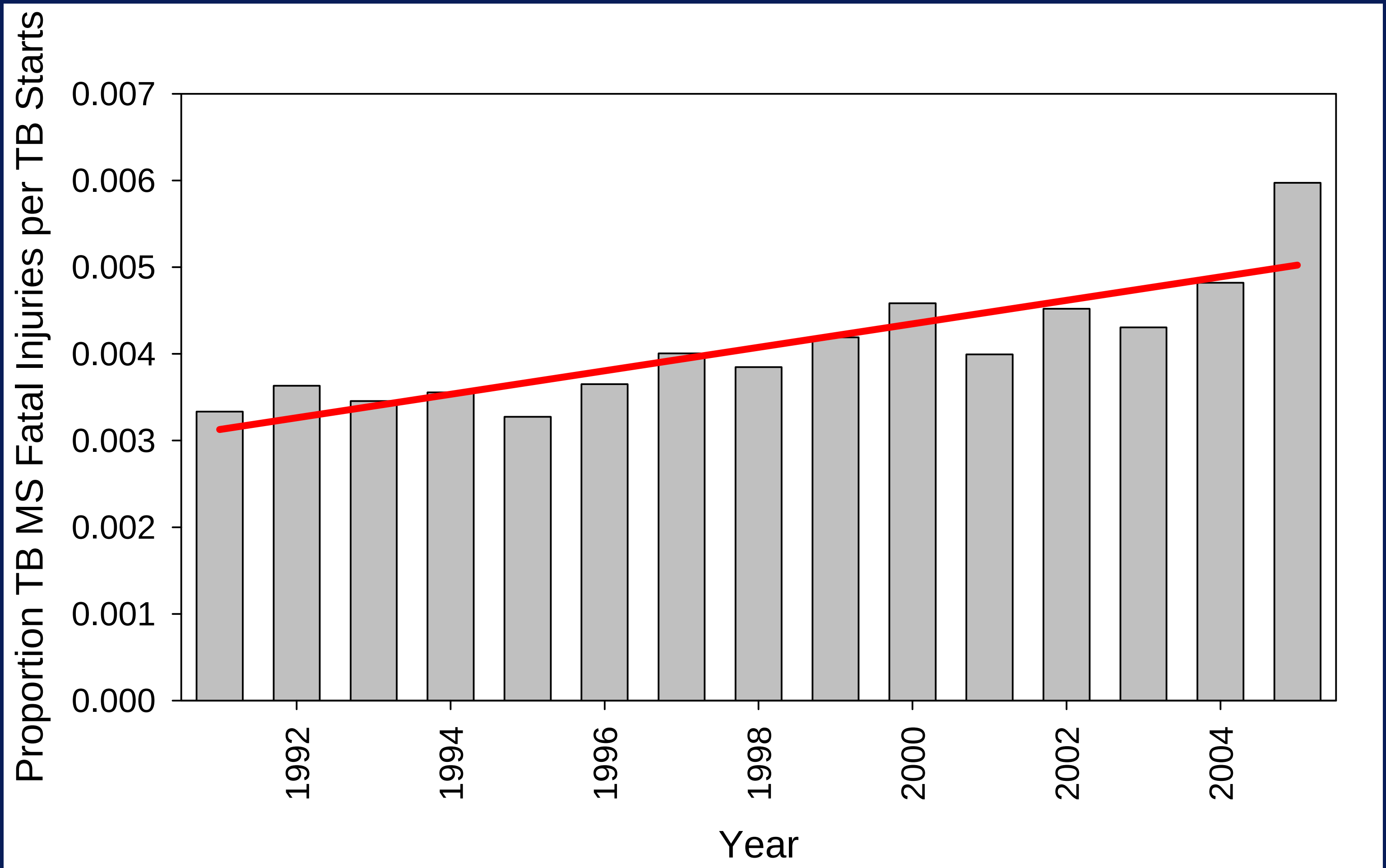
↓ DCL peak strain

↓ SL peak strain

↑ SL_{nav} peak strain

↓ peak accelerations

TB MS Fatal Injuries / Starts by Year

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