Tuning the Turf

A modeling approach to the complex nature of synthetic turf
Natural Grass
Trends in the Literature

- mild Traumatic Brain Injury (mTBI, Concussion) → Chronic Traumatic Encephalopathy (CTE)

- 11.4% of all on field NFL mTBI occurred when the back of the helmet impacted the ground (Pellman et al., 2004)
Synthetic Turf
Turf

- AstroTurf Alone has multiple
Infill

- Crumb rubber
- Greenplay Organic Infill
- Ethylene Propylene Diene Monomer (EPDM)
- Nike Grind Infill
- Thermoplastic Elastomers (TPE)
Shock Pad (Turf Sub liner)

- Standard Closed Cell
- Rubber Pad (Gym Floor)
- Beaded Polypropylene
Previous Research

- Synthetic turf has been used for around 50 years in sports
- Debate about use of synthetic turf when compared to natural turf
  - Significantly higher lower extremity injury vs no difference
  - Training injuries more frequent on natural turf
- Landing styles and jump techniques, landing surfaces, and the inclusion of shock absorbing layers all have affects on GRFs
Previous Research

- ACL injuries have increased by 1.3% in last 16 years
  - Expensive and long recovery time

- Result of:
  - High loading to the knee
  - Tibiofemoral displacements caused by compressive forces on posterior tibial slope
  - GRFs

https://healthfixit.com/tibiofemoral-joint/
Landing styles

- Soft landing- high knee flexion angle
- Stiff landing- low knee flexion angle
- Normal landing- mid-range knee flexion angle
- Higher landing stiffness resulted in $1^{st}$ and $2^{nd}$ peak vertical GRFs increases
  - Peak extensor moments and powers in hips, knees, and ankles increased
  - Energy absorption increased by knee and hip extensors
Landing heights

- Higher heights result in greater peak vertical GRFs because of greater contact velocity
  - peak joint moments and powers
  - Energy absorption in ankle and knee and hip extensors
- Height changes could result in landing style changes
Landing styles

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• Higher landing stiffness resulted in 1\textsuperscript{st} and 2\textsuperscript{nd} peak vertical GRFs increases
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  • Energy absorption increased by knee and hip extensors
Landing surfaces

- Stiff surfaces reduce energy loss and provide higher GRFs
- Compliant surfaces absorb energy and prevent injury
- Greater knee kinematic variability on synthetic turf in single-leg landing from a jump (Jones et al)
- Material type, density, and thickness are major factors in mechanical performance of turfs
- Stress, energy return, and cyclic loading endurance increases as shock pad density increases (Alleguer et al)
Current Landing Studies

• At this time we see are currently seeing interesting trends in our current data.

• With the shockpad we see greater ground reaction force when they know the shockpad is placed under the turf/infill.

• Why is this?
Previous Study

- Mills 2006
  - Modeled the Viscoelastic of Gymnastics Landing Mats During Impact
  - A three Layer Landing Matt
  - Mat was placed over a Kistler Force Plate
  - Multiple impacts at 4.3 and 6.5m/s with a flat 24kg impactor instrumented with a uniaxial accelerometer (calculate force)

\[ m_i = \text{Mass of Layer}, \ k_i = \text{Vertical Spring Stiffness}, \ r_i = \text{Vertical Damping}, \ z_i = \text{vertical spring displacement} \]
Aim of Our Study

- Establish the degree of complexity for modeling the layers of synthetic turf.
- Does increase complexity increase simulation time
Methods

- In place of using calculated forces us a pneumatic cylinder with a mounted triaxial load cell calibrated to the force plate. This load cell would be mounted to either flat 20cm diameter circulate impactor.

- Turf and turf layering will be place in a gravel box designed to fit an AMTI force plate.

- This box also allows up to breakdown each layer in place of attaching it as a system.

- Load cell, cylinder position sensor (1mm accuracy), and force plate will all be synchronized to quantify vertical force of the impactor, GRF, and vertical spring deformation.
Goals

• What defines successful model?
  • Key characteristic between the model and reality need to be met.
    • Peak Forces
    • Time to peak
    • Rate of force development
Additional Aims

• In the future we would like to model with a synthetic foot form, and load cells mounted within the foot.

• Model natural grass vs synthetic turf with the goal to develop a most natural acting synthetic turf
References


