University of Exeter

School of Sport and Health Sciences

Cranfield Centre for Sports Surfaces

Cranfield University

Biomechanical response to variations in natural turf surfaces during running and turning

Victoria H. Stiles [1], Sharon J. Dixon [1], Igor N. Guisasola [2], & Iain T. James [2]

[1] School of Sport and Health Sciences, University of Exeter, UK

[2] Cranfield Centre for Sports Surfaces, Cranfield University, UK

EPSRC

School of Sport and Health Sciences
Exeter Biomechanics Research Team (ExBiRT™)

Introduction

- Important health benefits gained from participation in sport and exercise

DOH, 2004

➡ Traditional sports at elite and recreational level, e.g. hockey, soccer, tennis, rugby, cricket, lacrosse

➡ Require adequate sports facilities ……appropriate, affordable and safe.

Artificial Turf

Hockey: Natural to Artificial turf 1970's

Spencer et al., 2004)

Lack of Natural Turf Replication

Natural Turf → Artificial Turf

Reluctance of some sports to change to artificial turf due to loss of playing characteristics

The Case for Natural Turf

1. Maintain fundamental characteristics of sports such as soccer, rugby, golf, cricket and lacrosse

2. Protect green spaces in the built environment

Meeting Surface Provision

Advancement in construction and sustainability of natural turf to meet surface provision for training and competitive use in sports

Natural Turf Testing

Lack of research

Assessment of…

- studded footwear on artificial turf *Morag & Johnson, 2001*
- grip performance during cutting manoeuvres in the field *Coyles et al., 1998*
- plantar pressures during sports specific movements in the field *Eils et al., 2004*

Specific Research

An Initial Investigation of Human-Natural Turf Interaction in the Laboratory

Stiles, Dixon & James, 2006

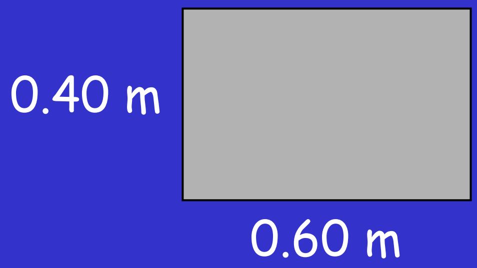
Advancement in construction and sustainability of natural turf surface requires

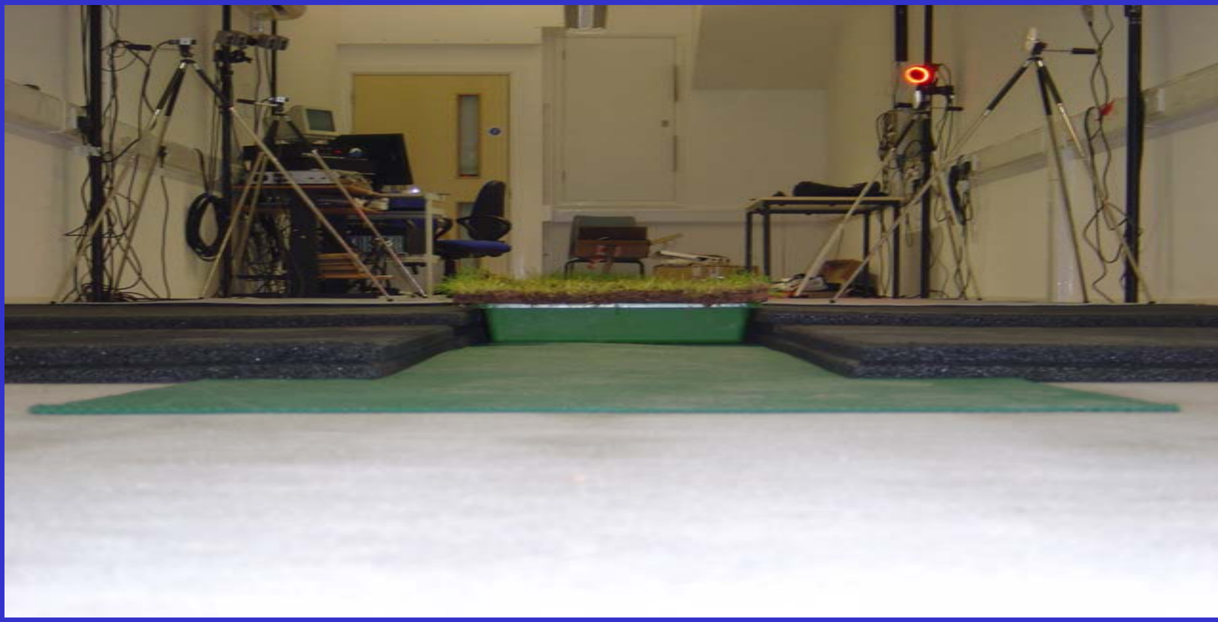
Increased understanding of how humans respond to variations natural turf properties
(Biomechanical)

Increased understanding of how turf responds to variations in sports specific human movement.
(Mechanical)

Hypothesised that a surface with the highest mechanical hardness and shear strength would yield the highest peak impact forces and peak rates of loading.

Methods





Turf Conditions

	Clay (%)	Silt (%)	Sand (%)	Density (kg/m^3)
Clay Loam (Heavy clay soccer pitch)	27	44	29	1294
Sandy Loam (Intermediate sandy pitch)	13	28	59	1517
Rootzone (Modern, elite turf pitch)	1	1	98	1736

Methods

8 male participants (soccer/rugby)

Session 1: Running ($3.83 m.s^{-1} \pm 5\%$)

Session 2: Turning, (sub-maximal, subject specific speeds)

10 trials / condition

Right-footed contact with force plate (AMTI, 960 Hz)

Standard metal studded boots (UK, 10, 11 &12)

Ethical approval obtained from School of Sport and Health Sciences, University of Exeter

Mechanical Testing - Before and After measures

Clegg Hammer

Hardness (peak deceleration – ‘peak g’)
Three test sites on tray used to obtain measure of average hardness

Dielectric probe

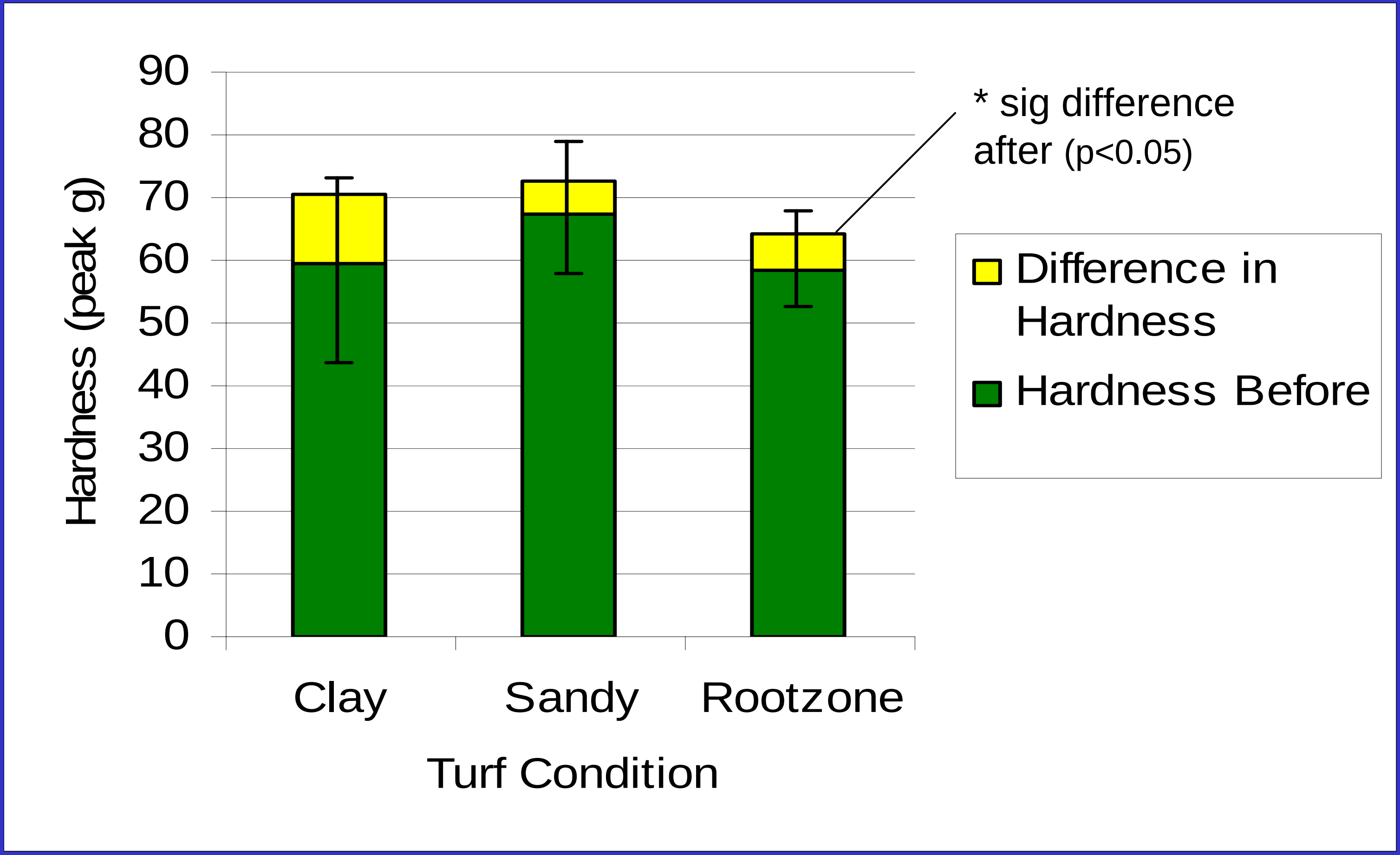
(e.g. a Theta Probe, Delta-T, Cambridge)
Determines the volume of water per unit volume of soil as a percentage (vol%)

Cruciform Shear Vane

Measures shear strength. Inserted to depth of 33 mm and rotated to soil failure (kPa; BS1377-9, 1990)

Results - Running

Mechanical property: Hardness



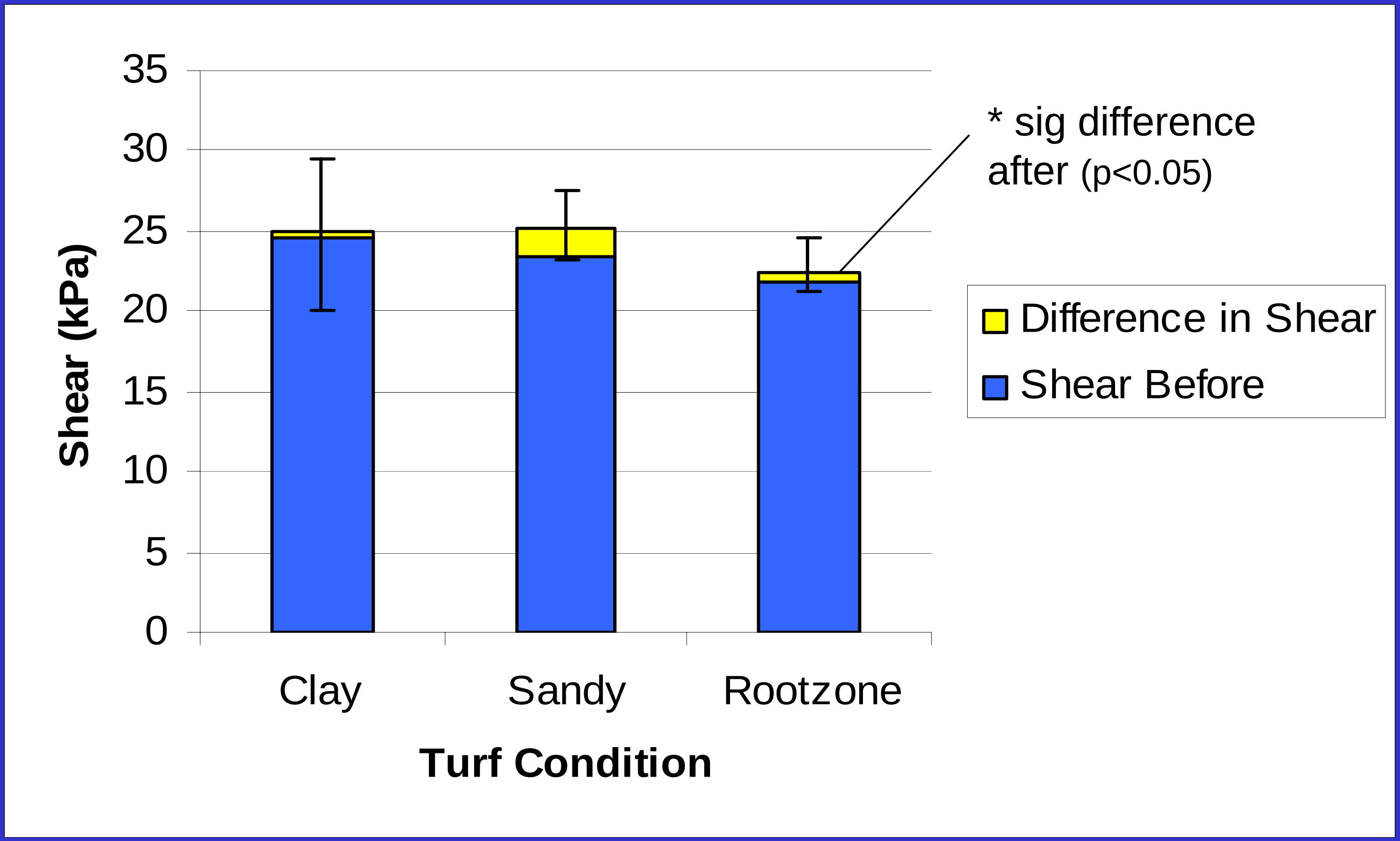
Heavy clay soccer pitch

Intermediate sandy pitch

Modern, elite turf pitch

Results - Running

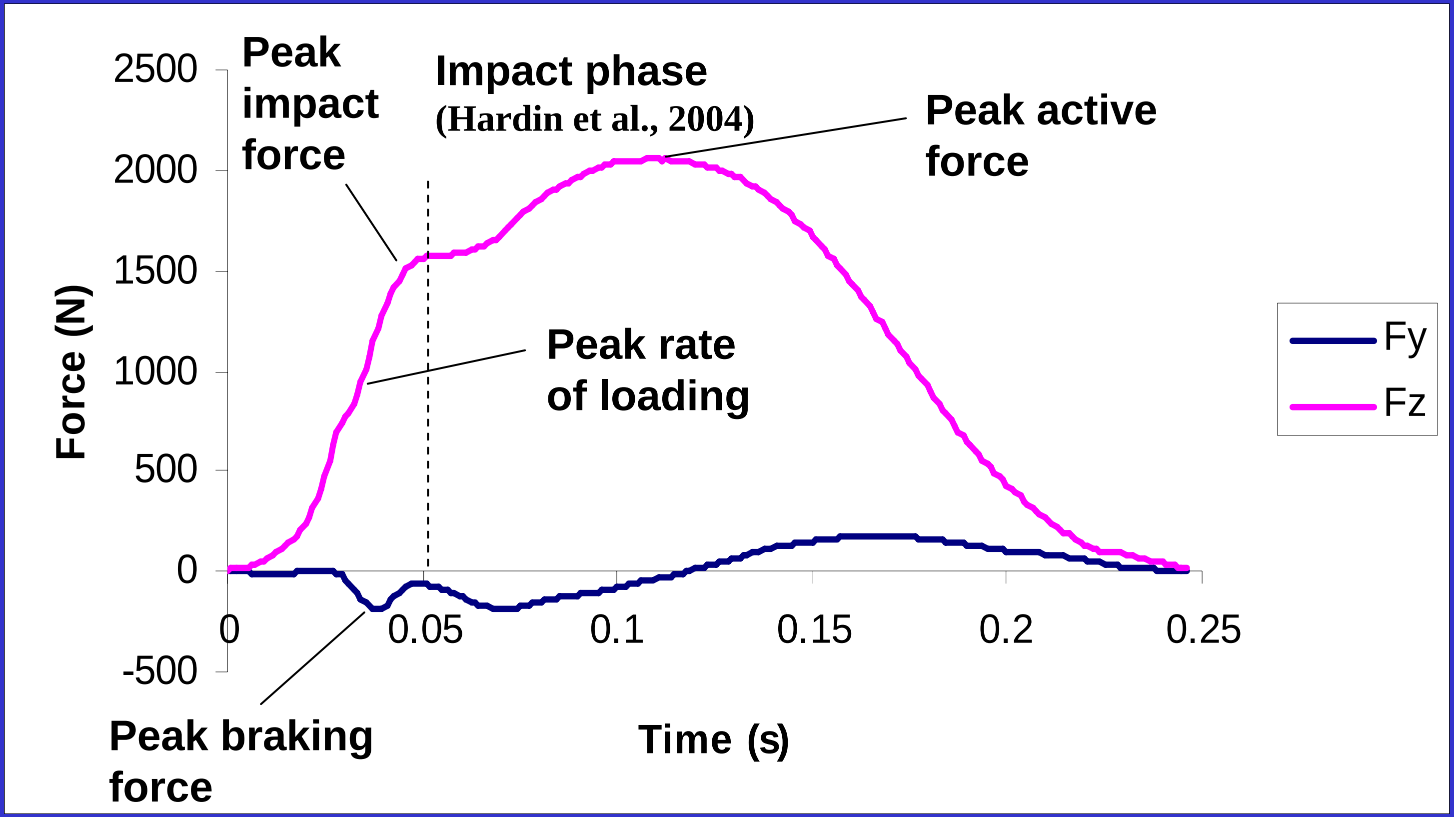
Mechanical property: Shear



Heavy clay soccer pitch | **Intermediate sandy pitch** | **Modern, elite turf pitch**

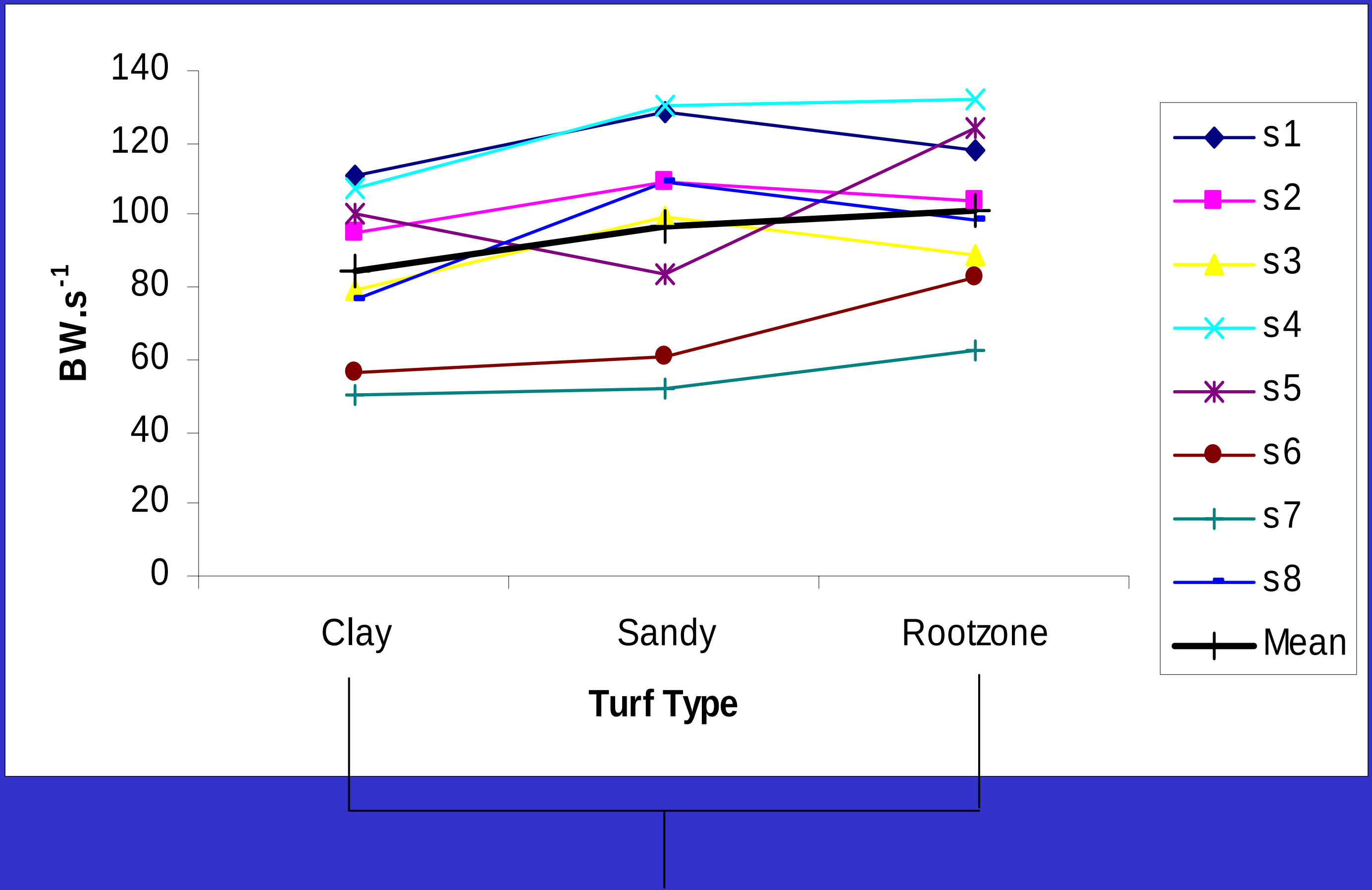
Results - Running

Typical ground reaction force-time history



Results - Running

Peak loading rate



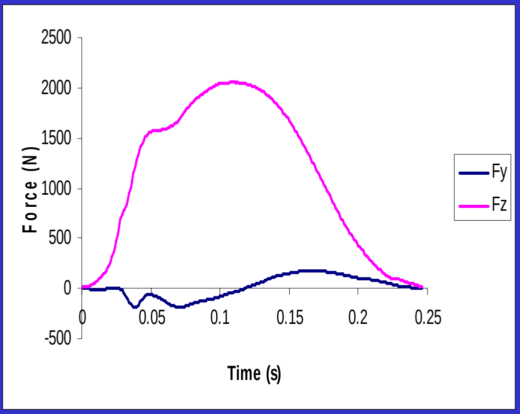
Significant difference between clay and rootzone ($p<0.05$)

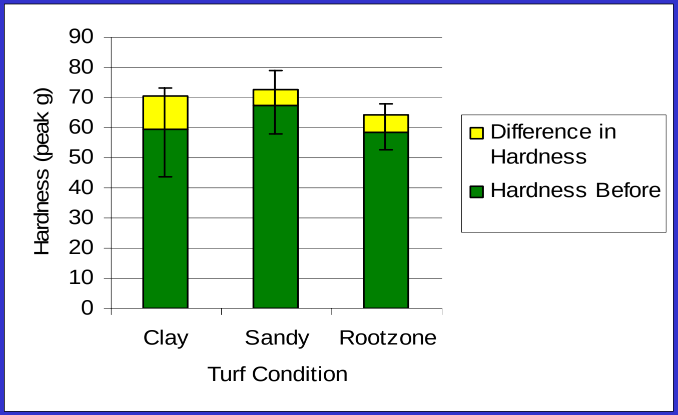
(RMANOVA and post hoc Tukey test)

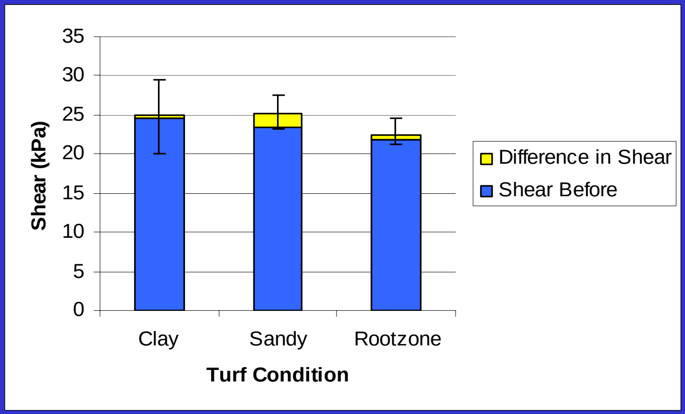
Results - Running

Biomechanical and Mechanical Summary

	Heavy clay soccer pitch Clay	Intermediate sandy pitch Sandy	Modern, elite turf pitch Rootzone
Peak LR (BW.s^{-1}) ***sig**	* 84.67 (±22.9)	96.74 (±29.1)	*** 101.48** (±23.3)
Peak braking force (BW)	-0.21 (±0.07)	-0.22 (±0.09)	-0.22 (±0.08)

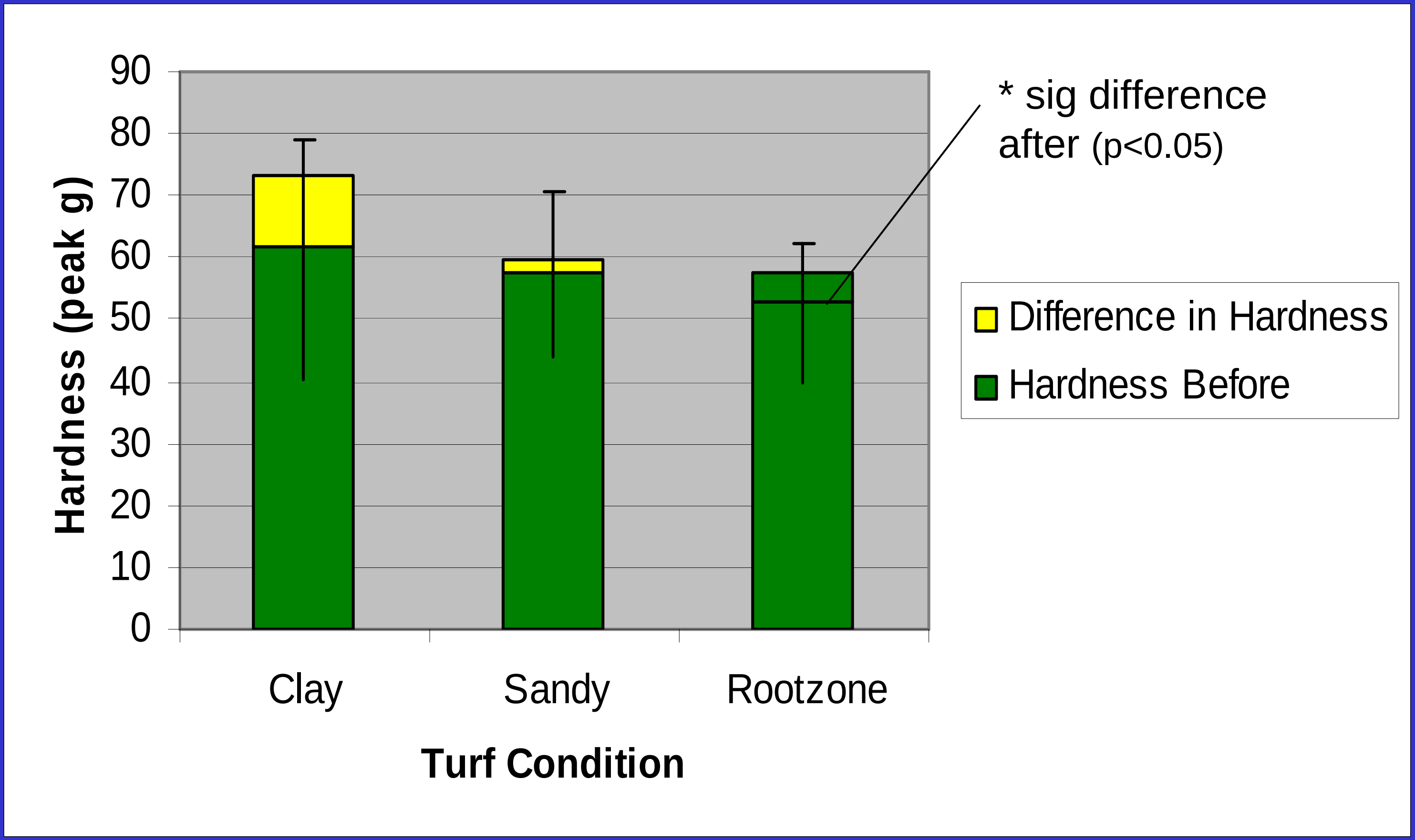






Results - Turning

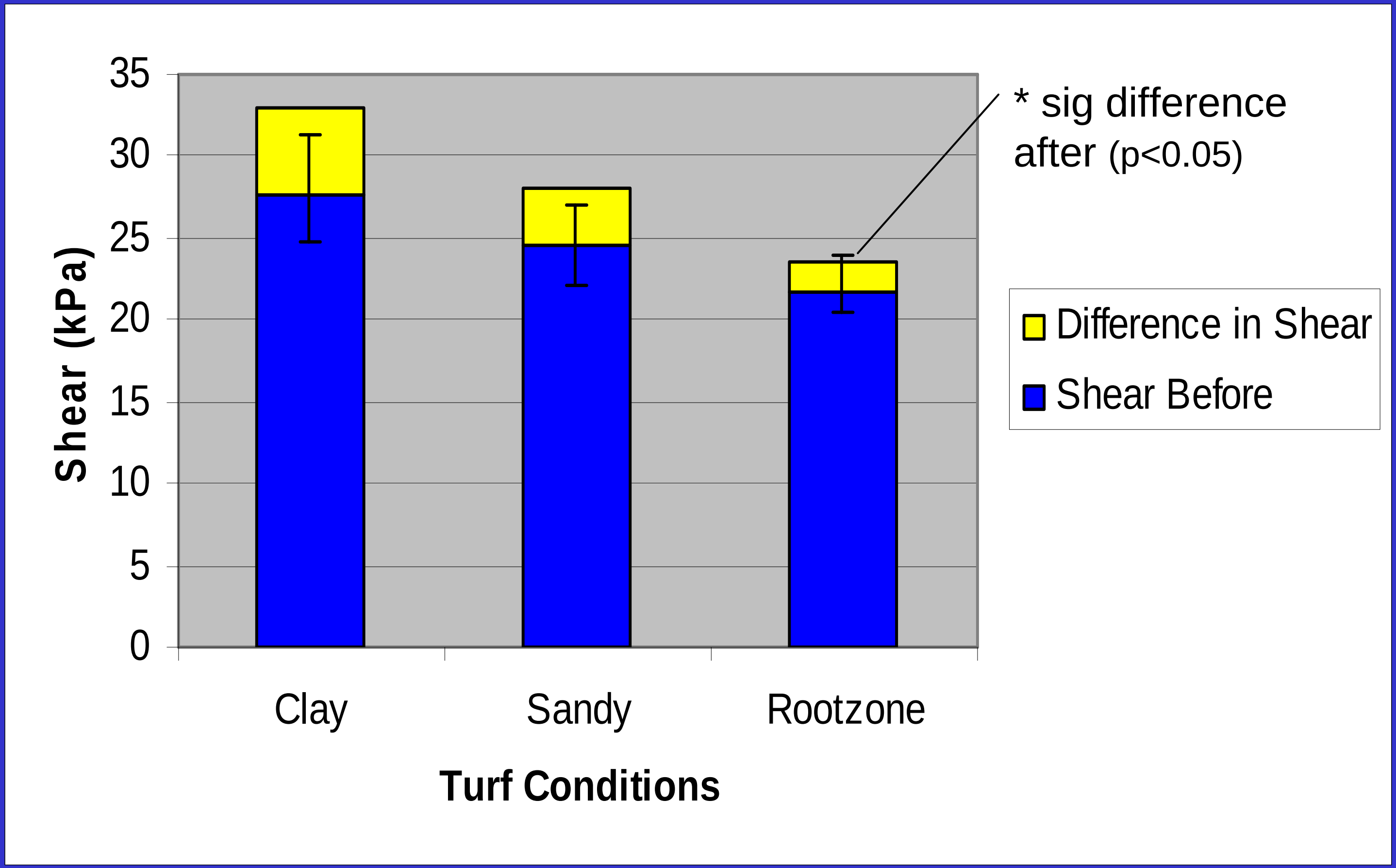
Mechanical property: Hardness



Heavy clay soccer pitch **Intermediate sandy pitch** **Modern, elite turf pitch**

Results - Turning

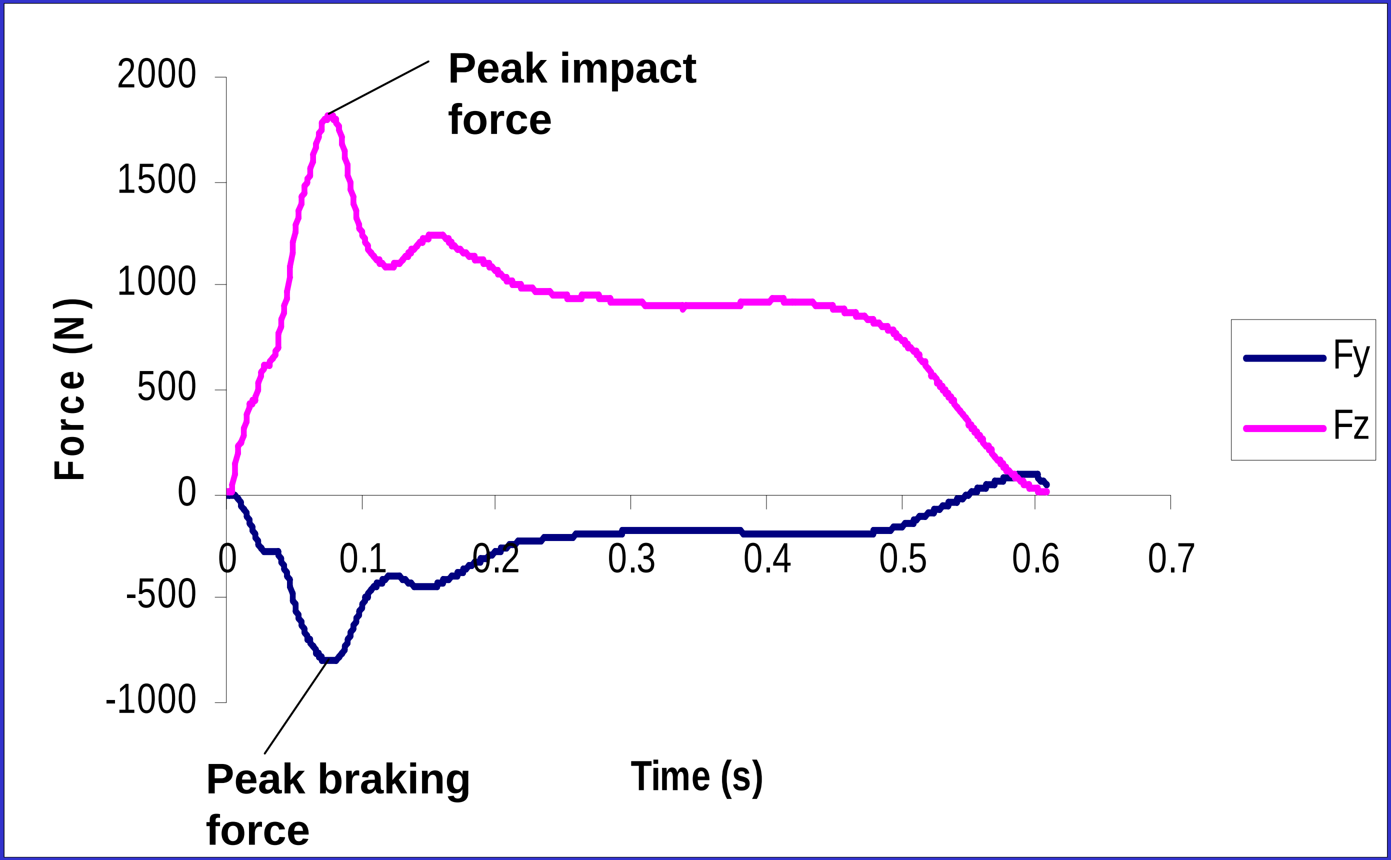
Mechanical property: Shear



Heavy clay soccer pitch	**Intermediate sandy pitch**	**Modern, elite turf pitch**

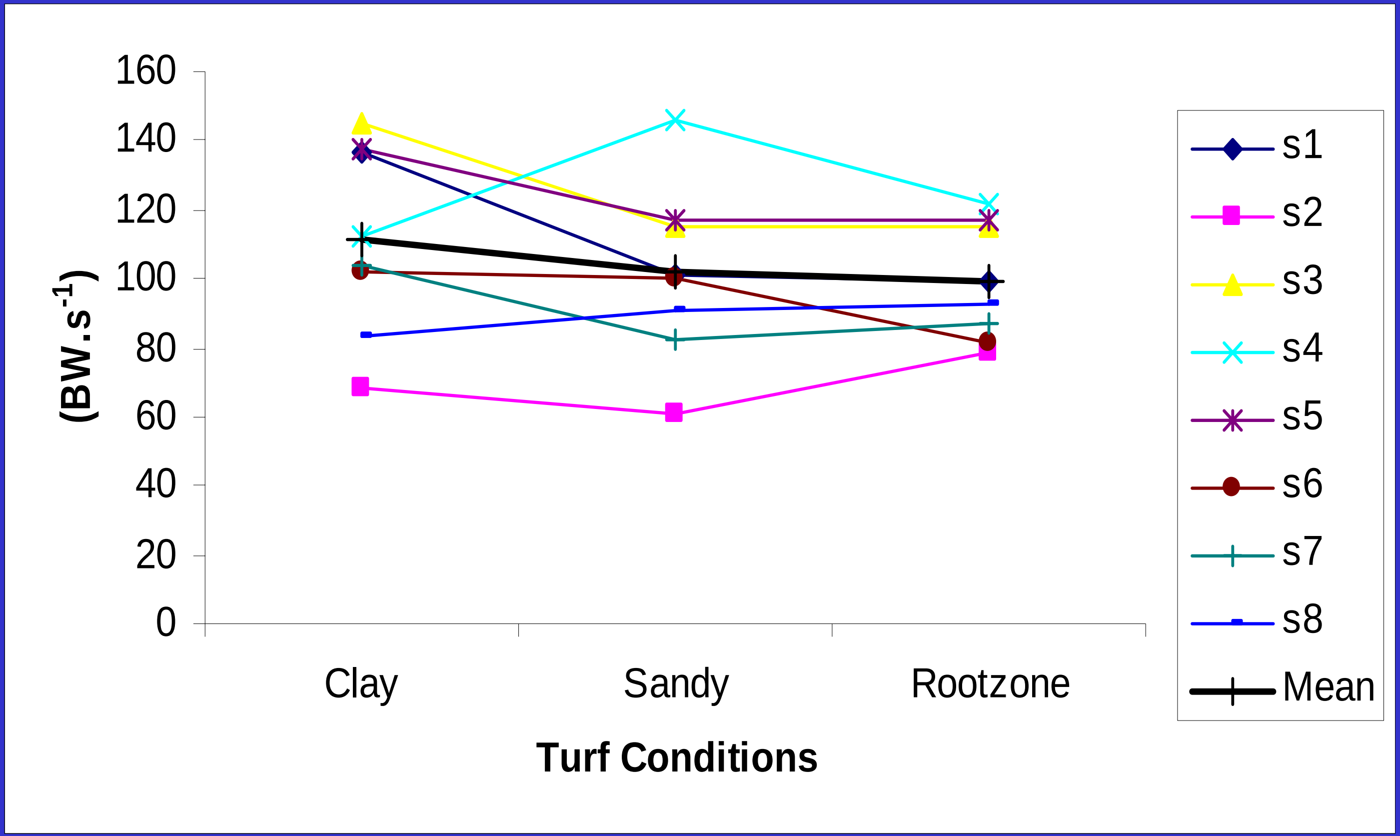
Results - Turning

Typical ground reaction force-time history



Results - Turning

Peak loading rate



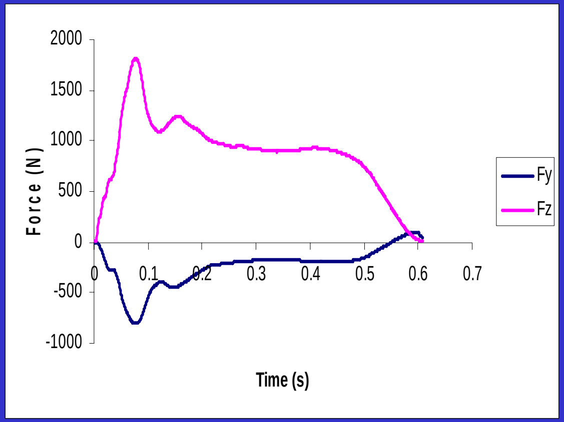
No significant differences (p<0.05)

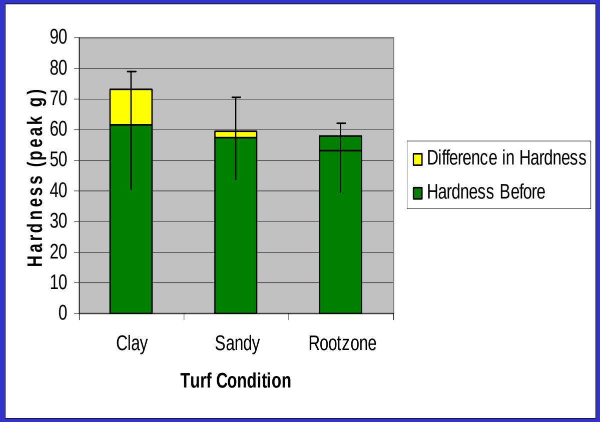
RMANOVA

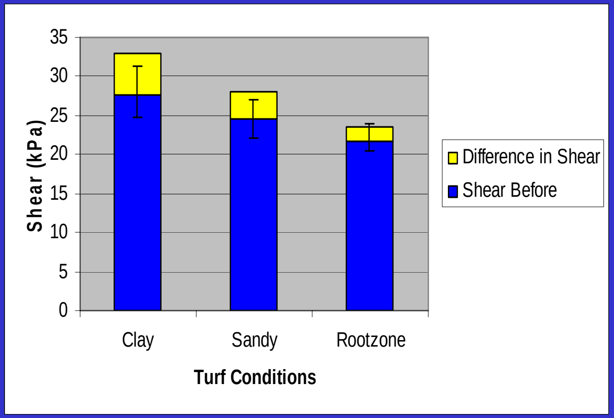
Results - Turning

Biomechanical and Mechanical Summary

	Heavy clay soccer pitch **Clay**	Intermediate sandy pitch **Sandy**	Modern, elite turf pitch **Rootzone**
Peak impact force (BW)	2.32 (±0.2)	2.25 (±0.2)	2.33 (±0.2)
Peak LR ($BW.s^{-1}$)	111.09 (±27.2)	101.63 (±25.5)	98.90 (±17.0)
Peak braking force (BW)	-0.88 (±0.06)	-0.89 (±0.07)	-0.88 (±0.06)







Discussion - Two-pronged approach

Mechanical:

Sig’ differences in hardness and shear between ‘clay’ and ‘rootzone’ (‘sandy’ condition - subtly different)

Biomechanical:

Running
- PKLR sig. higher on ‘rootzone’ compared to ‘clay’ (similar hardness before testing, clay harder after)

Turning
- No sig. differences in PKLR
- Different pattern of response in PKLR across surfaces compared to running
- Higher horizontal braking forces compared to running (supports Stiles, Dixon & James, 2006)

Conclusion

Hypothesis rejected

PKLR's for running and turning demonstrate conflicting patterns of response with variations in surface mechanical properties

Observations

Turning - performed at faster pace
- elicited greater braking forces (4 x)
- consistent braking forces across conditions
- greater implications for turf degradation
- assess movement on more extreme turf conditions

Future Research

Ground reaction forces are not the only measure of human response

Alternative measures of human response

- 3D kinematic analysis
- Pressure insole analysis

Overall Aims

- Increase understanding of human-natural turf interaction
- Engineer a more sustainable natural turf surface

References

BS1377-9:1990. Soils for civil engineering purposes – Part 9: in-situ tests. British Standards Institute, London. ISBN 0 580 18242 8.

Clegg, B. (1976), Australian Road Research Bureau Proceedings, 8, 1-6

Cox, A.L. (2003). In B.M. Nigg, G.K. Cole & D.J. Stefanyshyn (Eds.), Sports Surfaces (p. 269-291). University of Calgary.

Department of Health (2004), Department of Health, Physical Activity, Health Improvement and Prevention.

Gaskin, G. J., Miller, J. D. (1996), Journal of Agricultural Engineering Research. 63, 153-160.

Holmes, G., Bell, M. J. (1986), Journal of the Sports Turf Research Institute. 63, 74-91.

Hardin, E.C., Van den Bogert, A.J. & Hamill, J. (2004). Medicine and Science in Sports and Exercise, 36, (5), 838-844.

Kolitzus, H.J. (1984), In: E.C. Frederick (Ed.), Sports Shoes and Playing Surfaces: Biomechanical Properties. Human Kinetics Publishers Inc: Champaign, IL, 98-118.

Nigg, B.M. and Yeadon, M.R. (1987), Journal of Sports Sciences, 5, 117-145.

Spencer, M., Lawrence, S., Rechichi, S., Bishop, D., Dawson, B. and Goodman, C. (2004), Journal of Sports Sciences, 22, 843-850.

Stiles, V.H., Dixon, S.J., & James, I.T. (2006), In E.F Moritz & S. Haake (Eds.), The Engineering of Sport 6, Vol 3, (pp. 255 - 260). New York: Springer.

UEFA, Turf first in the Netherlands, (2005) Retrieved from www.uefa.com 06/10/05.