Performance Testing and Player Safety
Gerald Henry, PhD
University of Georgia

Athlete Injuries
- Injuries will always occur
- Focus is primarily placed on safety equipment

Athlete Injuries
- Field playability is also linked to player safety

Sports Field Management
- Athletic fields often blamed first for poor athletic performances
- Monetary inputs for field management are insufficient and usually an afterthought

Artificial Turf vs. Natural Grass Sports Fields
- Neither are management free
- Both exhibit field variability
- Injuries occur on either surface
- Focus needs to be on player safety and field playability

Artificial vs. Natural Turf
- Collaboration: Henry and Thompson
- Why choose synthetic over natural turf?
- Anthropological assessment
- Walking interviews (multiple; long-term)
  - Administration
  - Coaches
  - Athletes
- Strategic Surveys
Performance Testing

• Gather information about your field/facility
• Use everything from low to high tech
• Due diligence should outweigh legal concerns

Performance Testing

• Player-Surface Interactions:
  – Compaction
  – Hardness
  – Traction
  – Uniformity
  – Wear Tolerance

Sensor Technology

Soil Moisture Meter

• TDR Probe
• Measures soil moisture from a depth of 1.5 to 8 inches
• Recorded as % volumetric water content (%VWC)
• GPS compatible

Hand-held Sensors

Soil Compaction

• Penetrometer
• Determines soil compaction (to a depth of 18 inches) and potential water infiltration
• Recorded in pounds per square inch (PSI)
Surface Hardness
- Clegg Impact Tester
- Determines surface hardness in the upper 2 inches of the soil profile
- Recorded in gravities (G-max)

Shear Strength
- Shear Vane
- Measures rotational strength of the turfgrass (Nm)
- Influences the ability of athletes to grip the turf and make cuts

Plant Health/Turf Color
- NDVI Chlorophyll Meter
- Readings are reported on a scale of −1 to 1
- The NDVI value is a measure of leaf area index and green biomass
- Color Meter
- Readings reported as turf color on a scale of 1 to 9

Mobile Sensors
- Strong correlations for soil moisture and NDVI
- Moderate correlation for soil compaction
  - Mobile sensors insert penetrometer rods at a uniform speed = more accuracy
Taking Data and Creating Maps

Field Measurements

Sample points ➔ Spatial Maps

Kriging

Variability

• Occurs when a measured quantity is different across and between locations

Causes of Variability

• Natural Occurrence
• Field use
  – Sport specific
  – Frequency
• Cultural practices
  – Irrigation
  – Aerification
  – Etc.

Soil Moisture
Measurable Variables

- Soil Moisture
- Soil Compaction
- Surface Hardness
- Turfgrass Health
- Shear Strength
- Turfgrass Thatch

Links Between Variables

Case Study: Oconee County H.S., GA

- Measured Variables
  - Soil moisture (VWC)
  - Soil compaction (PR)
  - Turf quality (NDVI)
  - Surface hardness (Gmax)
  - Thatch depth
  - Root mass
    - 0-2 inch depth
    - 2-5 inch depth

Spatial Variability

<table>
<thead>
<tr>
<th>VWC (%)</th>
<th>PR (lbs. force)</th>
</tr>
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<tbody>
<tr>
<td>0-1</td>
<td>0-10</td>
</tr>
<tr>
<td>1-2</td>
<td>10-30</td>
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<tr>
<td>2-3</td>
<td>30-100</td>
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<td>3-4</td>
<td>100-250</td>
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<td>750-1000</td>
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<td>1000-1500</td>
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<td>4000-4500</td>
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<td>• Surface Hardness</td>
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Spatial Variability

<table>
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<tbody>
<tr>
<td>• Root Length and Mass</td>
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Influence of Soil Moisture

How many samples are needed to accurately depict field performance?

Historical Testing Procedures

Testing Natural Turf Sports Surfaces: The Value of Performance Quality Standards

Bartlett et al., 2009

ASTM F1936 – Test Procedure

Accuracy of Sample Size

10 Clegg Readings – Surface Hardness

450 Samples 115 Samples 36 Samples
Dry Down Following Irrigation Events
- 5 day soil dry down
- 120 samples
  - Soil moisture (VWC)
  - Soil compaction (PR)
  - Turf quality (NDVI)
  - Surface hardness (Gmax)
  - Traction

Influence of Sampling Time

Accuracy of Sample Size

<table>
<thead>
<tr>
<th>Sample Size</th>
<th>Mean</th>
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<tbody>
<tr>
<td>450 Samples</td>
<td>22.9</td>
</tr>
<tr>
<td>115 Samples</td>
<td>22.7</td>
</tr>
<tr>
<td>36 Samples</td>
<td>21.5</td>
</tr>
</tbody>
</table>

Influence of sampling time on data collection

Volumetric Water Content

Penetration Resistance

Normalized Difference Vegetative Index

Day 1  | Day 3  | Day 5

Surface Hardness

Shear Strength

-34%  +25%  +3%
Influence of Sampling Time

<table>
<thead>
<tr>
<th>Surface Hardness (Gmax)</th>
<th>Shear Strength (Nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>Day 1</td>
<td>60</td>
</tr>
<tr>
<td>Day 2</td>
<td>72</td>
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</tbody>
</table>

Change: Day 2 to Day 1: +45.0% -12.5%

Influence of Soil Moisture on Data Collection

Irrigation System Efficiency

<table>
<thead>
<tr>
<th>Volumetric water content</th>
<th>Rainfall</th>
<th>Irrigation</th>
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<tbody>
<tr>
<td>%</td>
<td>21.02 - 25.12</td>
<td>25.12 - 30.02</td>
</tr>
<tr>
<td>%</td>
<td>30.12 - 35.02</td>
<td>35.02 - 40.02</td>
</tr>
<tr>
<td>%</td>
<td>40.02 - 45.02</td>
<td>45.02 - 50.02</td>
</tr>
<tr>
<td>%</td>
<td>50.02 - 55.02</td>
<td>55.02 - 60.02</td>
</tr>
<tr>
<td>%</td>
<td>60.02 - 65.02</td>
<td>65.02 - 70.02</td>
</tr>
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</table>

How does variability impact player injuries?

Malfunctioning Irrigation Head
• Collaboration with UGA Biomechanics Lab and Rec Sports
• Men’s and Women’s Rugby, Ultimate Frisbee, Soccer, and Lacrosse

Participation

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
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</thead>
<tbody>
<tr>
<td>Rugby (fall and spring)</td>
<td>Ultimate Frisbee (fall and spring)</td>
</tr>
<tr>
<td>Male (n = 12)</td>
<td>Male (n = 14)</td>
</tr>
<tr>
<td>Female (n = 13)</td>
<td>Female (n = 4)</td>
</tr>
<tr>
<td>Ultimate Frisbee (spring only)</td>
<td>Rugby (spring only)</td>
</tr>
<tr>
<td>Male (n = 8)</td>
<td>Male (n = 12)</td>
</tr>
<tr>
<td>Female (n = 7)</td>
<td>Female (n = 16)</td>
</tr>
<tr>
<td>Total = 40</td>
<td>Total = 46</td>
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</tbody>
</table>

Baseline Screens

• Beginning of season
• Self-report previous sports-related injuries
• Identify outdoor footwear
• Assess movement abilities
  – Functional Movement Screen
  – 3D motion capture

Functional Movement Screen

0-3 score
21 = perfect

Injury Surveillance

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

Weekly:
• Soil moisture
• Turf health (NDVI)

Bi-weekly:
• Surface hardness
• Rotational traction

Hot Spot Analysis

Club Field Rec Field

Field Measurements

Weekly:
• Soil moisture
• Turf quality (NDVI)

Bi-weekly:
• Surface hardness
• Shear strength

Data were averaged by month

Injuries (Ground-derived)

<table>
<thead>
<tr>
<th>Team</th>
<th>Injuries</th>
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<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>
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</table>

Injuries (Ground-derived)

<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%)

Edge Effect

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

Managing Variability

- Can’t be eliminated
- Proper cultural practices
  - Site specific management
- Increasing rooting depth/mass
Improving the efficiency of your irrigation system

Irrigation audit - Catch Can Method

• Assessment usually based on a small number of samples
• Measures distribution uniformity
• No indication of “effective” irrigation

Catch Can Method

Water Infiltration

Fate of Irrigation

Mass Flow vs. Preferential Flow
Uniformity vs. Efficiency

- The use of a soil moisture meter following irrigation application will provide more valuable information
  - Water infiltration location
  - Rewetting potential
  - Soil compaction/thatch issues
  - Need for wetting agent applications

Soil Moisture Meter

- TDR Probe
- Measures soil moisture from a depth of 1.5 to 8 inches
- Recorded as % volumetric water content (%VWC)
- GPS compatible

New Water Audit Approach

- Initial mapping:
  - Conducted under “drier” conditions
  - Determine areas of concern (poor drainage, localized dry spot, leaking heads, etc.)
- Map following irrigation application:
  - Conducted after loss of gravimetric water

Irrigation Efficiency Audits

Soil Moisture vs. Catch Can

ID of Easily Correctable Problems

When a problem head is identified, field investigation is conducted to determine:

- Incorrect scheduling
- Localized dry spot
- Head alignment
- Head not operating
- Head spacing
- Wrong nozzle size
- Sprinkler or nozzle wear
- Mismatched sprinklers or nozzles
Water Cannons – Highly Variable

Increasing Root Length/Mass

- Wetting agents/soil surfactants
- Fertilizers, soil conditioners, and biostimulants

Wetting Agents – Rooting Depth

Wetting Agents – Rooting Depth

- Increase the uniformity of soil moisture throughout the soil profile
- Retain soil moisture deeper in the soil profile
- Decrease fertility leaching which may increase length of availability

Wetting Agents – Total N Leaching
Wetting Agents – Total N Leaching

- Total N (mg/L) Fertilizer Only
- 26 to 38% reduction
- 12-3-12 Fertilizer + Wetting Agents

Biostimulants
- Organic-based products that increase plant health, improve root and shoot growth, and enhance stress tolerance
- Active ingredients – amino acids, humic/fulvic acids, seaweed extracts, biochar, compost tea, enzymes, vitamins, etc.

Biostimulants - Seeding
- Treated
- Non-treated

Biostimulants - Sodding
- Non-treated

Soil Conditioners + Fertilizers
- Retain soil structure, increase water infiltration, and encourage deeper rooting

Questions?
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@UGATurfgrass