Biomechanical and Mechanical Testing of Playing Surfaces

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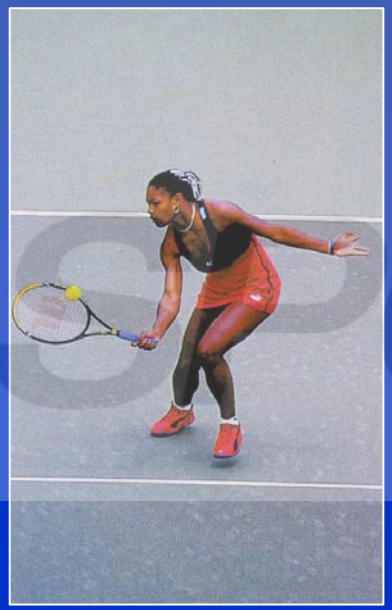
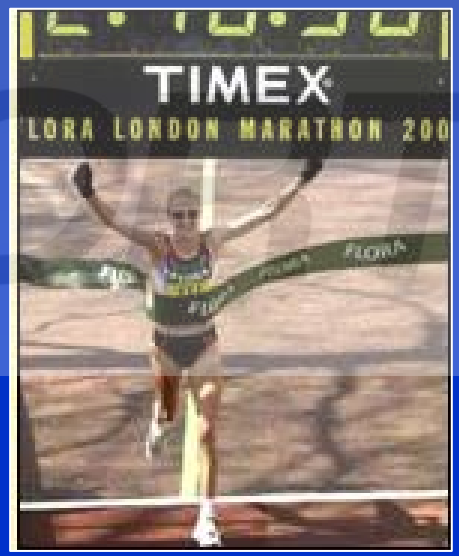
Overall Aim of Research

- To improve understanding of shoe-surface-player interaction



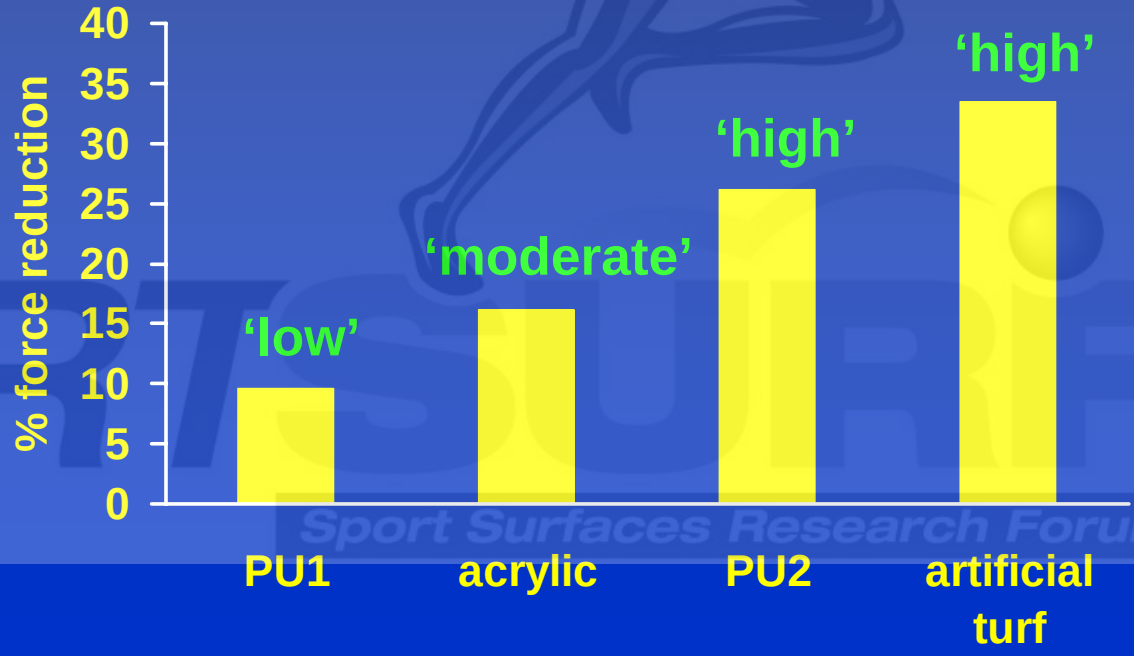


Presentation Structure

- Research examples
- Summary
- Suggested directions for interdisciplinary study

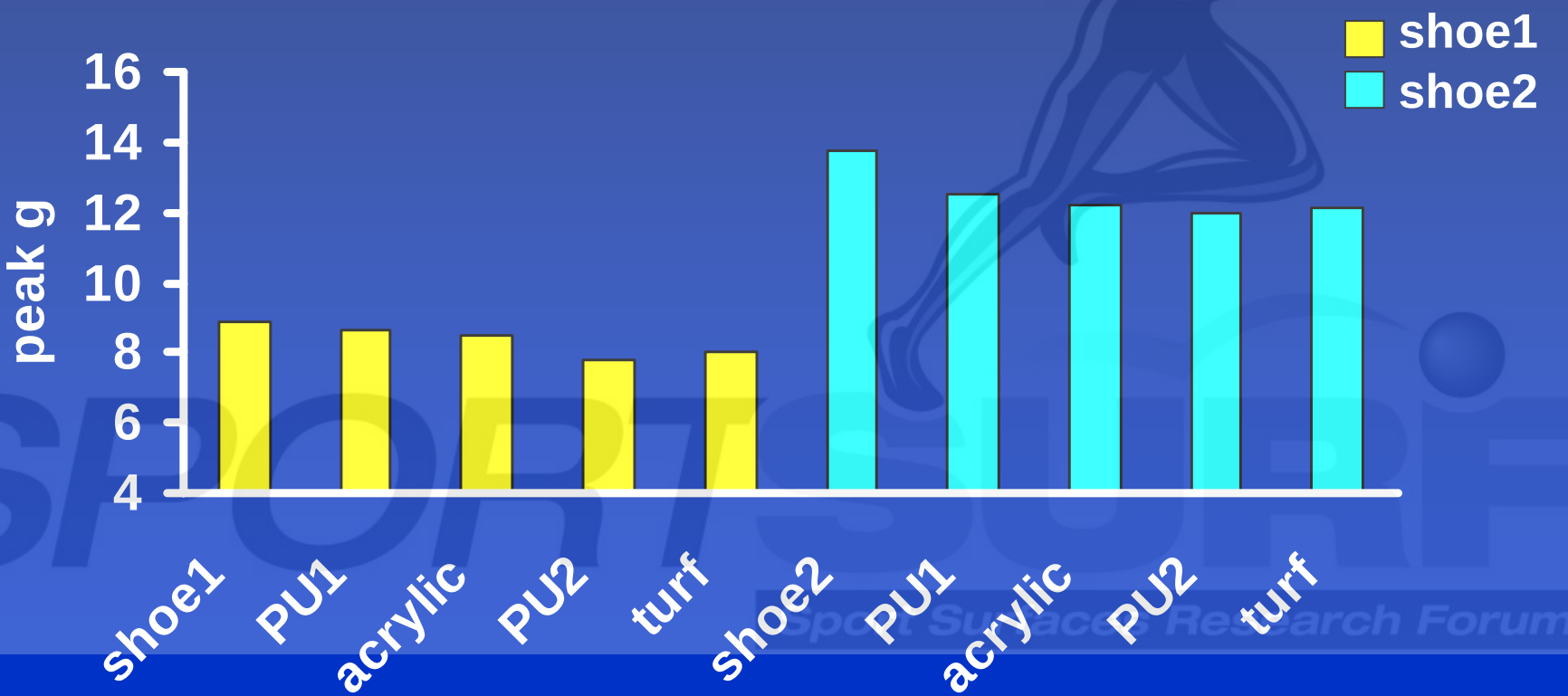
Tennis Surfaces: Running Study

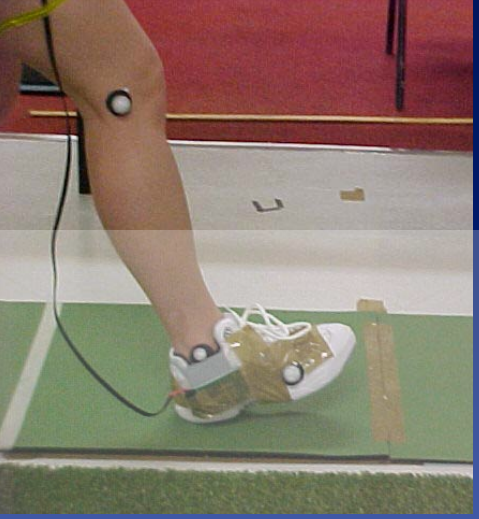
- Berlin Artificial Athlete
- ITF categorisation



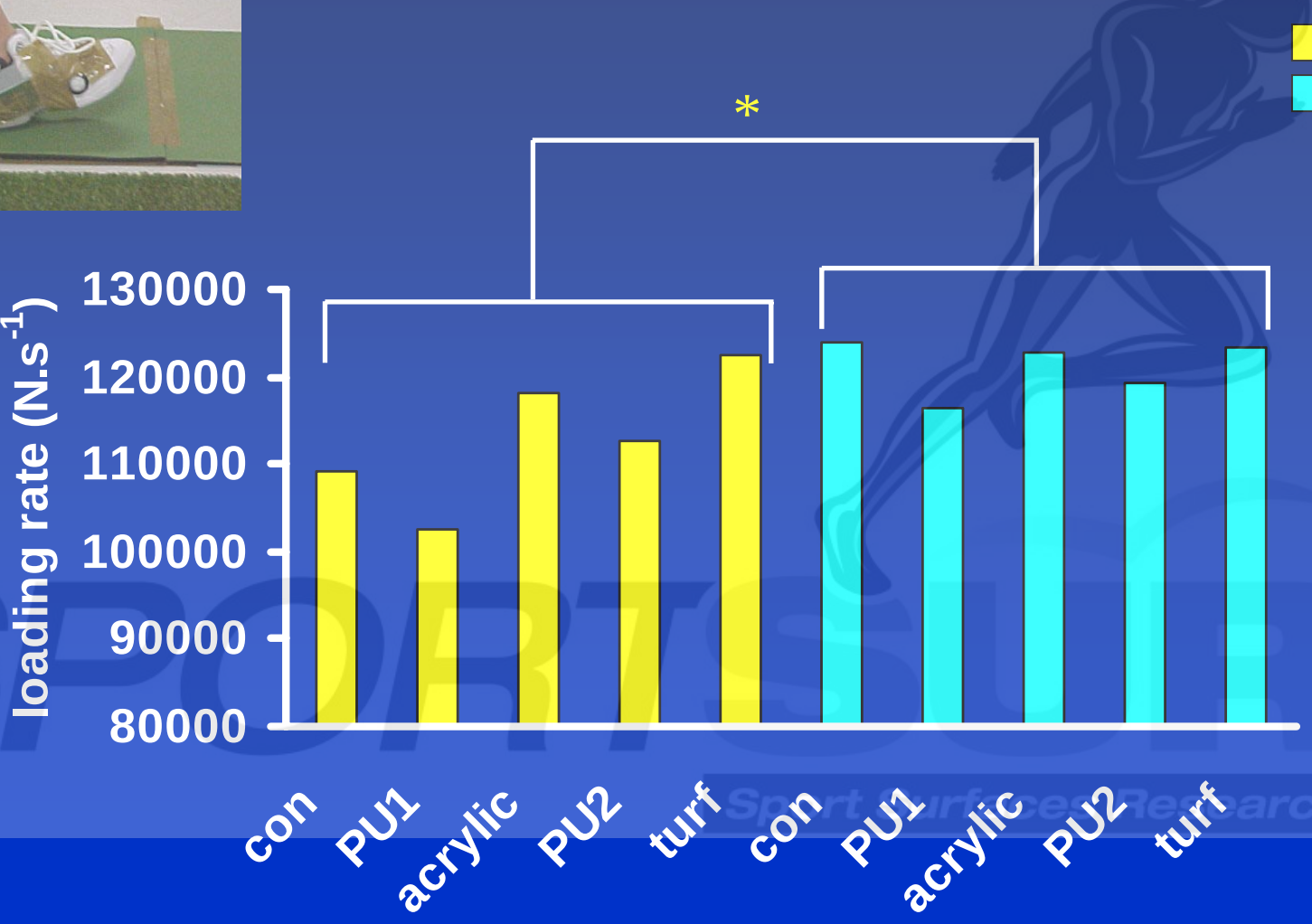
Dixon and Stiles (2003) *Sports Eng* 6, 1-10

Drop Test Results



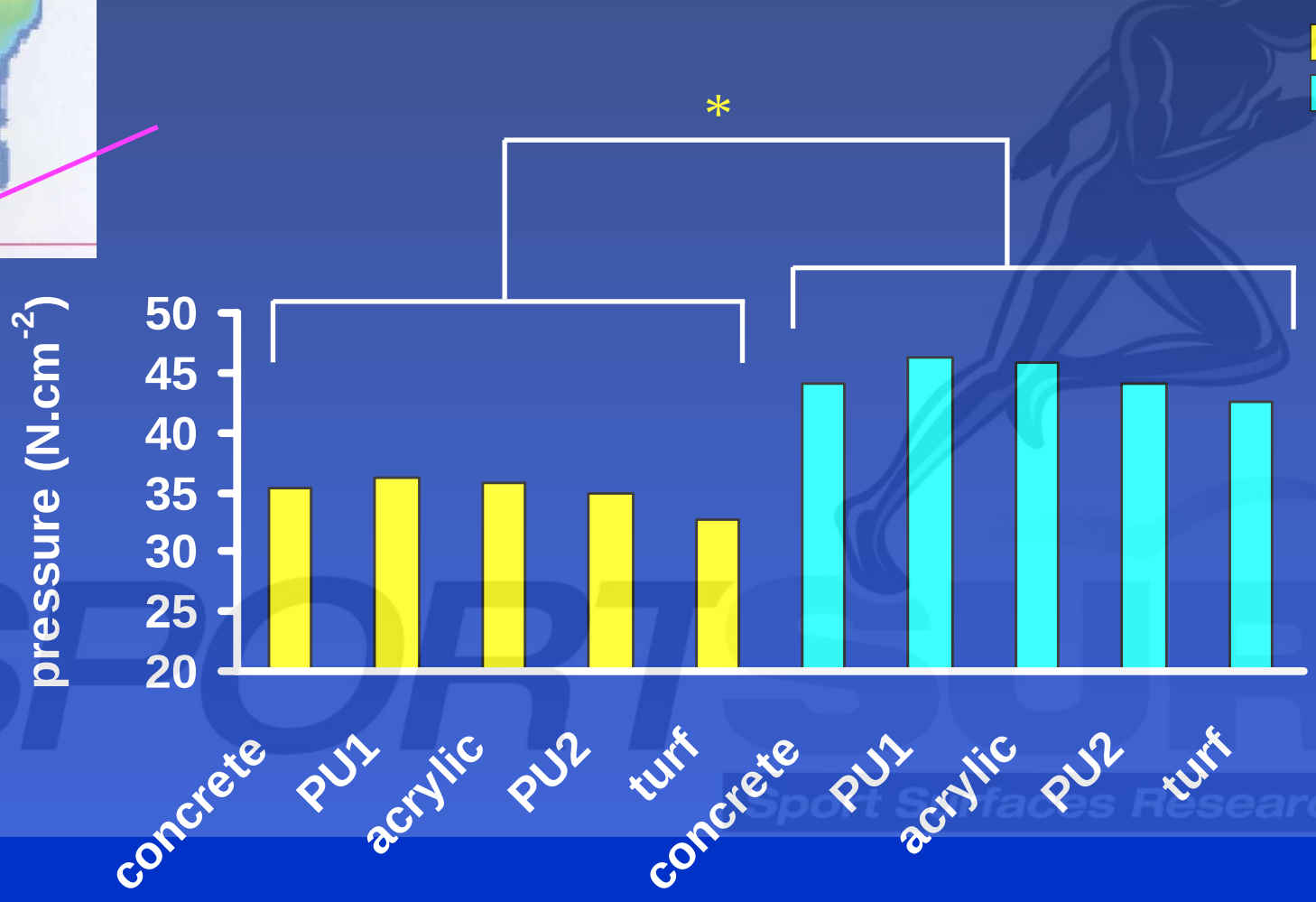


Peak Loading Rate



* p<0.05

Peak Lateral Heel Pressure

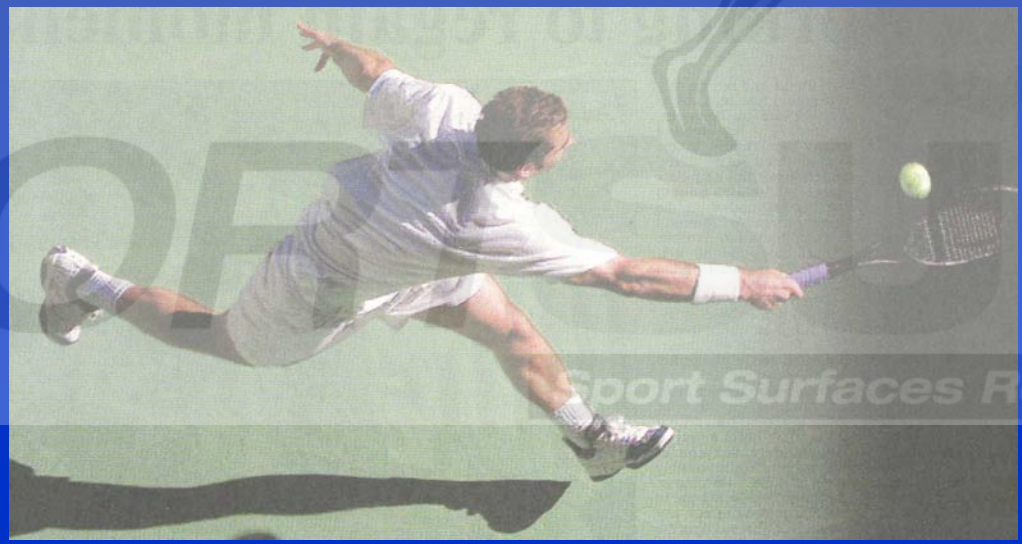


* p<0.05

Conclusions

- For the surfaces studied, similar impact loading occurs during running
- The choice of shoe has potential to influence impact loading on the test surfaces
- Weak biomechanical support for the large differences between surfaces indicated by Berlin Artificial Athlete
- Investigation of different movement patterns suggested

Biomechanical response to systematic changes in surface cushioning properties while performing a tennis specific movement in a basic neutral shoe

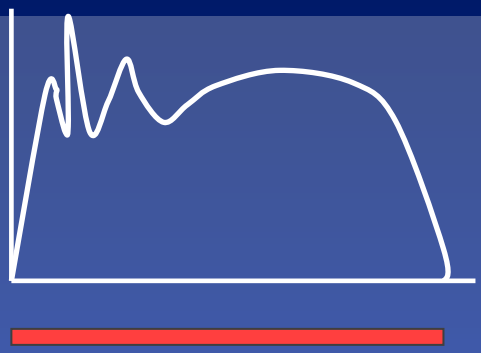


Stiles & Dixon, JSS, in press

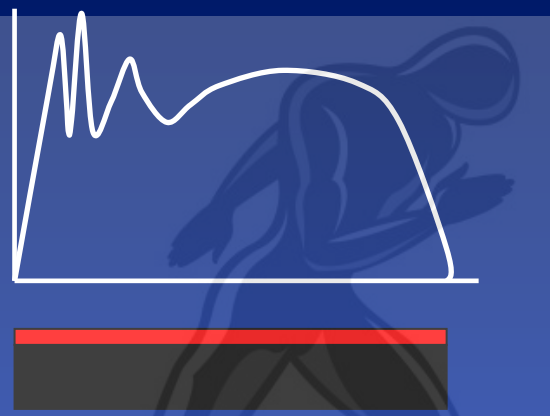
Human response to changes in surface cushioning

- Systematically altered surface cushioning while maintaining a consistent top surface
- Surface conditions spanned a large range of impact reduction
- Removed the influence of a sports shoe by using a neutral cushioned shos (plimsolls)
- 10 subjects performing running forehand footplant

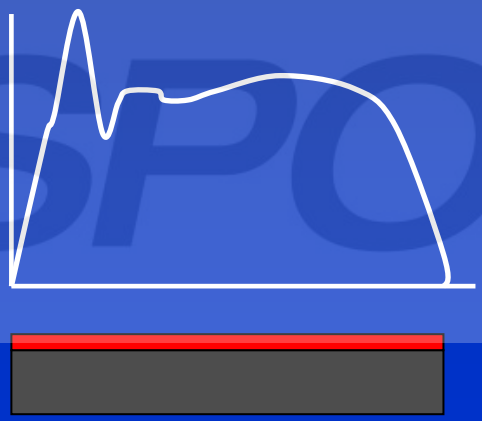
Change in GRF profiles



Acrylic only



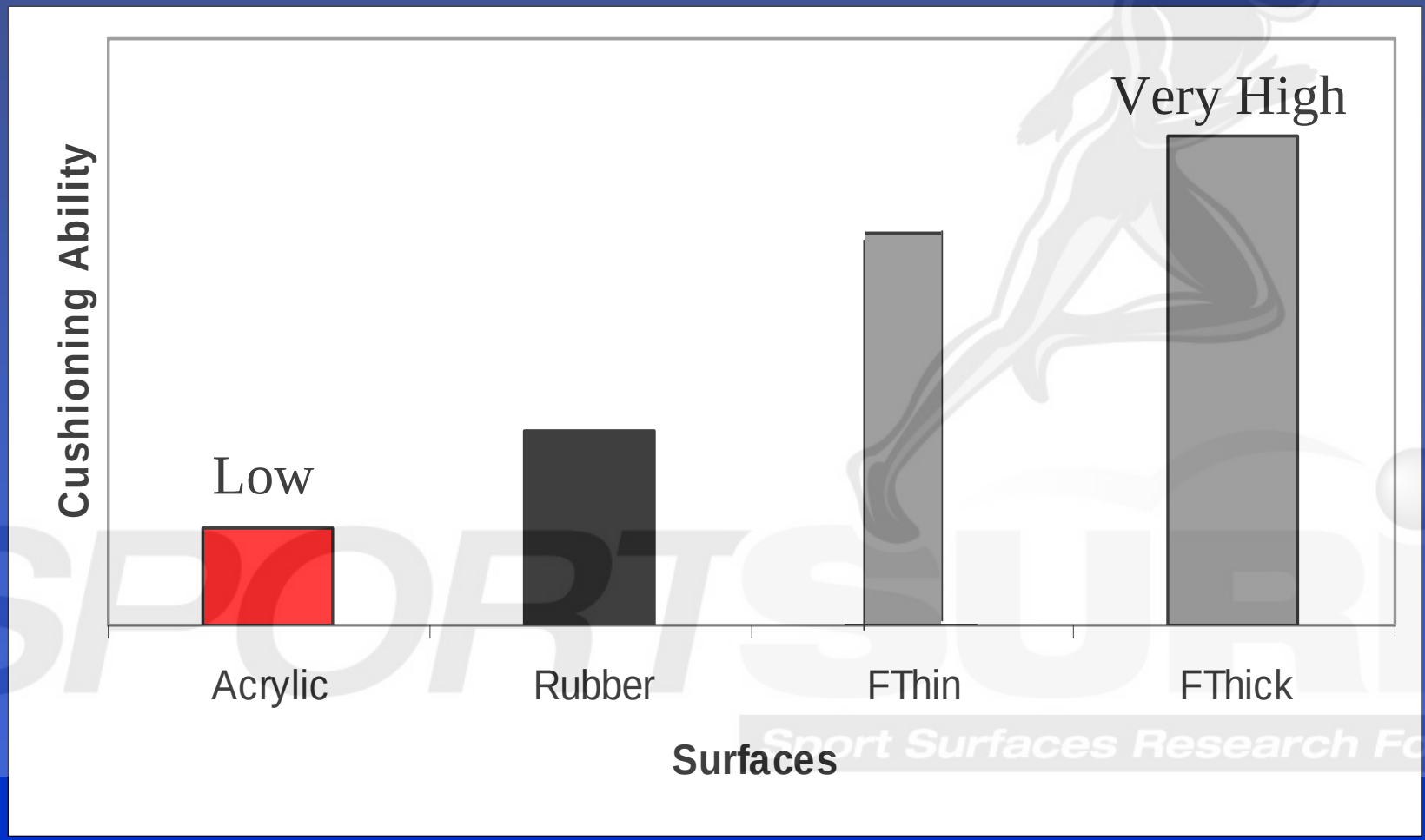
Rubber and acrylic



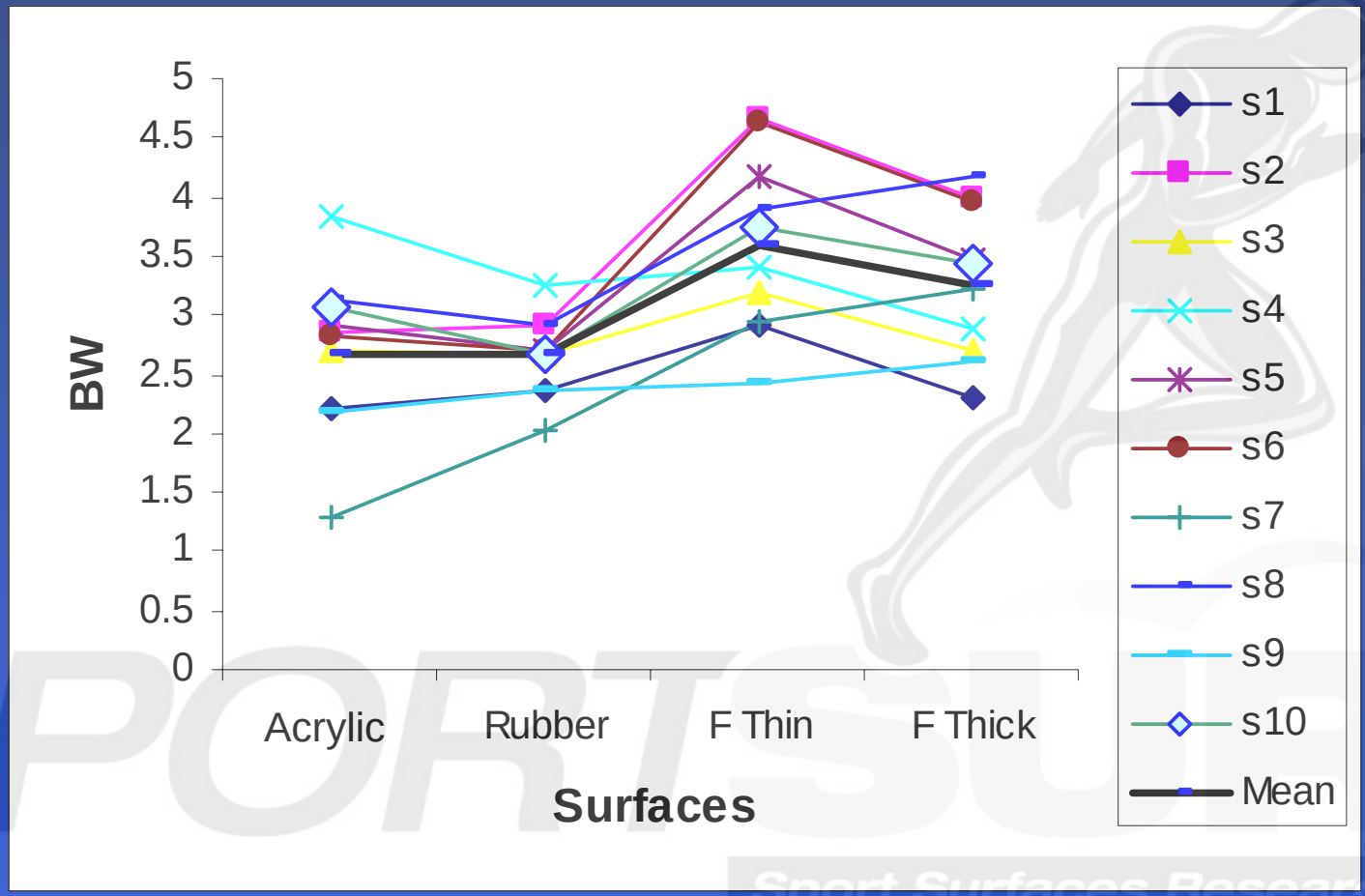
Thin foam and acrylic

Thick foam and acrylic

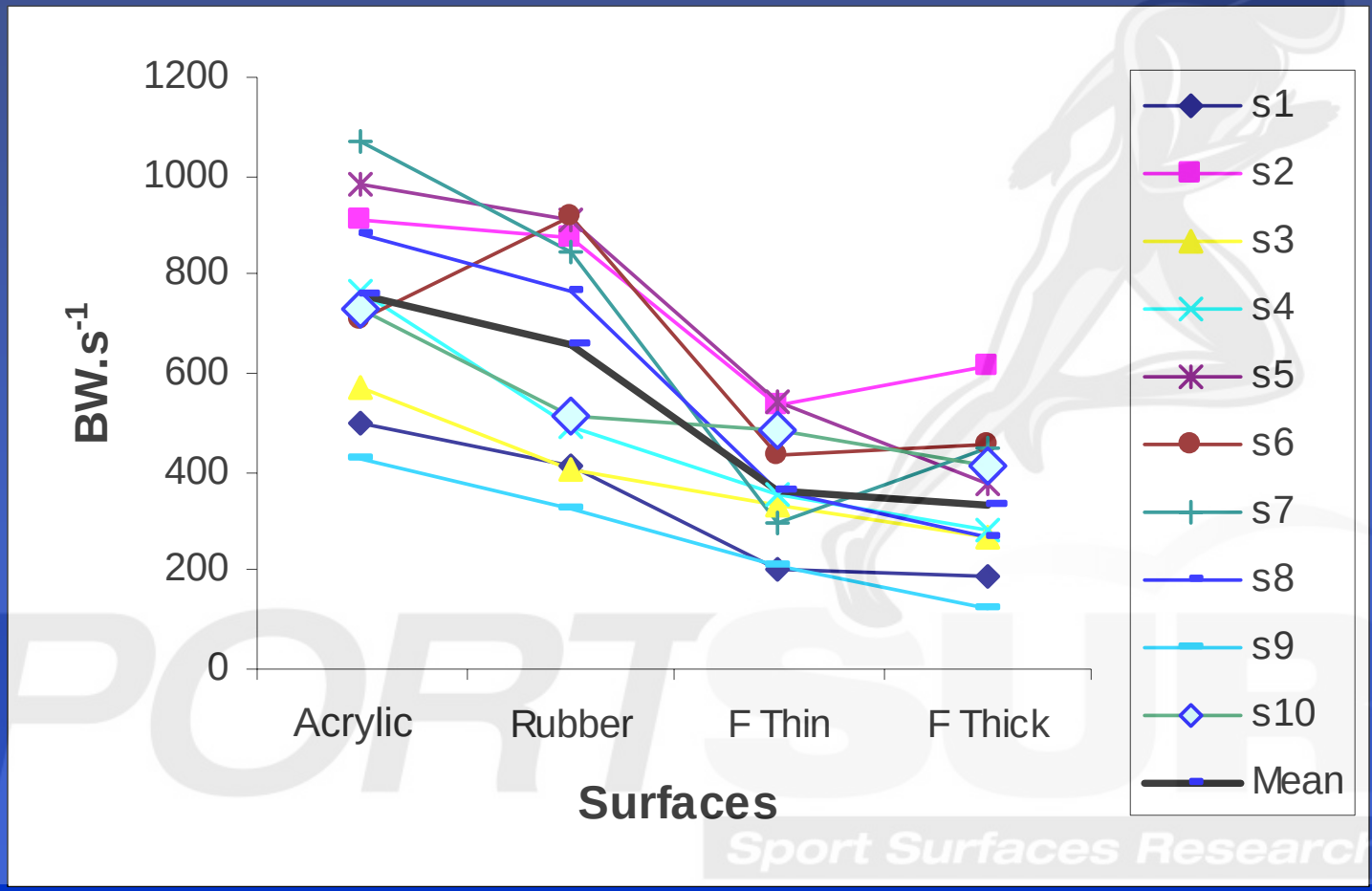
Surface cushioning ability (Drop test)



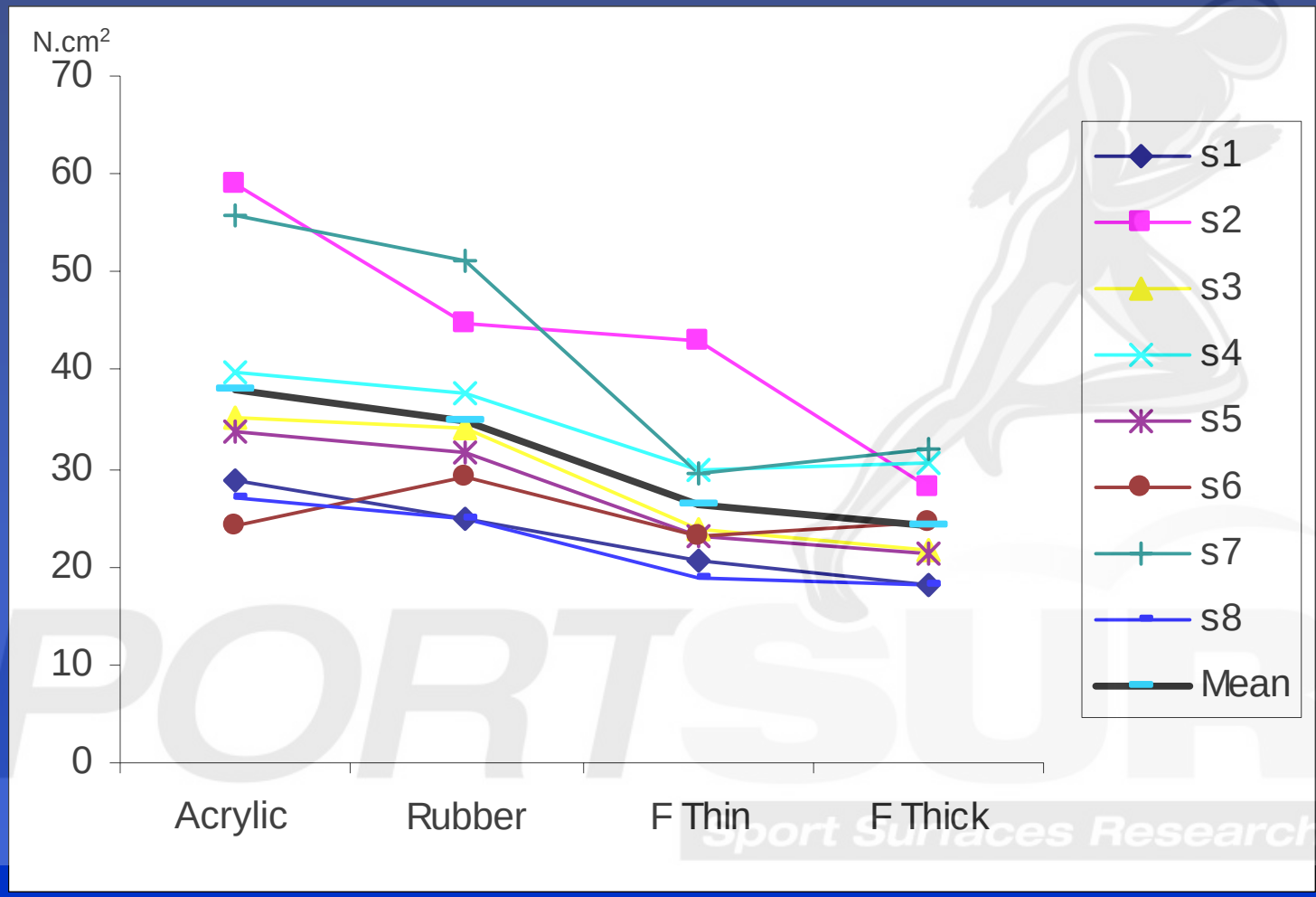
Peak Impact Force (Fz)



Peak Loading Rate

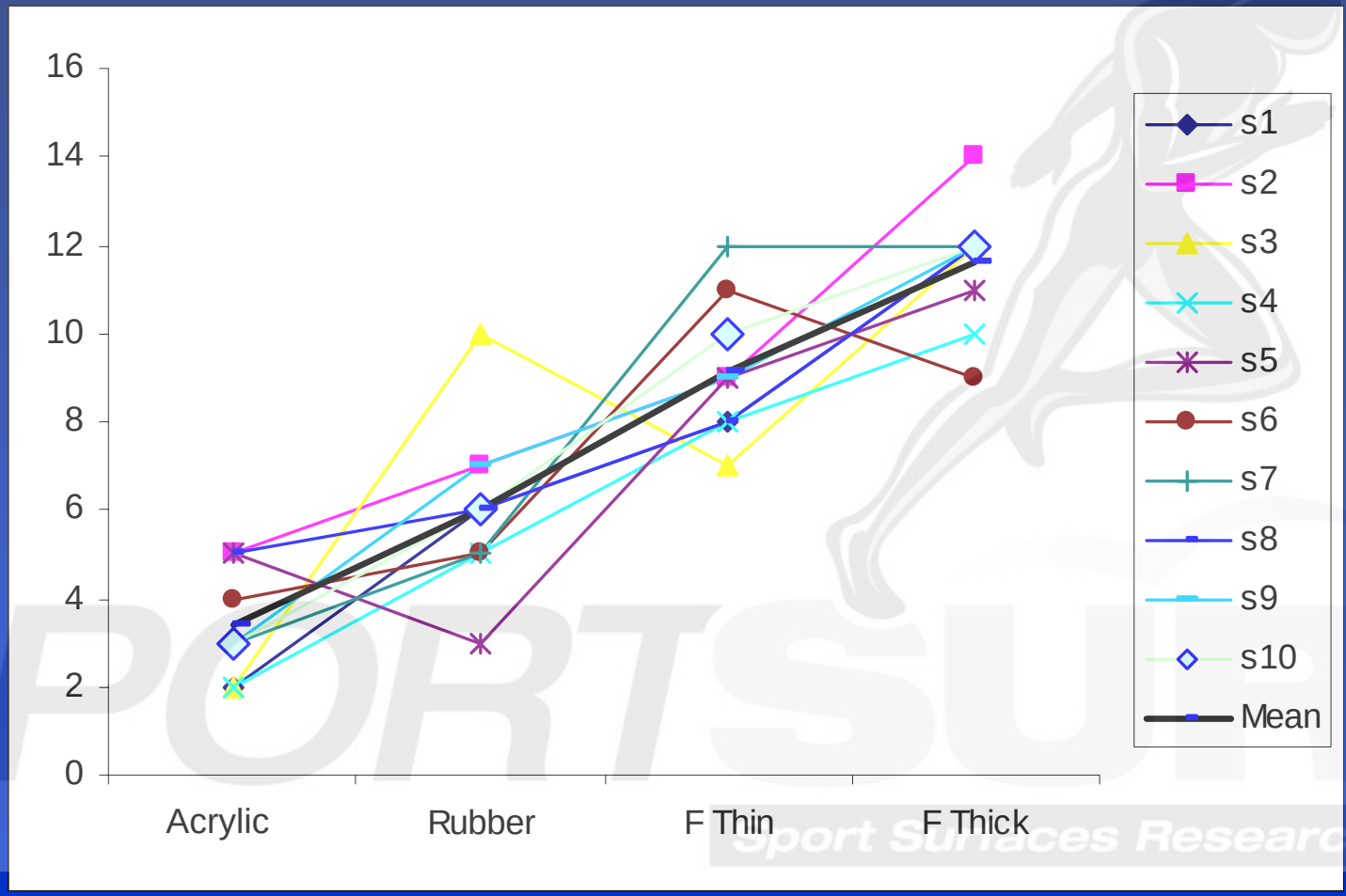


Peak Heel Pressure



Cushioning Perception

Hennig et al., 1996



Results Summary

Using selected variables, biomechanical classification of surface cushioning ability matched classifications derived from mechanical tests

- **Peak rate of loading**
- **Peak heel pressure**
- **Peak and average heel pressure loading rate**

Conclusions

Biomechanical findings support the use of mechanical methods of surface cushioning assessment

Suggested:
Where possible, both mechanical and biomechanical assessment of surface cushioning should be performed

Advised that peak impact force should not be used as a lone indicator of surface cushioning

(Stiles & Dixon, JSS in press)

Study of Natural Turf

Soil Dynamics Laboratory

- developed for testing of agricultural machinery

- potential for biomechanical testing of human subjects?

Dixon, James and Low (2006) *Sports Eng*

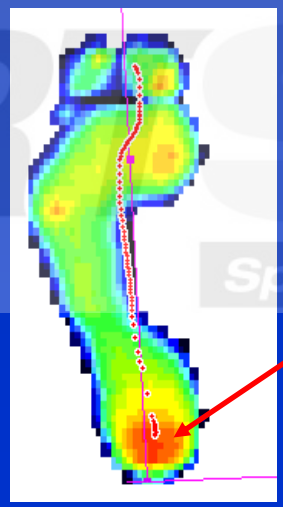
Shoe-Surface Conditions

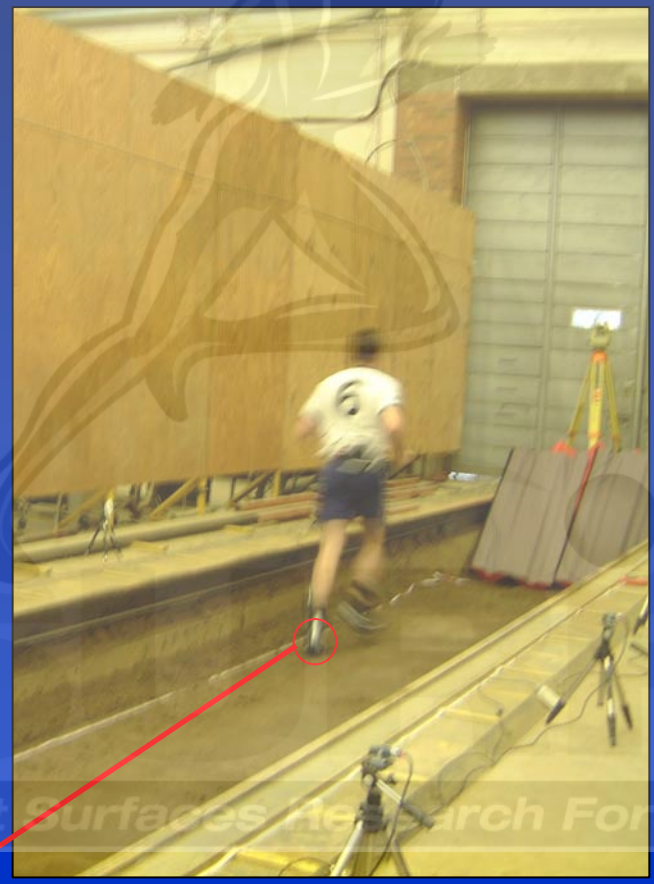
- Surface densities
  - 1460 kg.m^3 (‘soft’ soil: Surface 1)
  - 1590 kg.m^3 (‘hard’ soil: Surface 2)

- Footwear
  - traditional studs (‘studs’)
  - molded studs (‘molded’)
  - synthetic turf boots (‘synthetic’)

Biomechanical Data Analysis

- 6 steps per subject
- ‘cushioning’
  - peak resultant force
  - peak force at the heel





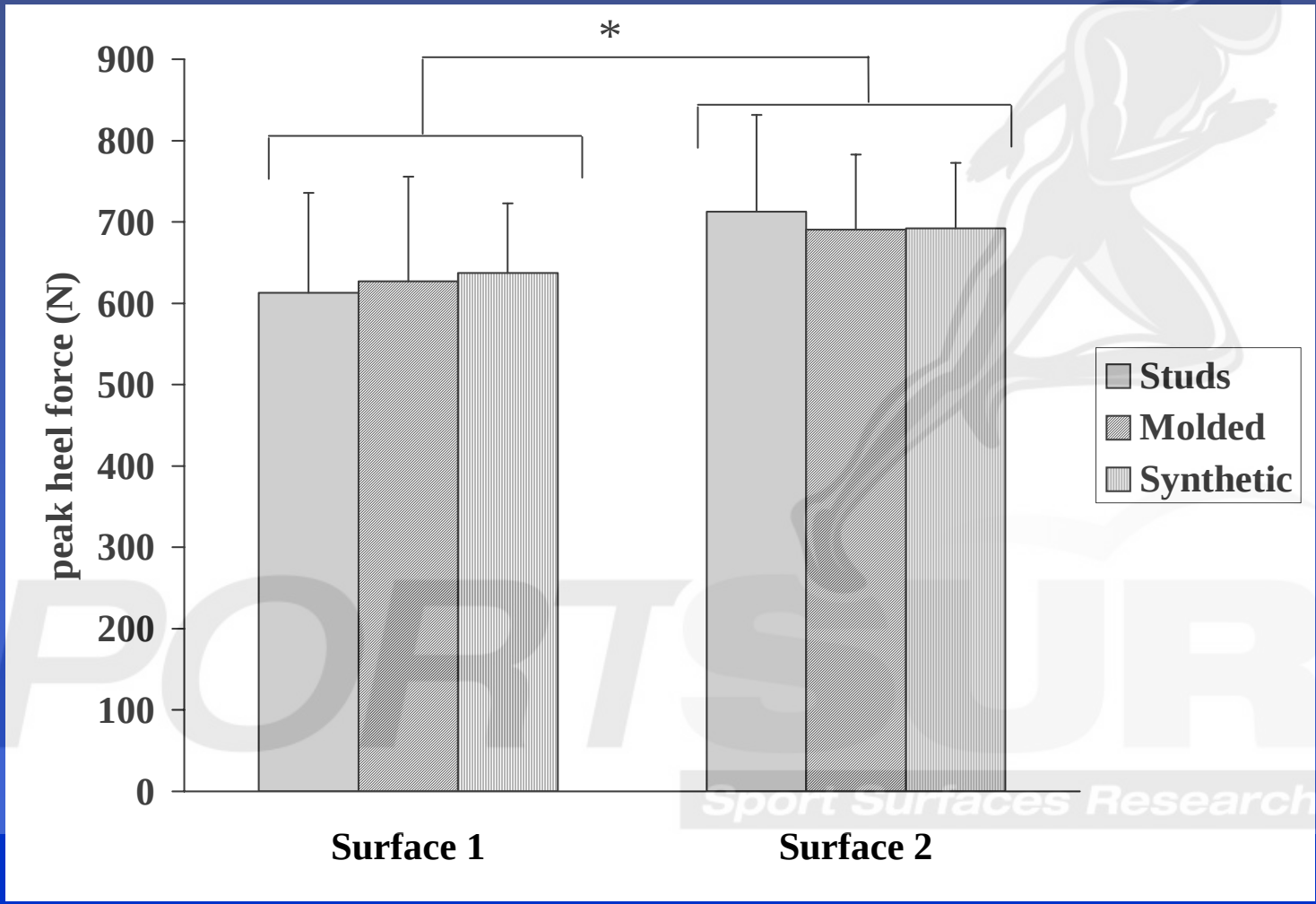
Mechanical Characterisation

- **Surface hardness (Clegg Hammer)**
  - **‘soft’ soil (Surface 1): 125 g**
  - **‘hard’ soil (Surface 2): 235 g**

- **Penetration resistance**
  - **‘soft’ soil (Surface 1): 1200 kPa**
  - **‘hard’ soil (Surface 2): 1800 kPa**

James et al (2006) *Eng of Sport 6*

Biomechanical Results



* p<0.05

Conclusions

- For the natural surfaces studied, differences in heel pressures detected
- Shoe selection not influential on impact loading on the test surfaces
- Biomechanical support for the large differences between surfaces indicated by mechanical testing
- Consideration of more realistic conditions

Biomechanical Assessment of Natural Turf in the Laboratory

- Examples of natural turf research in the field (Coyles et al., 1998; Eils et al., 2004)

- Limited research incorporating natural soil media in the biomechanics laboratory

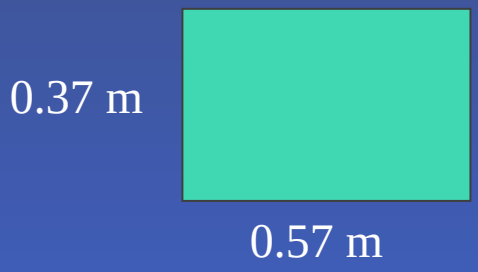
Conditions

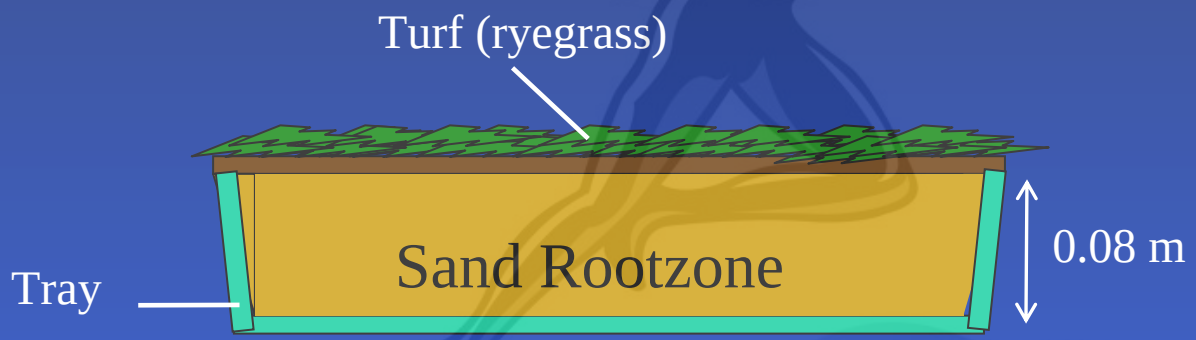
3 turf conditions: clay, sandy, rootzone

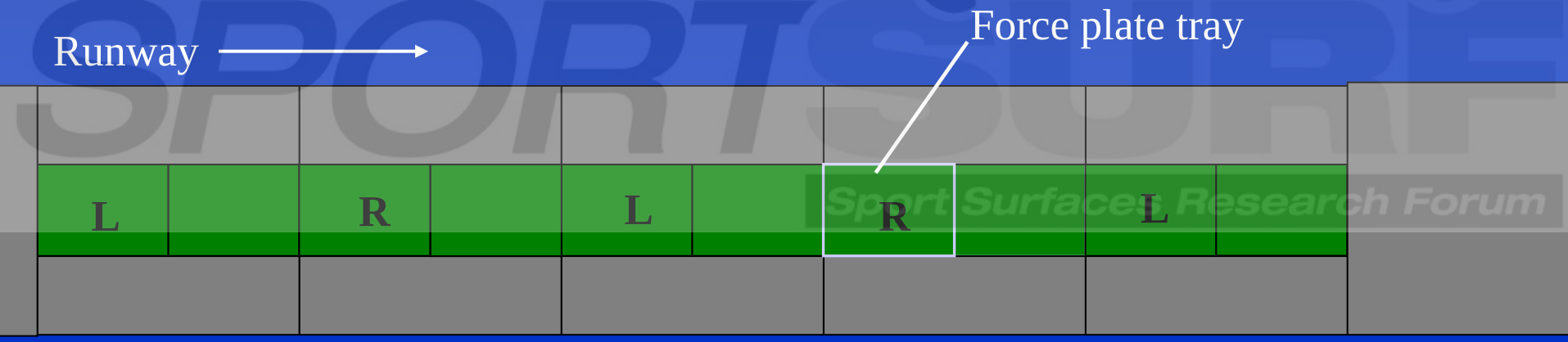
1 boot model

Methods

Portable Plastic Trays

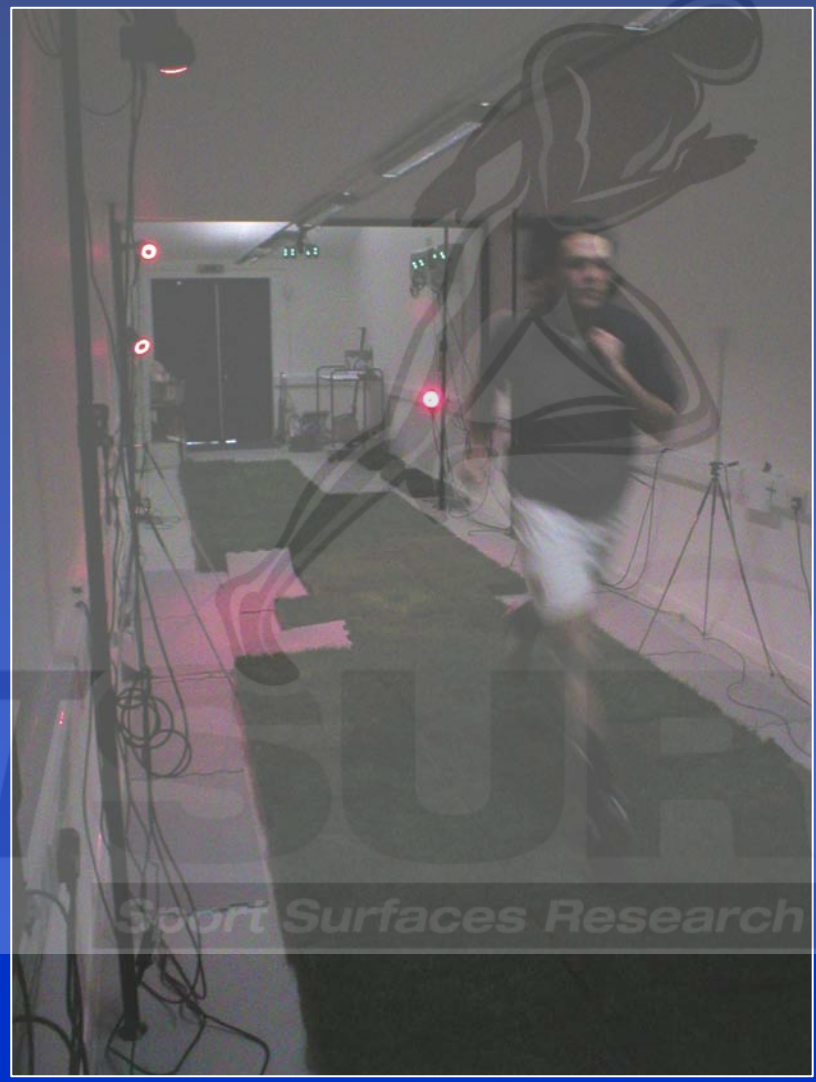






Data Collection

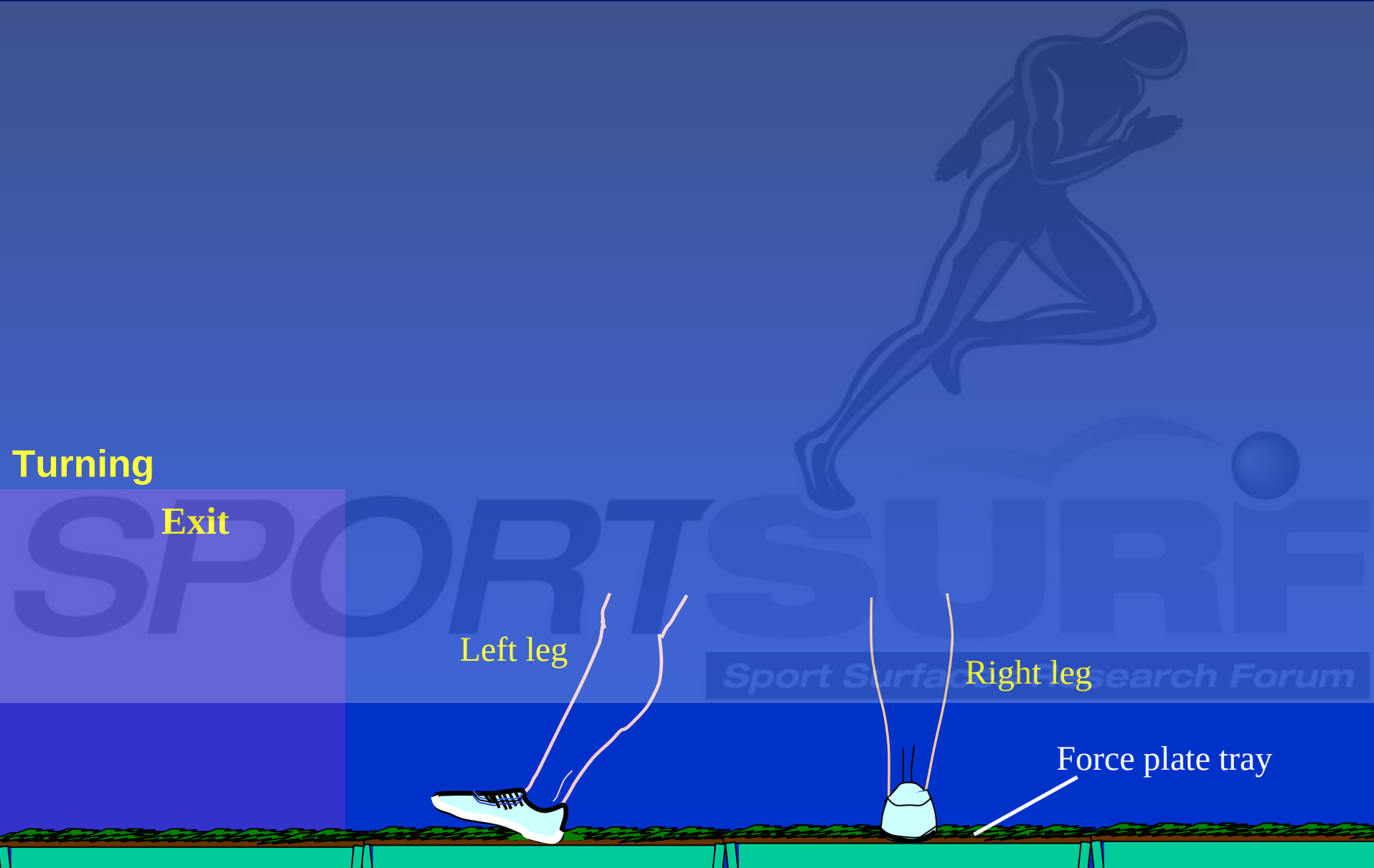
- Running
- Turning



Data Collection: Turning

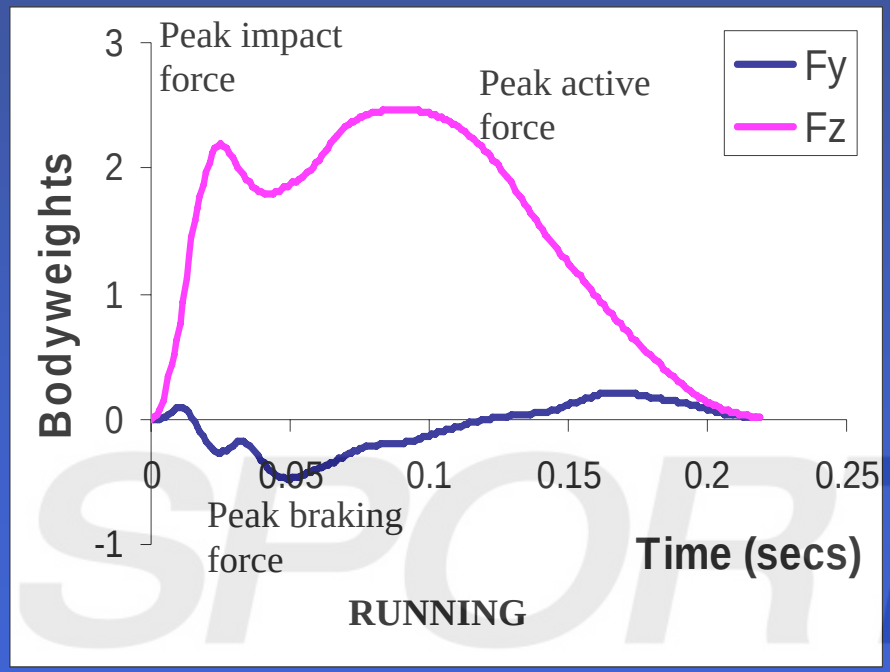
Turning

Exit

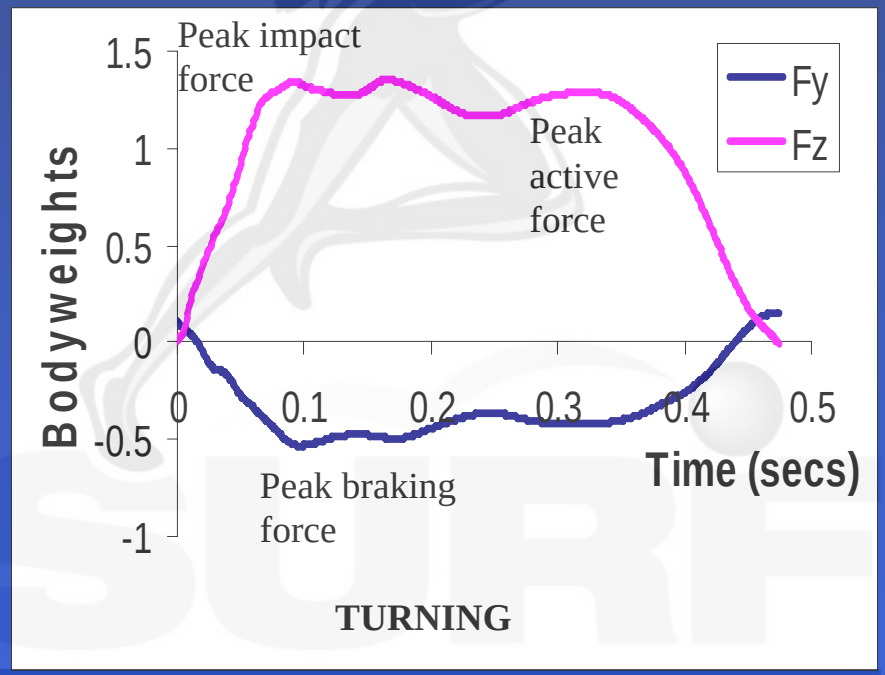


Results

Typical vertical (Fz) and horizontal (Fy) ground reaction force time histories

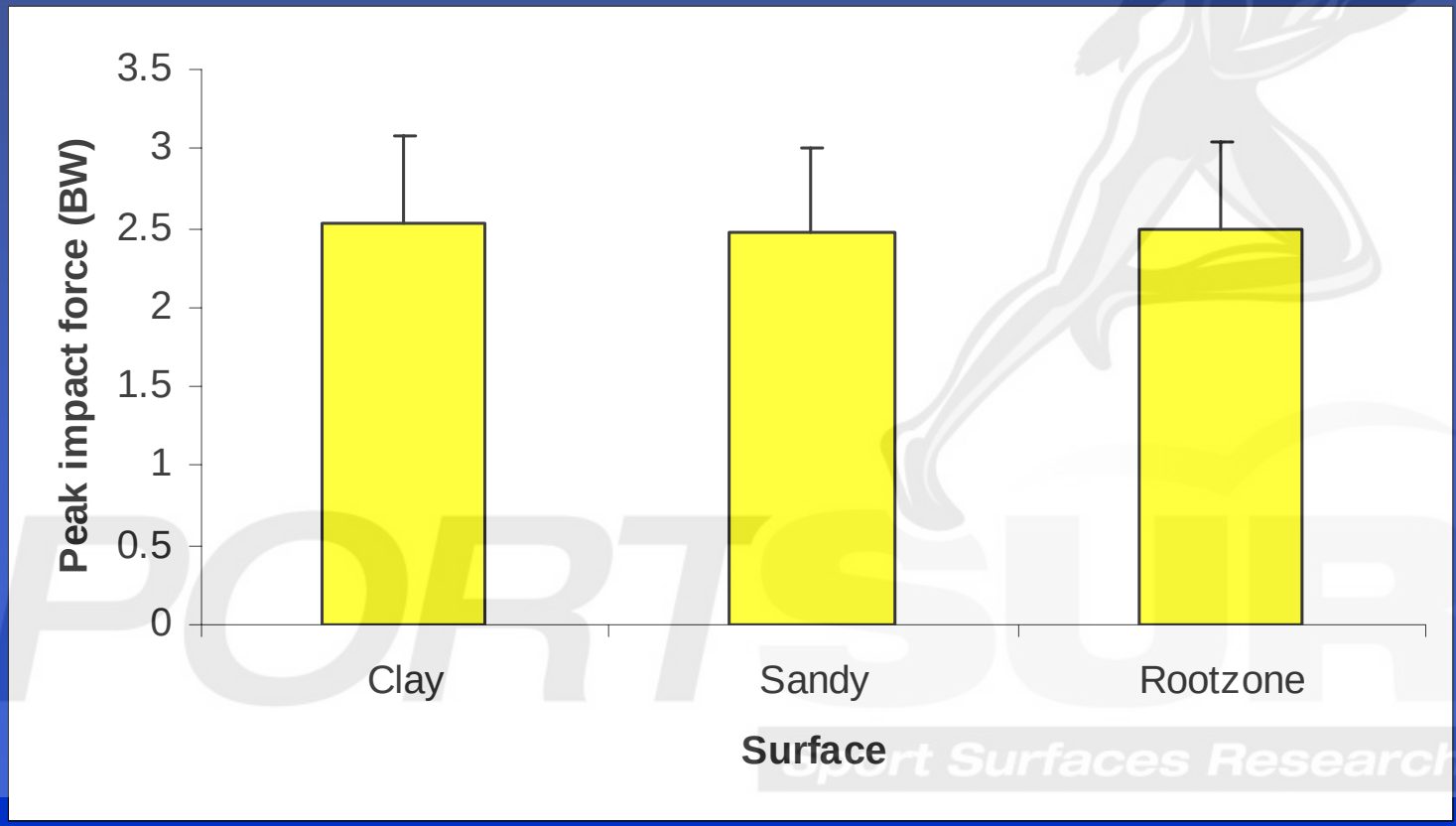


Running

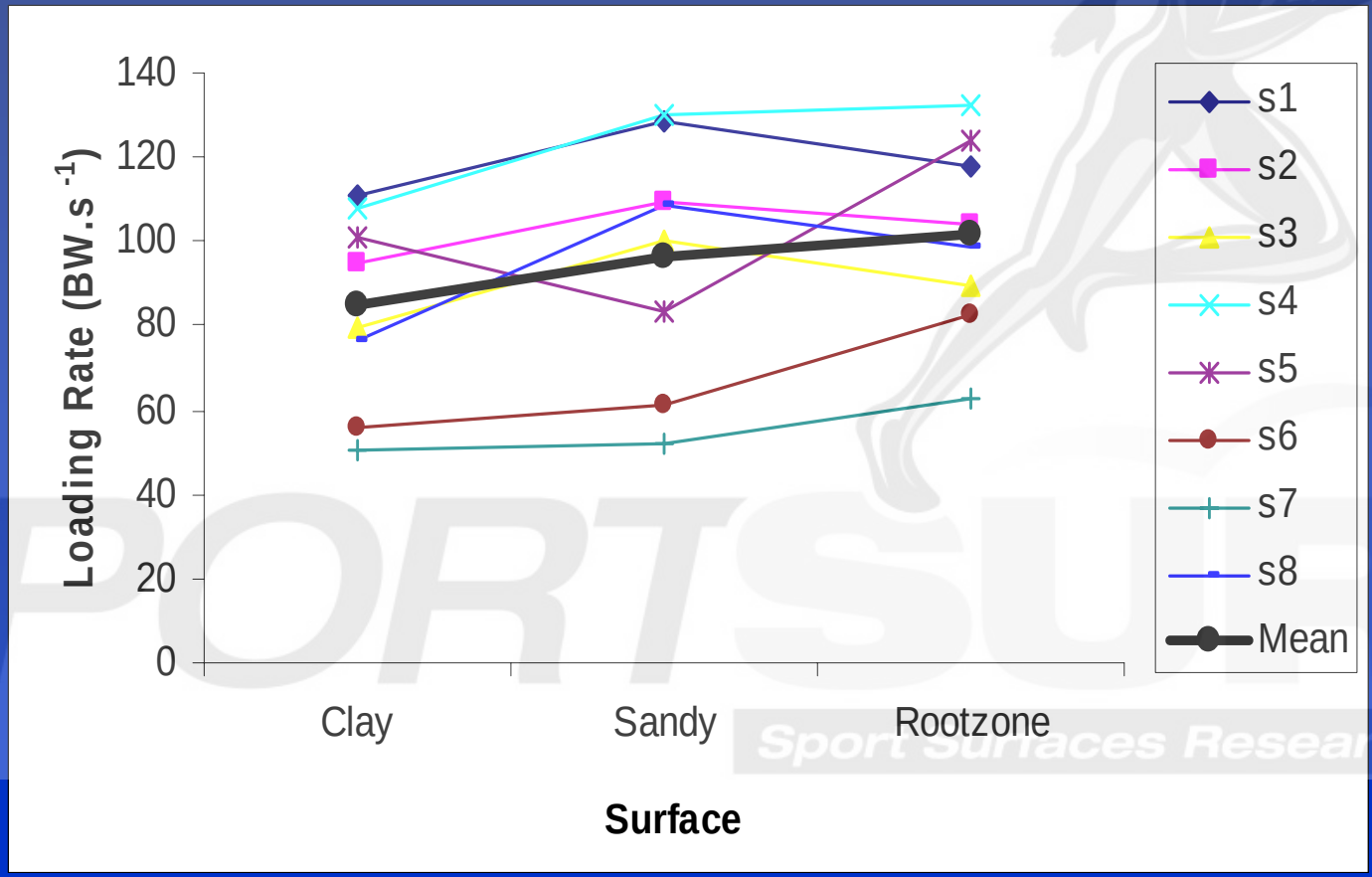


Turning

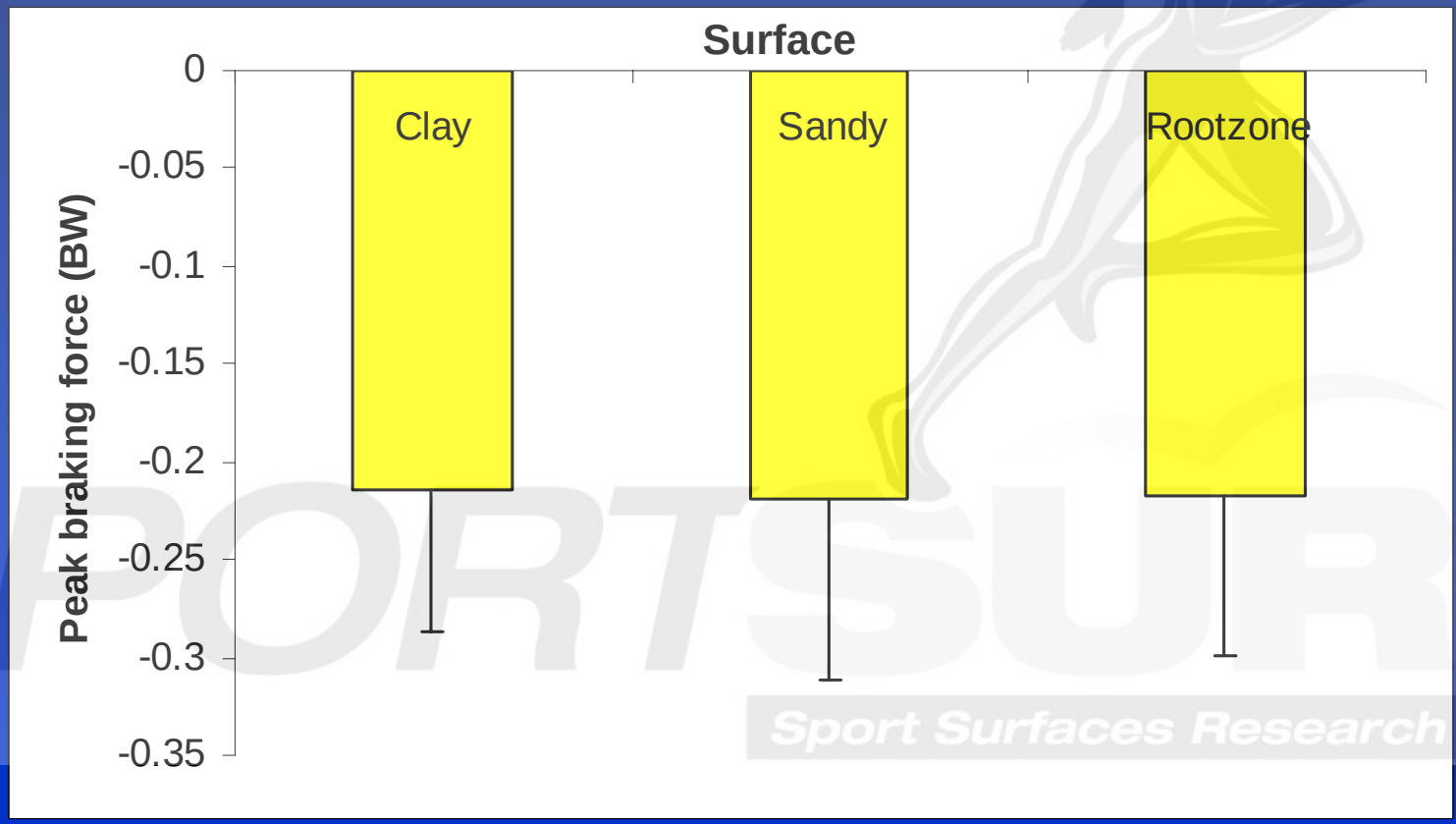
Results: Running impact force



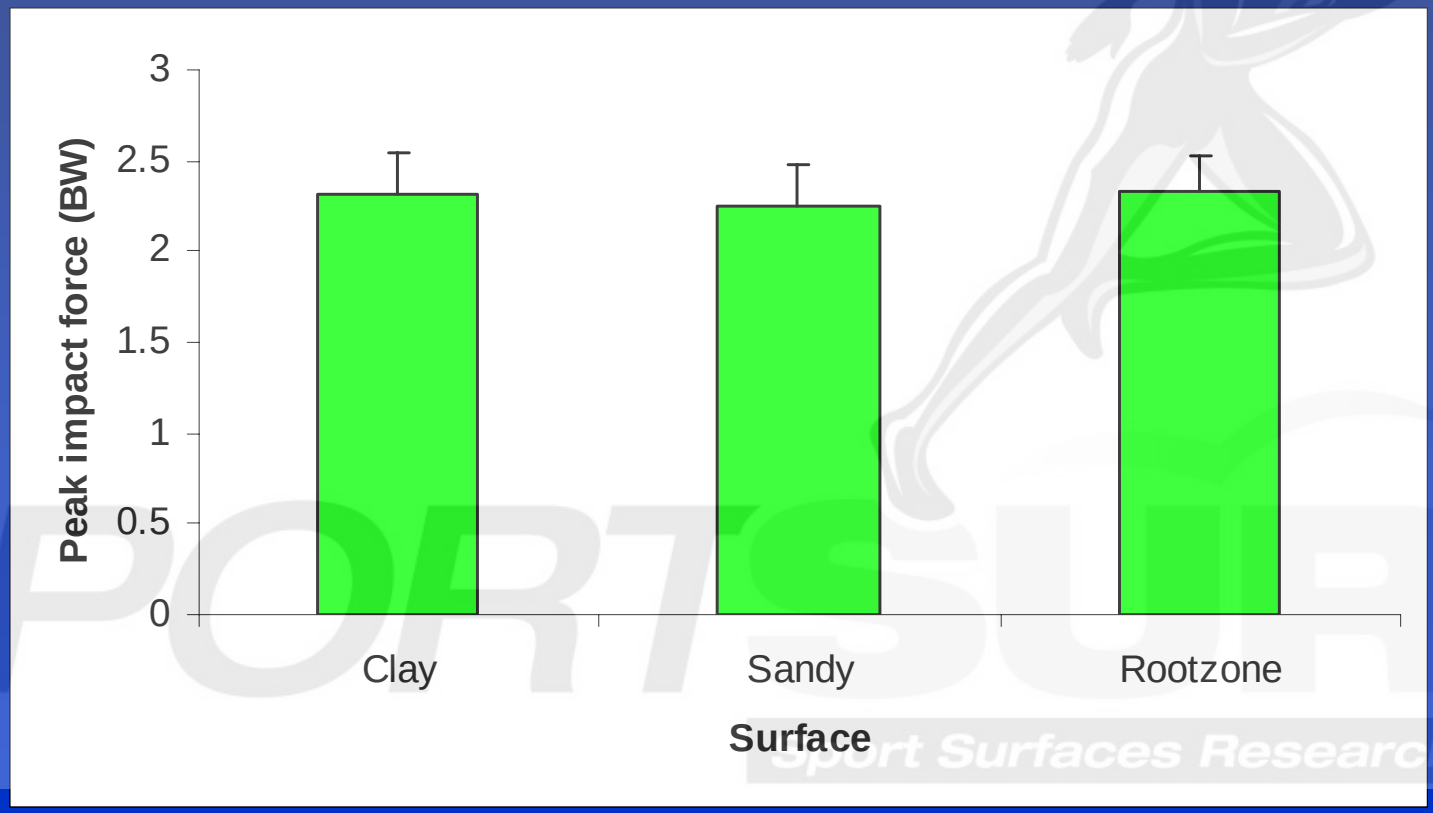
Running impact loading rate



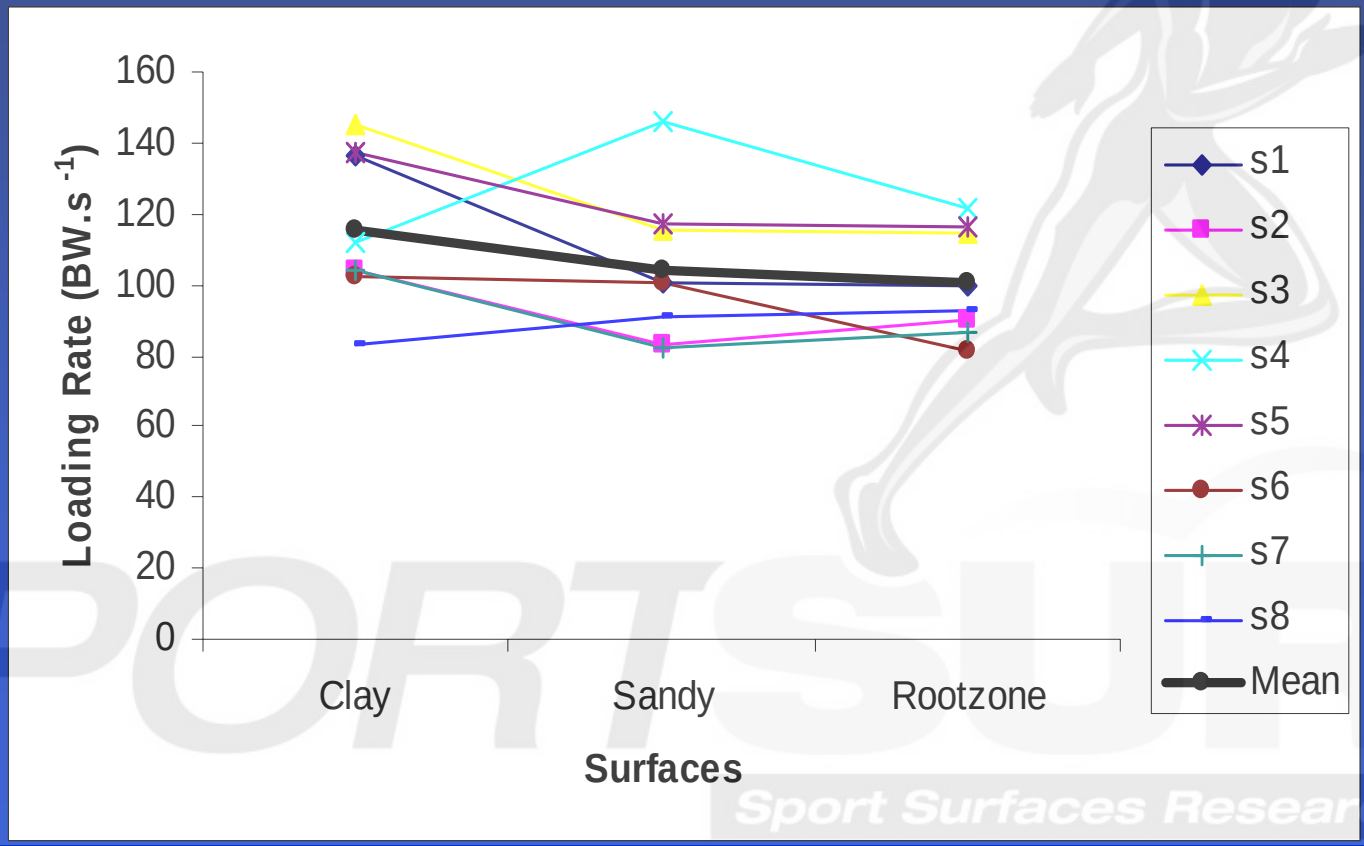
Running braking force



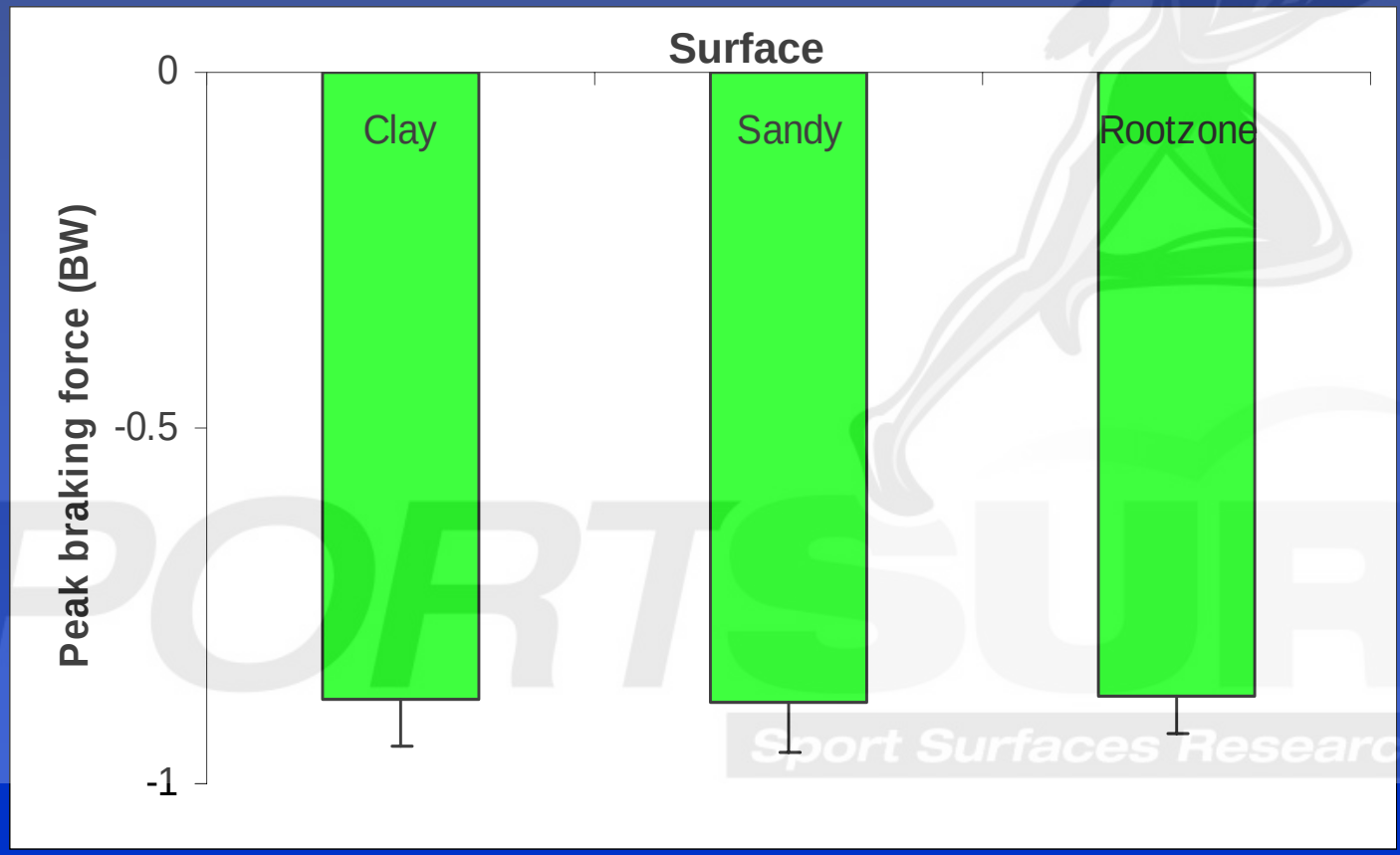
Results: Turning impact force



Results: Turning impact loading rate



Turning braking force



Results So Far…

- No significant differences in peak impact or peak braking force across turf conditions
- Significant ($p<0.05$) differences in peak loading rate across turf conditions

Summary

- **Biomechanical testing:**
  - **Loading rate of impact force**
  - **Peak heel pressures**
- **Mechanical testing**
  - **Synthetic surfaces: Berlin AA; drop tests**
  - **Natural turf: density; penetration; hardness**

Surface Characteristics

- What are the specific differences between surfaces that influence the player?
  - Stiffness & Damping
  - Traction
  - Spatial and temporal uniformity
- How do these influence the player?
- How are these quantified?

Future Interdisciplinary Study

- **Measurement of loads at different levels:**