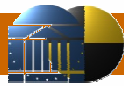


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A Systems Approach to Sports Injuries: Turf Toe and Lisfranc Injuries in American Football

Jeff Crandall and Richard Kent



CENTER for APPLIED BIOMECHANICS



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Professional Football-2010 Season

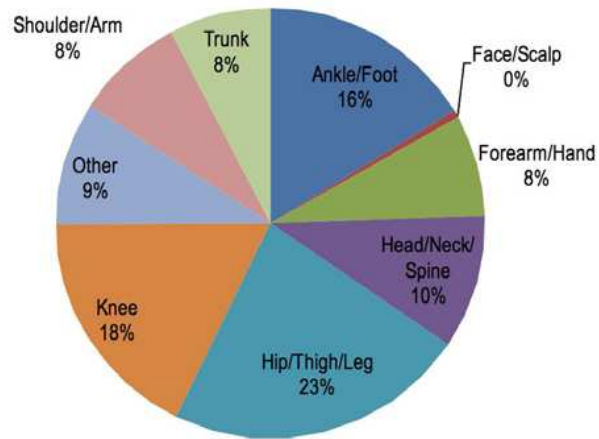
- 63% of players sustained at least one injury during season
- 30% of players missed-time due to injury
- On average, players out 4.7 weeks per missed-time injury



Source: Football Outsiders

Professional Football-2010 Season

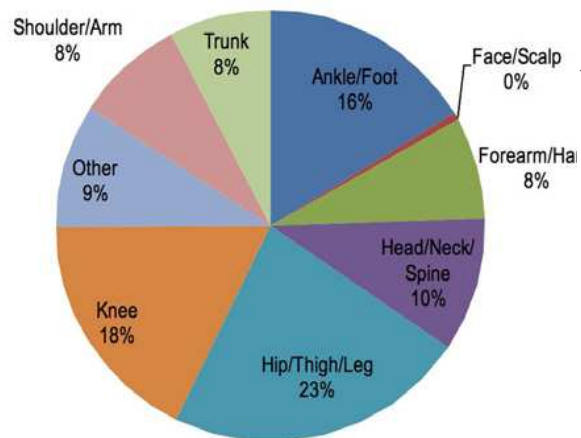
Injuries, by Body Location



Source: NFLISS

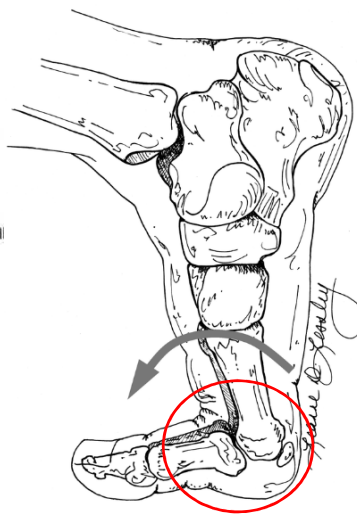
Professional Football-2010 Season

Injuries, by Body Location



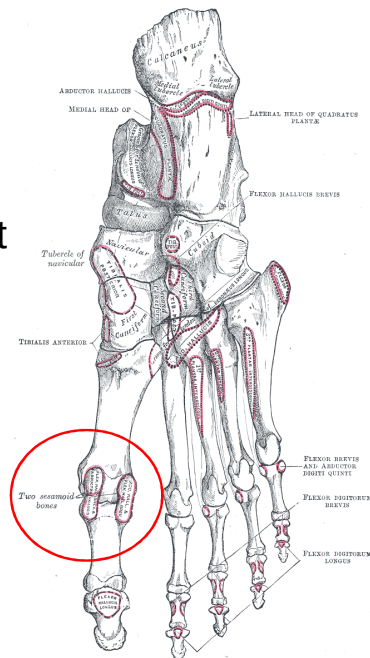
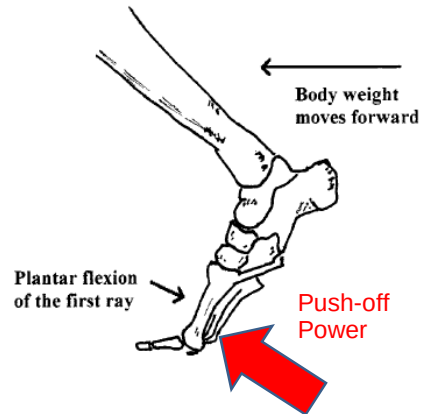
Source: NFLISS

Turf Toe
1.3% of All Injuries



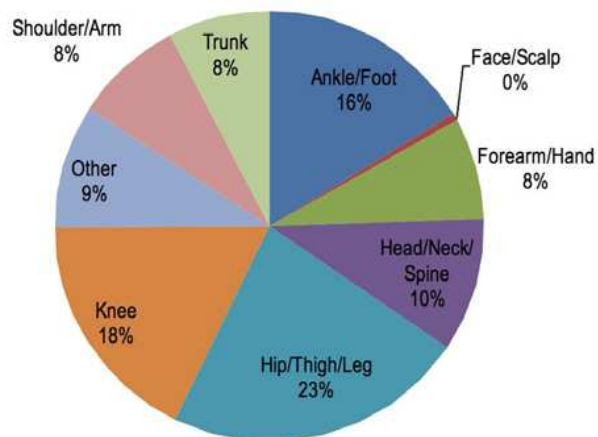
Turf Toe

Generic term describing injuries to the capsulo-ligamentous structures of the first metatarsophalangeal (MTP) joint

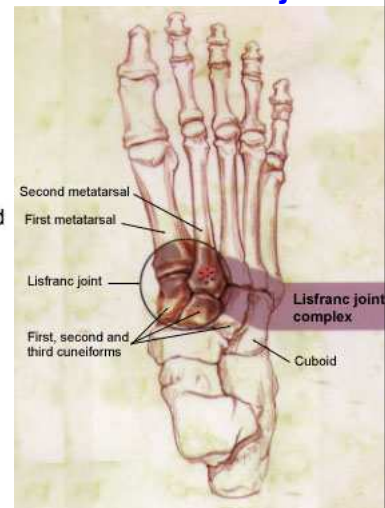


Professional Football-2010 Season

Injuries, by Body Location

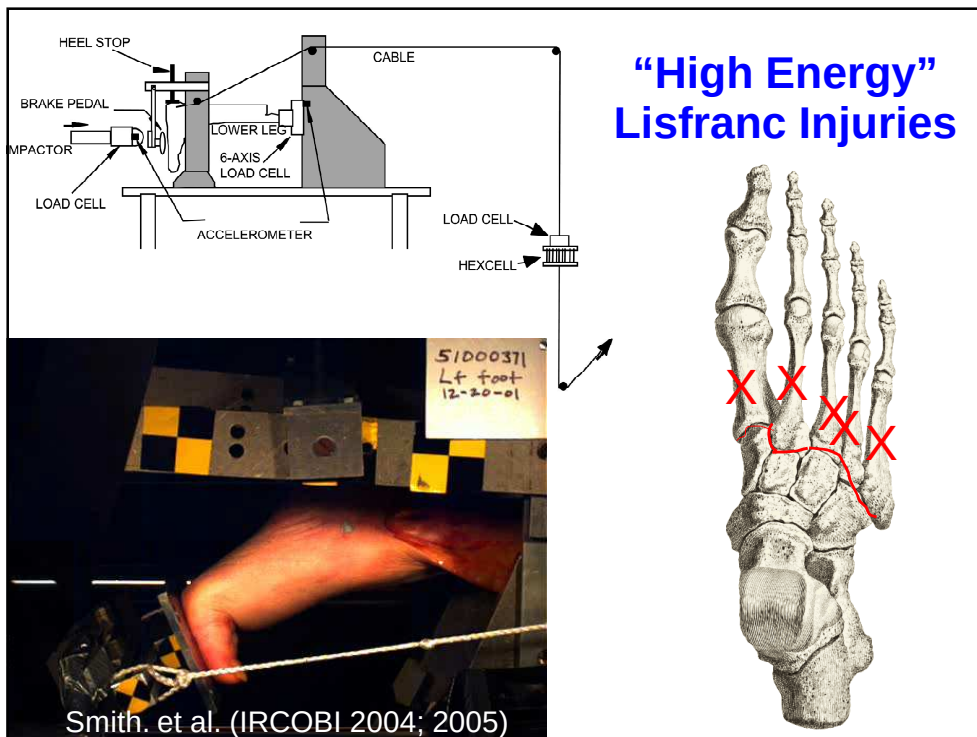
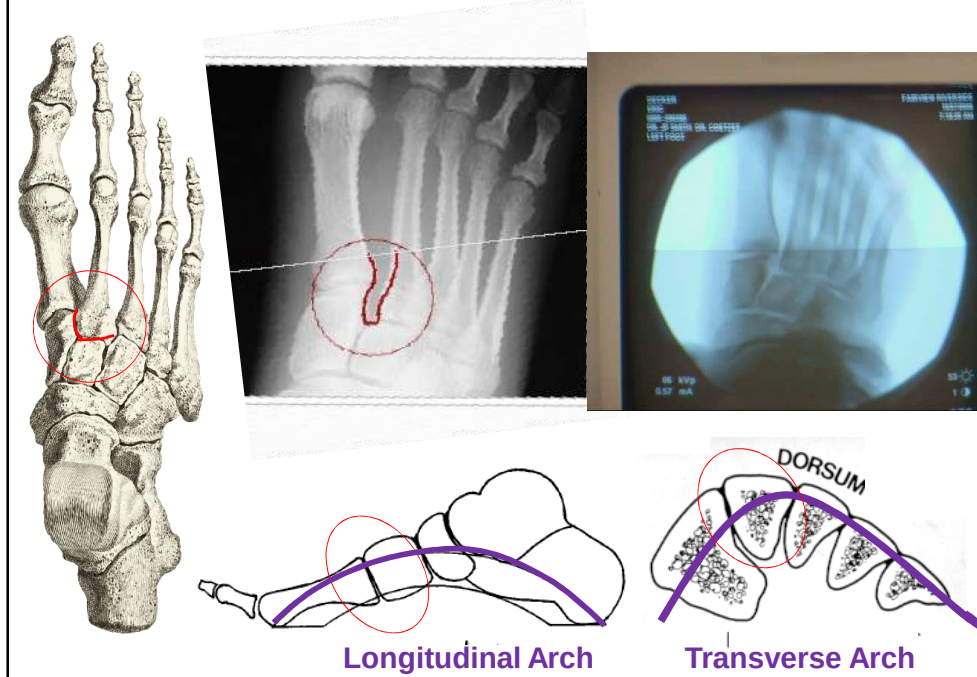


Lisfranc Joint
0.5% of All Injuries



Source: NFLISS (Feeley et al, 2008)

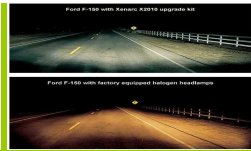
Predictable Pattern: *Purely ligamentous*



Systems Approach

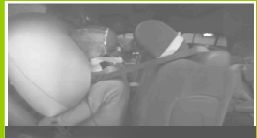
- **Can't** use **"high energy" injury biomechanics** research to study **turf toe** (doesn't exist) and **Lisfranc** (different pattern and mechanism) injuries
- Can use **injury prevention framework** for analyzing injury (**Haddon Matrix**)
- **Haddon model** used to conceptualize **etiologic factors** for injury and to identify potential **preventive strategies**

Haddon Matrix

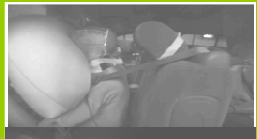
	Human	Vehicle	Environment
Pre-Event			
Event			
Post-Event			

Jac Wismans, 2007

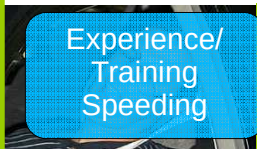
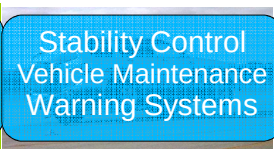
Haddon Matrix

	Human	Vehicle	Environment
Pre-Event			
Event			
Post-Event			

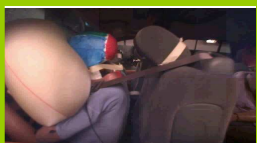
Haddon Matrix

	Human	Vehicle	Environment
Pre-Event	This is about stopping the injury event from occurring by acting on its causes		
Event			
Post-Event			

Haddon Matrix

	Human	Vehicle	Environment
Pre-Event			
Event			
Post-Event			

Haddon Matrix

	Human	Vehicle	Environment
Pre-Event			
Event			
Post-Event			

Haddon Matrix

	Human	Vehicle	Environment
Pre-Event			
Event	This is an attempt to prevent an injury or reduce the seriousness of an injury when an event actually occurs by designing and implementing protective mechanisms		
Post-Event			

Haddon Matrix

	Human	Vehicle	Environment
Pre-Event			
Event	Restraint Use	Crashworthiness Airbag	Medians/ Guardrails Breakaway Poles
Post-Event			

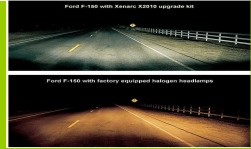
Haddon Matrix

	Human	Vehicle	Environment
Pre-Event			
Event			
Post-Event			

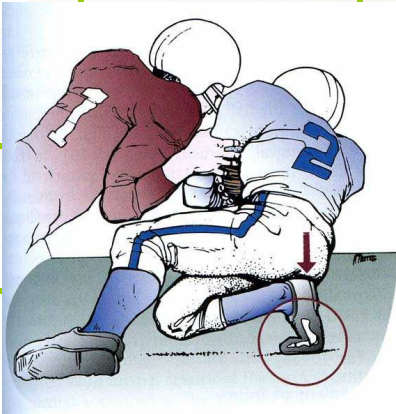
Haddon Matrix

	Human	Vehicle	Environment
Pre-Event			
Event			
Post-Event	This is where there is an attempt to reduce the seriousness of an injury or disability immediately after an event has occurred by providing adequate care		

Haddon Matrix

	Human	Vehicle	Environment
Pre-Event			
Event			
Post-Event	Crash Victim's Health Status	Fire Potential of Gas Tank AACN	Effective and timely EMS response

Haddon Matrix

	Human	Equipment	Environment
Pre-Injury			
Injury			
Post-Injury			

Haddon Matrix

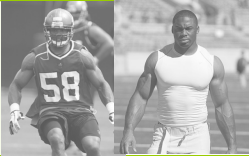
	Human	Equipment	Environment
Pre-Injury	Fitness Strength Training Education Previous Injury		
Injury			
Post-Injury			

Jac Wismans, 2007

Haddon Matrix

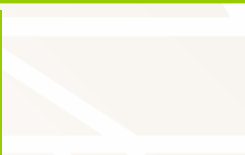
	Human	Equipment	Environment
Pre-Injury		Shoe Fit Footwear Cleat Patterns	
Injury	 		
Post-Injury	 		
Turf		Grass	

Haddon Matrix

	Human	Equipment	Environment
Pre-Injury			
Injury	Footwear Use		
Post-Injury			

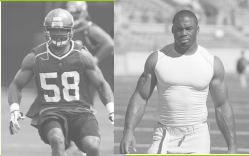
Jac Wismans, 2007

Haddon Matrix

	Human	Equipment	Environment
Pre-Injury			
Injury	Proper Footwear Use		
Post-Injury			

Jac Wismans, 2007

Haddon Matrix

	Human	Equipment	Environment
Pre-Injury			Field Maintenance Turf Type
Injury			
Post-Injury			

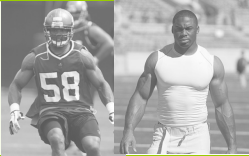
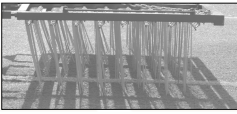
Jac Wismans, 2007

Haddon Matrix

	Human	Equipment	Environment
Pre-Injury			Field Maintenance Turf Type
Injury			
Post-Injury			

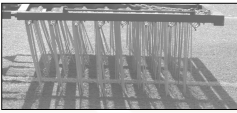
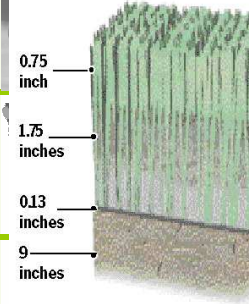
Jac Wismans, 2007

Haddon Matrix

	Human	Equipment	Environment
Pre-Injury			
Injury			Breakaway Strength of Turf
Post-Injury			

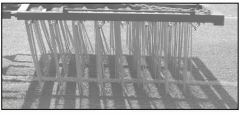
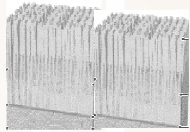
Jac Wismans, 2007

Haddon Matrix

	Human	Equipment	Environment
Pre-Injury			
Injury	 0.75 inch 1.75 inches 0.13 inches 9 inches	Hybrid fiber: Plastic blades, made of polyethylene and polypropylene, are placed in a pattern that emulates real grass. FieldTurf infill: A mixture of sand and ground rubber (from recycled Firestone tires) supports the grass fibers. Geotextile: Holds grass in place. Base: The turf is laid on top of 2 feet of crushed stone and 9 inches of concrete.	Breakaway Strength of Turf
Post-Injury			

Jac Wismans, 2007

Haddon Matrix

	Human	Equipment	Environment
Pre-Injury			
Injury		Footwear motion Tape/Brace	
Post-Injury			

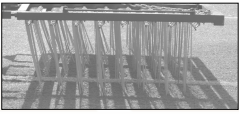
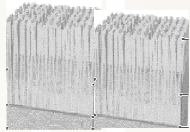
Jac Wismans, 2007

Haddon Matrix

	Human	Equipment	Environment
Pre-Injury			
Injury			
Post-Injury			

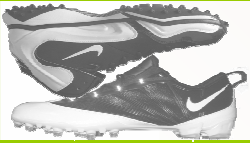
Jac Wismans, 2007

Haddon Matrix

	Human	Equipment	Environment
Pre-Injury			
Injury			
Post-Injury	Reporting Rehab		

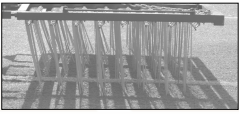
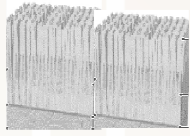
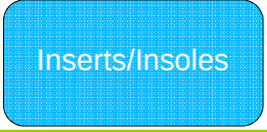
Jac Wismans, 2007

Haddon Matrix

	Human	Equipment	Environment
Pre-Injury			
Injury			
Post-Injury	Reporting Rehab		

Jac Wismans, 2007

Haddon Matrix

	Human	Equipment	Environment
Pre-Injury			
Injury			
Post-Injury			

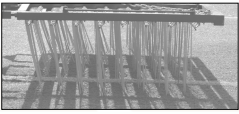
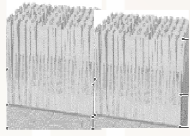
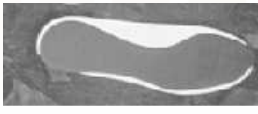
Jac Wismans, 2007

Haddon Matrix

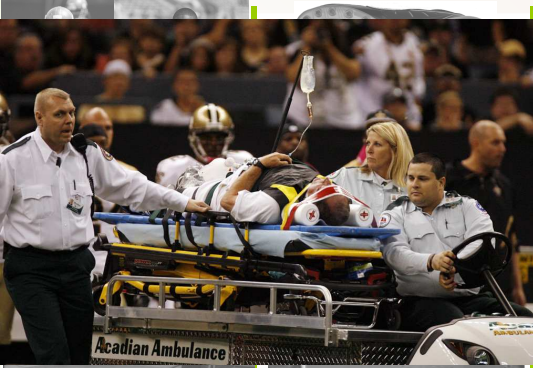
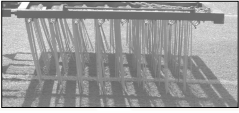
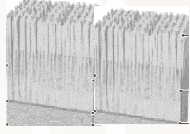
	Human	Equipment	Environment
Pre-Injury			
Injury			
Post-Injury			

Jac Wismans, 2007

Haddon Matrix

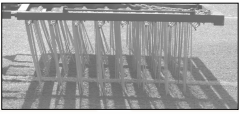
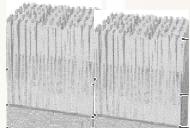
	Human	Equipment	Environment
Pre-Injury			
Injury			
Post-Injury			Emergency/ Medical Coverage

Haddon Matrix

	Human	Equipment	Environment
Pre-Injury			
Injury			
Post-Injury			Emergency/ Medical Coverage

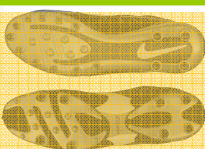
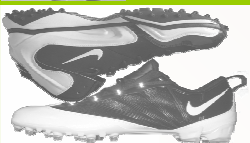
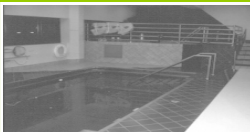
Jac Wismans, 2007

Haddon Matrix

	Human	Equipment	Environment
Pre-Injury			
Injury			
Post-Injury			

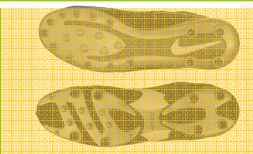
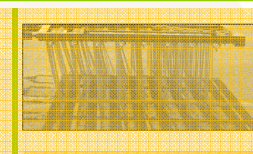
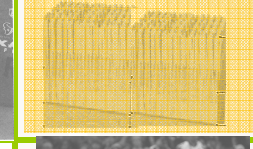
Jac Wismans, 2007

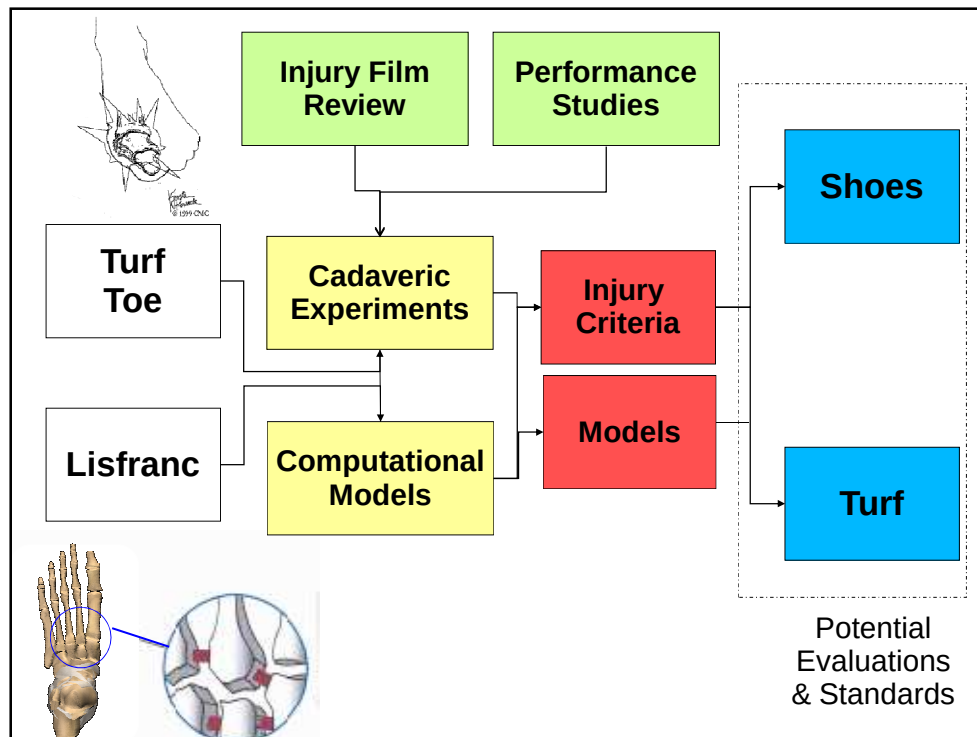
Haddon Matrix

	Human	Equipment	Environment
Pre-Injury			
Injury			
Post-Injury			

Jac Wismans, 2007

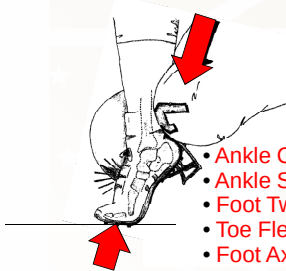
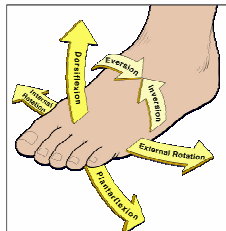
Haddon Matrix

	Human	Equipment	Environment
Pre-Injury			
Injury			
Post-Injury			



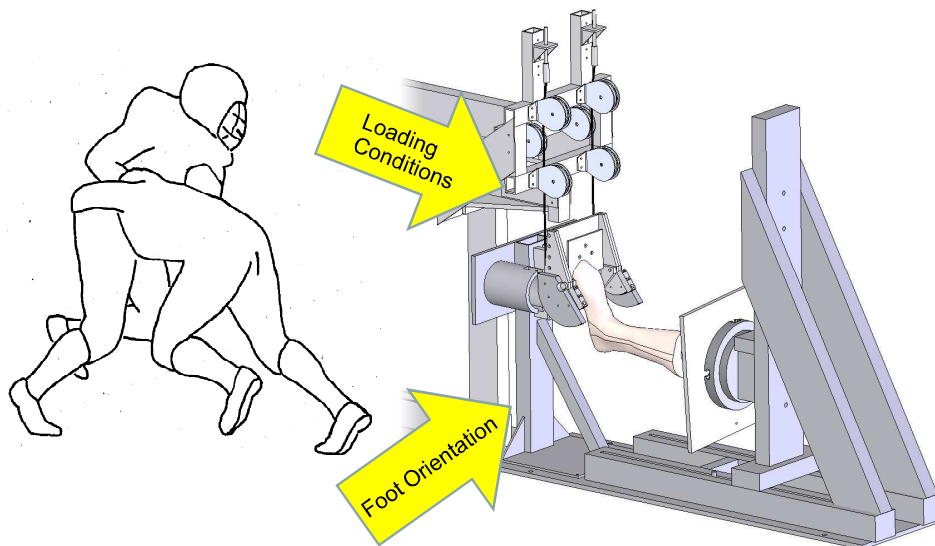
Game Film Review (Injury Event)

- Foot/Ankle Position at Initiation of Load
- Motion/Loading Prominent During Injury
- General Mechanism



- Direct Blow to Foot
- Direct Loading of Lower Limb
- Player Engaged with another player

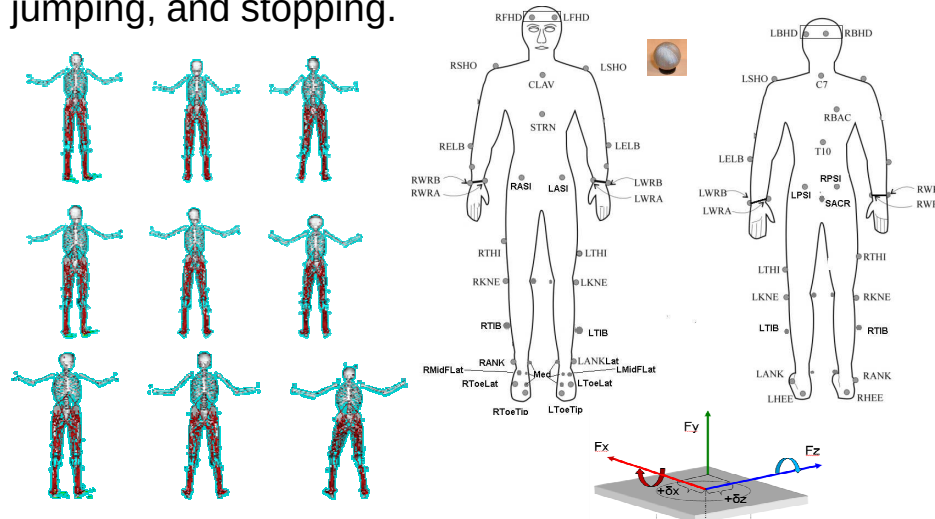
Video Analysis



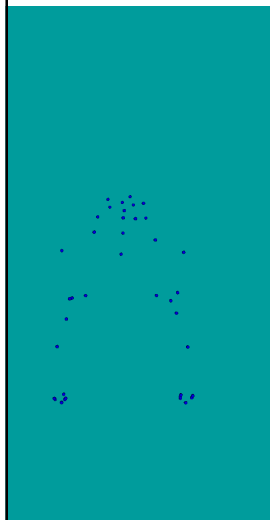
Player picture from Bowman and Martin

Player Performance Testing

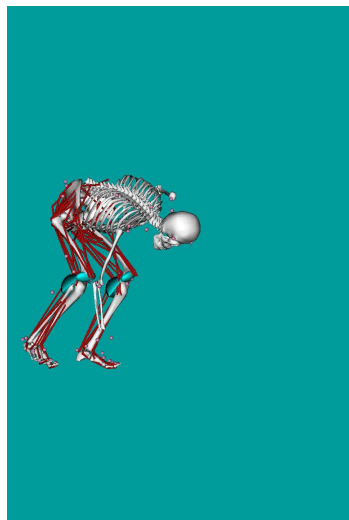
- Objective: Determine lower limb kinematics and ground reaction forces for players performing a range of maneuvers include cutting, starting, landing, jumping, and stopping.



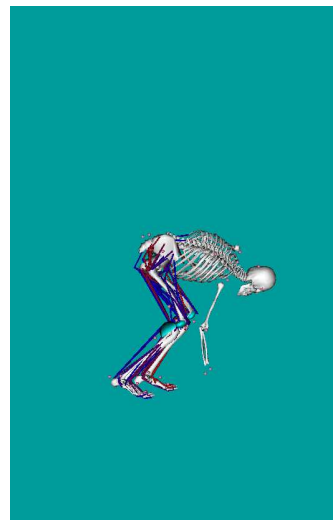
Performance Testing



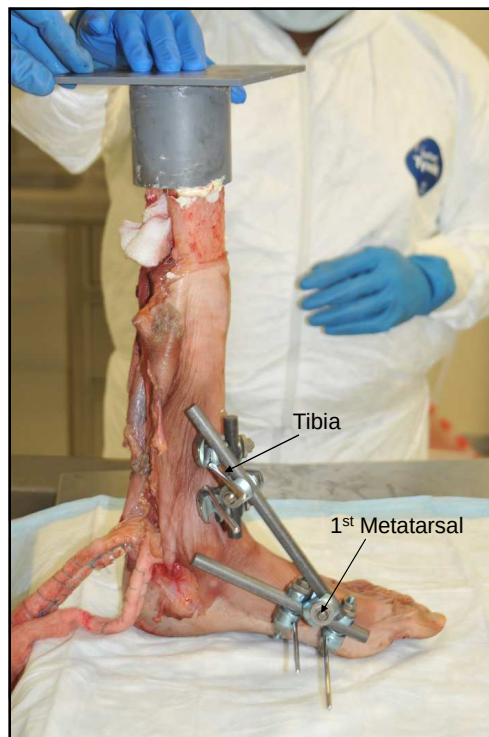
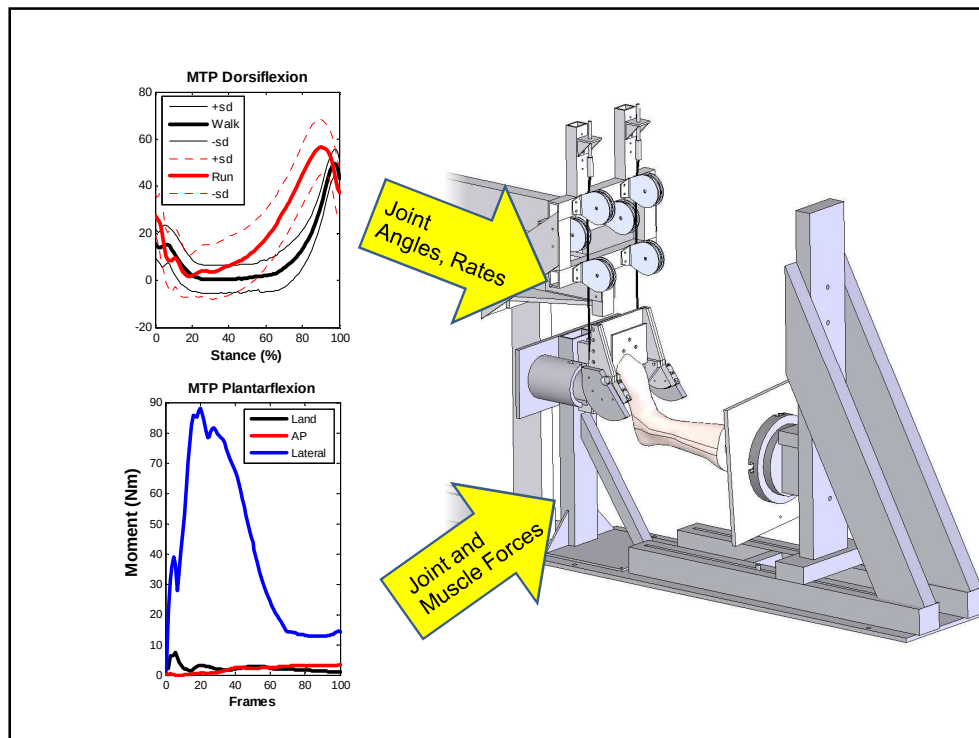
Raw motion capture
(markers)



Motion, ground reaction force, and anthropometry define joint torques

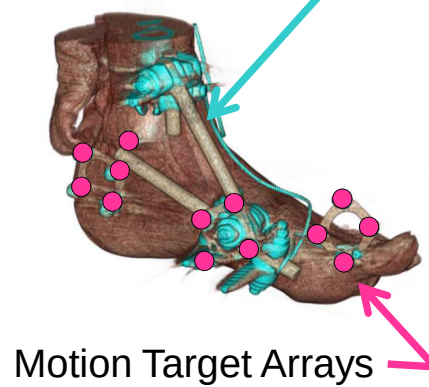


Joint torques and muscle geometry give muscle forces



Turf Toe Testing

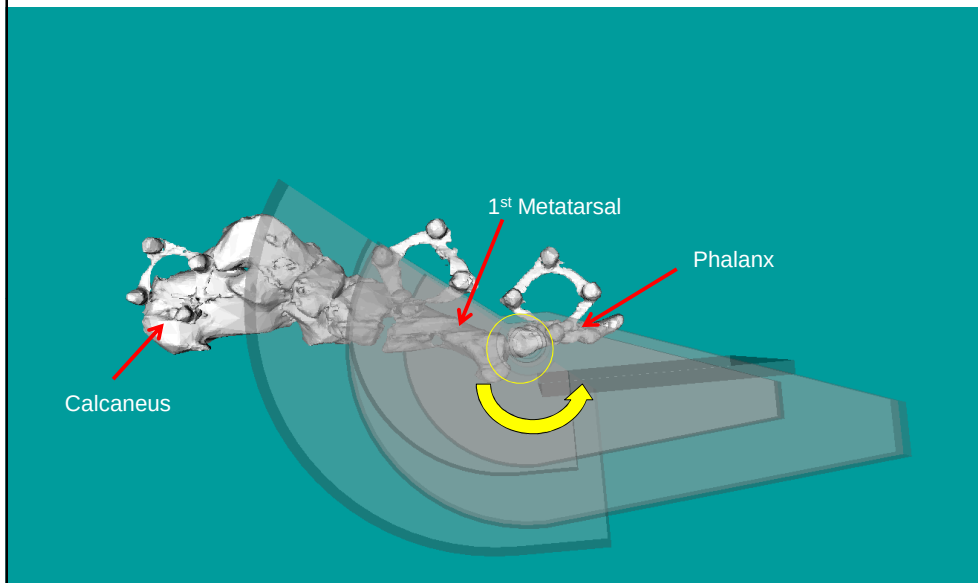
External fixation was used to restrict deformation to MTP Joints

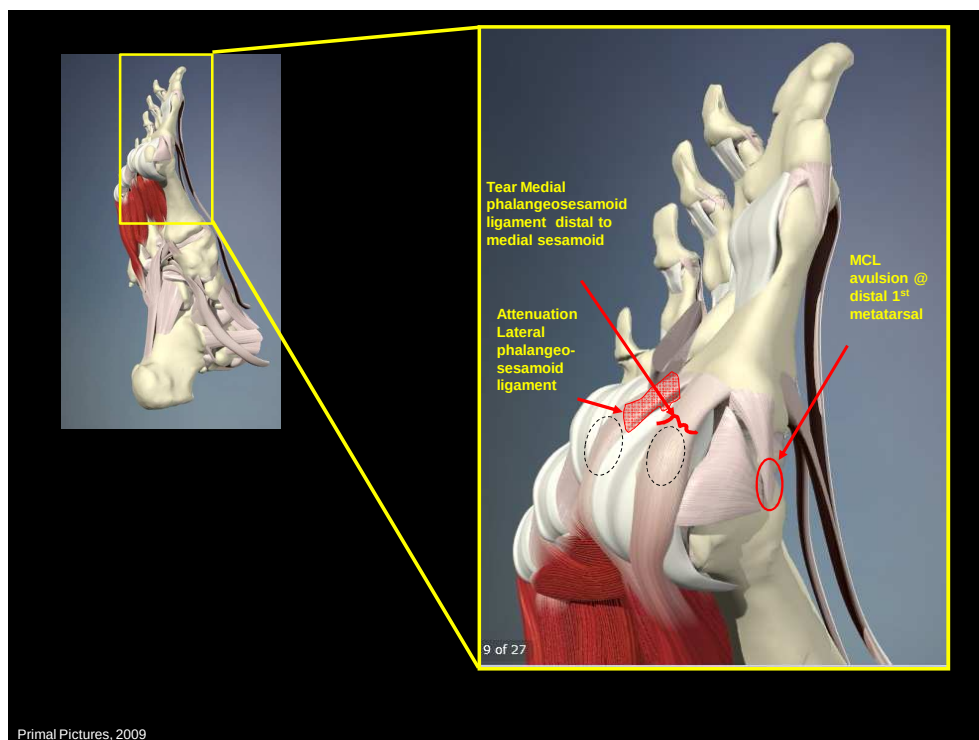
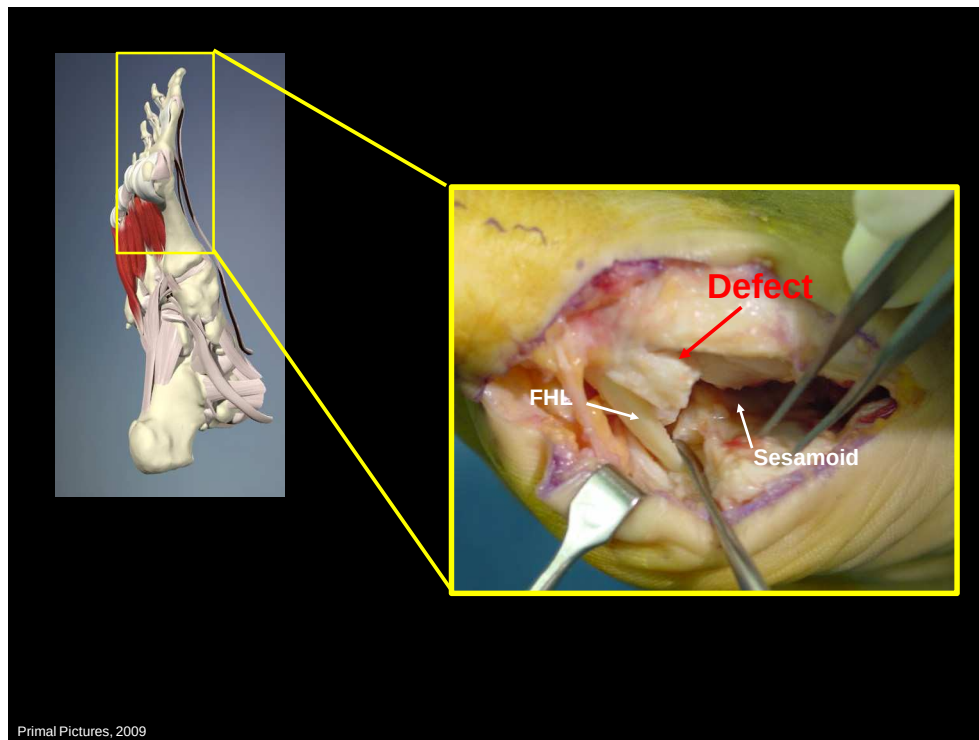


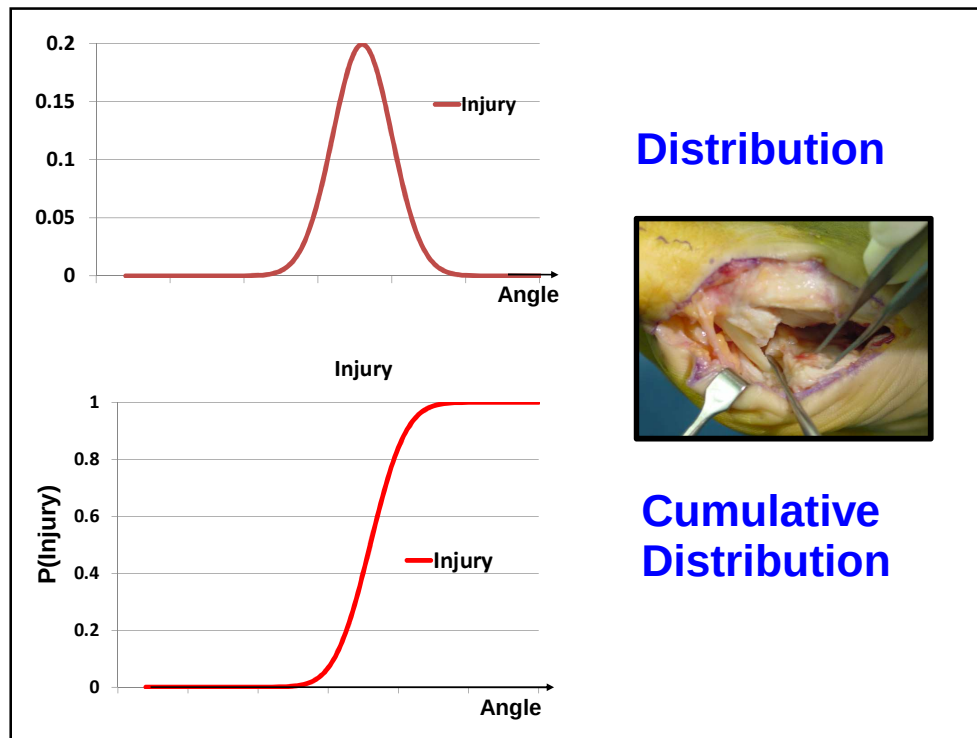
Turf Toe High Speed Video



Vicon Array and Video Motion

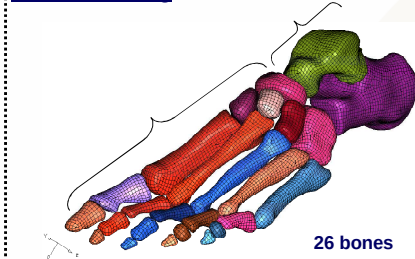




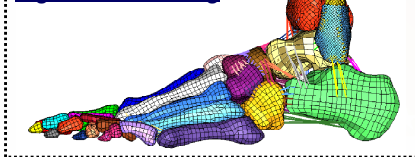


Foot and ankle model development

Bone modeling



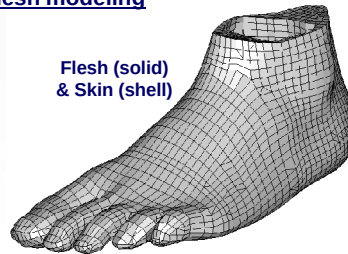
Ligament modeling



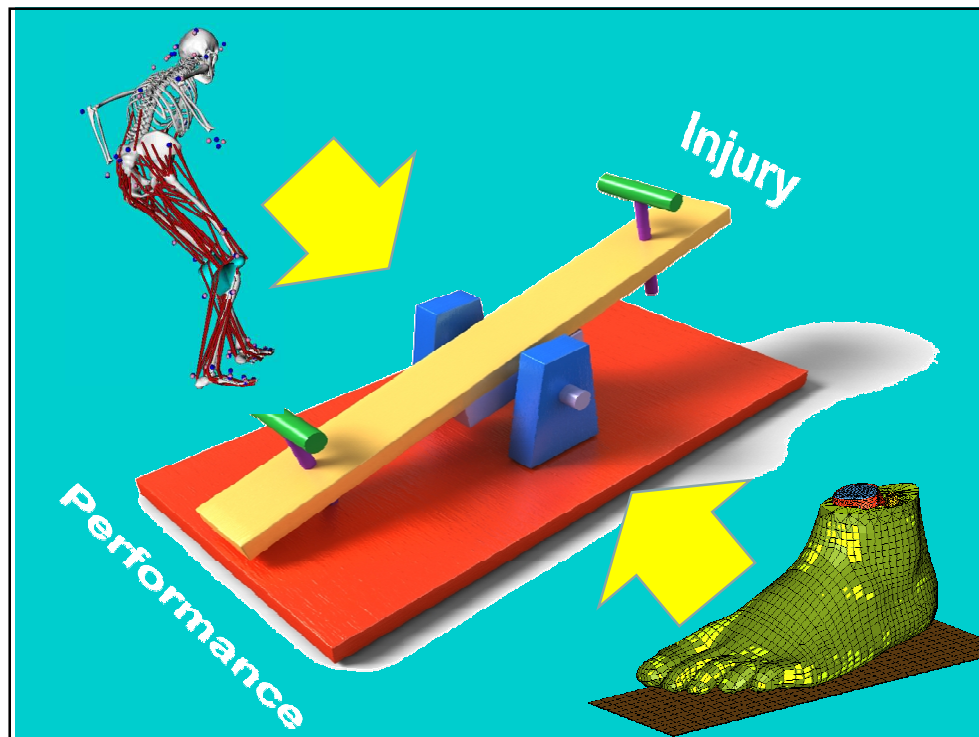
elements: 19,385

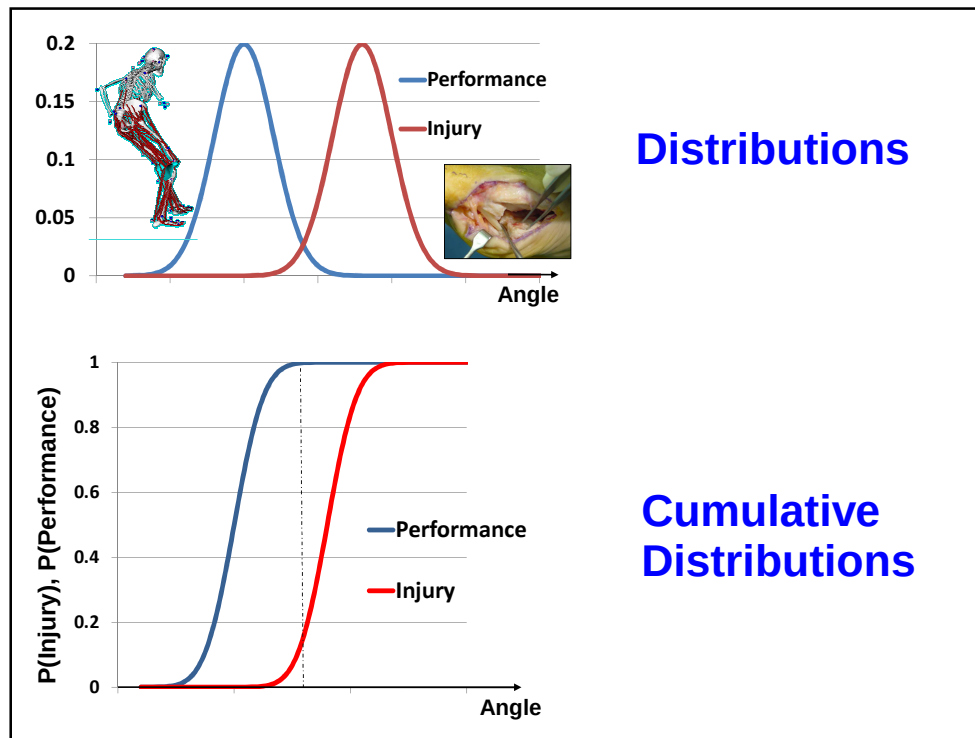
Flesh modeling

Flesh (solid)
& Skin (shell)



53





Conclusions

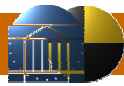
- ❏ **Sports injuries** can exhibit **different patterns** than those from **automotive**
- ❏ **Haddon Matrix** conducive to study of sports injuries
- ❏ Study of **sports injuries**, especially in elite athletes, will require **adjustment of injury criteria** using **computational means**
- ❏ Balance of **performance** and **injury risk** must be evaluated



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