Athlete Perception and Injury Risk Within Natural Turfgrass Sports Fields

Chase Straw, Ph.D. – University of Minnesota
Gerald Henry, Ph.D. – University of Georgia
Identifying Variability

Performance Testing

Quantifying surface properties to guide management and assess field playability and player safety

Outline

1. Identifying variability
2. UGA case studies
3. Potential solutions

Surface Hardness

- Clegg impact hammer (ASTM F1702)
- Gmax = peak deceleration on impact (g) acceleration due to gravity
- Influences loads and impact of athletes
Surface Hardness

- Turf Gmax F556.A
- Hardplate Gmax F55 E
- Drop 2500.0
- 2 ft Drop Height
- 20 lbs
- 3" dia. Face
- 4.25 ft Drop Height
- Variable
- 10 lbs
- 6.5" dia. Hemis Face
- 1.5 ft Drop Height
- 5 lbs
- 2" dia. Face

Soil Moisture

- %VWC = \frac{\text{volume of water}}{\text{volume of soil}}
- Strongly influences all soil physical properties, shear strength, and visual turfgrass quality

NDVI

- NDVI = \frac{(NIR - Red)}{(NIR + Red)}
- Used in turfgrass as an indicator of plant stress and density (0-1 scale)
- “Turfgrass quality”

NDVI (Turfgrass Quality)

- Healthy = 0.77
- Stressed = 0.43
- (46% NIR 6% Red 40% NIR 16% Red)
- (46-6/46+6) (40-16/40+16)

Turfgrass Shear Strength

- Rotational strength of the turfgrass (Nm)
- Influences athletes' grip and ability to make cuts

ASTM F1936 – Test Procedure

- Rotational strength of the turfgrass (Nm)
- Influences athletes' grip and ability to make cuts
How can we better visualize?

- More data samples
- GPS technology
- Geographic information systems
Identifying Variability

Interpolation

Soil Moisture

NDVI

Soil Compaction
**Within-field Variability**

• Typically unaccounted for regarding impact on athletes and management strategies

• Improved technology and new methodological approaches allows for us to better identify and understand its influence

---

**Athlete Perceptions**

*Previous research:*

• Close-ended questionnaires

• Several athletes and fields

• General understanding of perceptions

---

**Objective:**

To gain insight on athletes’ perceptions and behavioral changes due to within-field variability

**Participants:**

– UGA Competitive (Club) Sports – men’s and women’s rugby and ultimate frisbee

– 25 total; 12 in spring and 13 in fall of 2016
Walking Interviews

Semi-structured ‘on the move’ interviews following an interview guide

Example questions:
“What would you consider the worst location on this field?”
“What influence would this location have when playing?”

Field Measurements

- Surface hardness
- Turfgrass quality (NDVI)
- Shear strength (rotational traction)

Interpolation
Hot Spot Analysis

Mixed Methods Approach

Athletes’ “Best” and “Worst” Locations

<table>
<thead>
<tr>
<th></th>
<th>Hot spot</th>
<th>Cold spot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface hardness</td>
<td>“Best” location 36</td>
<td>“Worst” location 56</td>
</tr>
<tr>
<td></td>
<td>“Best” location 76</td>
<td>“Worst” location 49</td>
</tr>
<tr>
<td>NDVI</td>
<td>56</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>“Best” location 32</td>
<td>“Worst” location 84</td>
</tr>
<tr>
<td>Shear strength</td>
<td>52</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>“Best” location 52</td>
<td>“Worst” location 84</td>
</tr>
</tbody>
</table>

Athletes’ Perceptions

Two main themes:
1) Turfgrass coverage
   • Dust
   • Surface hardness
   • Traction
2) Surface evenness
   • Ball bounce
   • Body positioning

Changes in Behavior

Two main themes:
1) Athletic maneuvers
   • Safety
   • Context of play
2) Strategy
   • Practice
   • Pre-game
   • Game
Additional Findings

- Perceived relationships corresponded with correlation coefficients:
  - NDVI and surface hardness
    - \( r = -0.68 \) (\( P < 0.001 \)) and \( r = -0.58 \) (\( P < 0.01 \)) in spring and fall, respectively
  - NDVI and turfgrass shear strength
    - \( r = 0.64 \) (\( P < 0.001 \)) and \( r = 0.26 \) (\( P < 0.01 \)) in spring and fall, respectively
- Athletes previously injured viewed within-field variability as a higher risk for injury

Athlete Injuries

Previous research:
Limited to “surface hardness”
Included several fields and compared injury incidence to:
- Averaged values
- Categories of magnitude
Minimal evidence of a strong relationship

Twomey et al., 2012

Athlete Injury Study

Objective:
To conduct a preliminary study to investigate if there is an association between within-field variations and ground-derived injuries

Participants:
- UGA Competitive (Club) Sports – men’s and women’s rugby and ultimate frisbee, as well as women’s lacrosse teams

Baseline Screens

- Beginning of season
- Self-report previous sports-related injuries
- Identify outdoor footwear
- Assess movement abilities
  - YR1: Functional Movement Screen (FMS) ONLY
  - YR2: FMS with 3D motion capture

Credit: Christine Samson
**Functional Movement Screen (FMS)**

0-3 score
21 = perfect

---

**Study Fields**

Club field (sand capped)  Rec field (sandy loam)

---

**Participation**

**Year 1**
- Rugby (fall and spring)
  - Male (n = 12)
  - Female (n = 13)
- Ultimate Frisbee (spring only)
  - Male (n = 8)
  - Female (n = 7)

**Total = 40**

**Year 2**
- Ultimate Frisbee (fall and spring)
  - Male (n = 14)
  - Female (n = 4)
- Rugby (spring only)
  - Male (n = 12)
  - Female (n = 4)
- Lacrosse (spring only)
  - Male (n = 7)
  - Female (n = 16)

**Total = 46**

---

**Injury Surveillance**

Distributed weekly to determine:
- Team activity
- Injury occurrence
  - Injury specifics
  - Treatment sought
  - Return to play abilities
  - Previous similar injuries

---

**Injury Definition**

“A physical complaint (pain, discomfort, etc.) that resulted from your team’s practice or competition, whether you sought medical treatment or not”

---

Credit: Christine Samson

Timpka et al., 2014
Weekly:
- Soil moisture
- Turf quality (NDVI)

Bi-weekly:
- Surface hardness
- Rotational traction

Binomial Proportions Tests

Observed proportions:
% of injuries in hot and/or cold spot

Expected proportions:
% of field that is hot and/or cold spot

Injuries (Ground-derived)

<table>
<thead>
<tr>
<th>Team</th>
<th>Injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men’s Rugby</td>
<td>2</td>
</tr>
<tr>
<td>Women’s Rugby</td>
<td>9</td>
</tr>
<tr>
<td>Men’s Ultimate</td>
<td>7</td>
</tr>
<tr>
<td>Women’s Ultimate</td>
<td>4</td>
</tr>
<tr>
<td>Women’s Lacrosse</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>23</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Body Region</th>
<th>Injuries</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head/neck/face</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>Upper limb</td>
<td>4</td>
<td>17</td>
</tr>
<tr>
<td>Lower limb</td>
<td>17</td>
<td>74</td>
</tr>
<tr>
<td>Total</td>
<td>23</td>
<td>100</td>
</tr>
</tbody>
</table>
Injuries in Hot/Cold Spots

1. Soil moisture (15/19 injuries; 79%)
2. Turfgrass quality (16/21 injuries; 76%)
3. Surface hardness and turfgrass shear strength (13/23 injuries; 57%)

Binomial Proportions Tests

Significant differences occurred with:

- Turfgrass quality cold spots (0.52 and 0.20, respectively) ($P < 0.001$)
- Soil moisture hot spots (0.43 and 0.21, respectively) ($P < 0.05$)

Edge Effect

- Turfgrass quality (11/15 injuries)
- Soil moisture (14/16 injuries)
- Surface hardness (9/13 injuries)
Summary

• Within-field variability can influence athletes’ perceptions and their behavior

• Within-field variability may influence injury occurrence

• Limitations: small-scale, short duration, reliability of injury responses

Potential Solutions

Precision Turfgrass Management

Does homogeneous management help mitigate variability?
Precision Turfgrass Management

- Accounting for variability by:
  - Managing fields at a smaller scale than current practices
  - Identification of SSMUs (Site-specific Management Units)

Site-specific Management Units (SSMUs)

Soil Moisture SSMUs

Soil Compaction SSMUs

Potential Solutions – Precision Turfgrass Management

- Short-term:
  - Immediate reduction in inputs
    - Reduced cost, leaching/runoff potential, equipment use, etc.

- Long-term:
  - Increased health and uniformity of turf
  - Requires less management inputs
    - Reallocation of budget
Precision Turfgrass Management

Applications for sports fields:
- GPS sprayer technology

GPS Sprayer Technology

Reduces total amount of material applied

Site-specific:
- Weed control
- Fertilization
- Fungicide application
- Wetting agents

No Spray Zone

Spray Zones

Individual nozzle control based on spray zone boundaries and previously sprayed areas
Precision Turfgrass Management

Applications for sports fields:

- GPS sprayer technology
- Controlling variability with irrigation

Dry Down – Native Soil

<table>
<thead>
<tr>
<th>VWC</th>
<th>Soil Compaction</th>
<th>NDVI</th>
</tr>
</thead>
<tbody>
<tr>
<td>21%</td>
<td>185 lbs. force</td>
<td>0.67</td>
</tr>
<tr>
<td>14%</td>
<td>254 lbs. force</td>
<td>0.63</td>
</tr>
<tr>
<td>7%</td>
<td>316 lbs. force</td>
<td>0.52</td>
</tr>
</tbody>
</table>

Day 1: -67%
Day 4: +71%
Day 11: -22%

Dry Down – Sand Capped
**Precision Turfgrass Management**

Applications for sports fields:

- GPS sprayer technology
- Controlling variability with irrigation
  - Does irrigation distribution and soil moisture variability correlate?

**Native Soil Field**

Applications for sports fields:

- GPS sprayer technology
- Controlling variability with irrigation
  - Does irrigation distribution and soil moisture variability correlate?
- Site-specific aerification
Site-specific Aerification Study

1. Control
2. 1x entire plot
3. 1x site-specific
4. 3x entire plot
5. 3x site-specific

Upper quartile map:
Top 25% surface hardness of this plot:

Bottom 75% surface hardness of this plot:

Soil Compaction SSMUs:
Low
Moderate
High
Precision Turfgrass Management

Applications for sports fields:

- GPS sprayer technology
- Controlling variability with irrigation
  - Does irrigation distribution and soil moisture variability correlate?
- Site-specific aerification
- Soil moisture sensor placement

PTM - Current Limitations

Must first understand variability of your field, and then implement practical strategies to mitigate it.

- Cost
- Technology
- Implementation

What can be done?

1. Precision Turfgrass Management
2. Improving relationships with those that use your sports fields
Improving Relationships

Service/product quality:
- Does quality meet expectations?

Understanding where field management does or does not align with user expectations is essential to making sports fields meet realistic user needs.

Athletes’ perspectives on improving a turfgrass sports field

Two primary questions:
• What influences field quality?
• What are solutions to improve field quality?

What Influences Field Quality?

Field Management
Field Use
Weather

“This is the best area] because it’s far from the [entrance] gate”
- female rugby player

Turfgrass Cover

%  0–10  10–20  20–30  30–40  40–50  50–60  60–70  70–80  80–90  90–100

“We never really play there, which is why it’s the best [area on the field]”
- male rugby player
What Influences Field Quality?

Field Management

Weather

“…drills happen within this third of the field, which might be the reason why it’s pretty bad”
- male ultimate frisbee player

Turfgrass Cover

Solutions to Improve Field Quality

Do Nothing

Management

Monitor Usage

“…rather than [managing the field]… use that money and put it towards space…that way each team [has] their own space, the field would last longer, and you wouldn’t have to pay people to come manage it”
- male rugby player

Solutions to Improve Field Quality

Do Nothing

Management

Monitor Usage

“Irrigation is where you poke holes in it?”
- female ultimate frisbee player

Solutions to Improve Field Quality

Do Nothing

Management

Monitor Usage

“…back home I used Roundup…I don’t know how effective that would be here, because I feel like that could kill a lot of the grass … but that would be my go-to”
- male rugby player

Solutions to Improve Field Quality

Do Nothing

Management

Monitor Usage

“…getting softer grass, or like taking care of it to be softer”
- female ultimate frisbee player
Athletes are aware of potential influences on field quality. Athletes were familiar with several management practices to improve field quality, but did not appear to fully understand how or why these practices are implemented. 

**Improving Relationships**

- Athletes are aware of potential influences on field quality.
- Athletes were familiar with several management practices to improve field quality, but did not appear to fully understand how or why these practices are implemented.

**Overall Conclusions**

- GPS-equipped technology assists in identifying variability.
- Within-field variations influence athletes’ perceptions, and possibly injury occurrence.
- Precision turfgrass management and improving relationships with those who use your sports field may mitigate variability.

**Future Work**

- Increasing awareness of the potential for GPS technology in the turfgrass industry.
- Continuing research and development of GPS technology.
- Implementation of Precision Turfgrass Management - Quantifying advantages.

**Acknowledgements**

UGA Faculty:
- Dr. Bob Carrow
- Dr. Jenn Thompson
- Dr. Cathleen Brown Crowell
- Dr. Jerry Shannon

UGA Students:
- Christine Samson
- Becky Grubbs
- Will Bowling
- Josh Andrews

Turfgrass Managers:
- Stephen Richwine – Oconee Co. Schools
- Tom Popps – Oconee Co. Park and Rec.
- Joe Morgan – UGA IM Fields

UGA Rec Sports

UGA Club Sports

The many undergraduate students that assisted with data collection.

Questions?

Chase Straw, Ph.D.
University of Minnesota
cmstra4@uga.edu

Gerald Henry, Ph.D.
University of Georgia
gmhenry@uga.edu
@UGATurfgrass