Outline

1. Significance of injury data
2. Kinematic (motion) study: HFR data analysis
3. Kinetic (forces) study: iKMS data analysis
4. Surface safety analysis
5. Track modelling and race simulation
6. Q & A
Significance of injury data
Data analysis in a glance

(1)

(2)

(3)
Retrospective review: 6 vs 8 runners
Kinematic ‘motion’ study: HFR data analysis
Greyhounds stride analysis
Straight running

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Greyhounds stride analysis
Straight running

Distance (m)

<table>
<thead>
<tr>
<th>Distance</th>
<th>Left foreleg</th>
<th>Right foreleg</th>
<th>Right hindleg</th>
<th>Left hindleg</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>0.8</td>
<td>2.22</td>
<td>2.93</td>
<td>5.36</td>
</tr>
<tr>
<td>6.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Flight compressed
Flight extended
Kinetic ‘force’ study: iKMS data analysis
UTS developed data acquisition device (iKMS)

A greyhound wearing a jacket with embedded Integrated Kinematic Measurement System (iKMS)

iKMS V1.1 central acquisition unit

12 June 2018
Example of Integrated Kinematic Measurement System (iKMS) raw data
Comparison of sand track vs grass track

A Sand

B Grass

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peaks of vertical acceleration (sand-bend)</td>
<td>7.4 g</td>
</tr>
<tr>
<td>Peaks of vertical acceleration (sand-straight)</td>
<td>5.0 g</td>
</tr>
<tr>
<td>Peaks of vertical acceleration (grass-bend)</td>
<td>7.1 g</td>
</tr>
<tr>
<td>Peaks of vertical acceleration (grass-straight)</td>
<td>4.3 g</td>
</tr>
<tr>
<td>Stride frequency (sand-bend)</td>
<td>3.60 Hz</td>
</tr>
<tr>
<td>Stride frequency (sand-straight)</td>
<td>3.50 Hz</td>
</tr>
<tr>
<td>Stride frequency (grass-bend)</td>
<td>3.85 Hz</td>
</tr>
<tr>
<td>Stride frequency (grass-straight)</td>
<td>3.45 Hz</td>
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</table>
Surface safety analysis
Advanced 3D paw imprint reconstruction

LIDAR
Light Detection and Ranging

iKMS
Integrated Kinematic Measurement System

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Advanced 3D paw imprint reconstruction

- Paw imprints can be seen as an objective measurement of track surface properties.
- It is hypothesised that optimum paw imprint will allow standardisation of current track surface analysis techniques such as penetrometer, moisture and impact testing.
- Print shape and depth may be correlated with variables such as compaction and moisture content.
- Change of surface preparation philosophy: Instead of changing variables to chase performance the greyhound racing industry chooses the performance and change the variables accordingly.
- Analysis may concluded that different surfacing properties are required where the greyhounds are subjected to different forces ie bend and straight may require different sand, moisture and/or preparation to optimise the performance.
- Additionally, paw imprint reconstruction allows analysis of previously unobtainable stride, gait and surface information.
Modified 2.28 kg Clegg hammer

- Modified 2.28 kg Clegg hammer
- Accelerometers
- Hammer with mass of 2.28 kg
- Data acquisition unit
Dynamic model of galloping greyhound

Estimated muscle force of a galloping greyhound on sand and synthetic rubber surface

Centre of mass trajectory line of greyhounds while galloping on sand and synthetic rubber
Track modelling and racing simulation
Track design investigation
Greyhounds on the bends

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Major forces acting on a greyhound on the straight side view
- Weight of greyhound
- Frictional force From the track / Shear strength of track
- Normal force from the ground

Reference frame
- X
- Y
- Z

Accelerations of a greyhound on the bend top view
- $a_x$: Forward acceleration
- $a_y$: Centripetal acceleration
- $a$: Resultant acceleration

Accelerations of a greyhound on the bend top view
Track design investigation
Greyhounds on the bends

Maximum constant galloping speed possible for greyhounds

\[ R \quad \text{Bend} \]
\[ g \quad \text{Acceleration due to gravity} \]
\[ \theta \quad \text{Cross fall of the track} \]
\[ v \quad \text{Greyhounds maximum constant speed} \]

Forces acting on a greyhound on the bend front view

Friction from the ground \((\mu_s)\) / ground’s shear strength

Greyhound’s weight
Greyhound’s centre of gravity
Centrifugal force
Normal force from the ground

\( \approx 57^\circ \) greyhound’s lean

Reference frame

Track width = 5m

Track cross fall \((\theta)\) = 7.9% (4.5°)
Track design investigation

Maximum speeds of greyhounds as limited by the physics

*An averaged value of static friction coefficient is considered for the data above
Track design investigation
What can be done for cross falls at the tracks

Optimum cross falls

<table>
<thead>
<tr>
<th>Track bend (m)</th>
<th>Track cross falls (%)</th>
<th>Track cross falls (deg.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>78.1</td>
<td>38</td>
</tr>
<tr>
<td>50</td>
<td>70</td>
<td>35</td>
</tr>
<tr>
<td>55</td>
<td>62.5</td>
<td>32</td>
</tr>
<tr>
<td>60</td>
<td>57.7</td>
<td>30</td>
</tr>
<tr>
<td>65</td>
<td>53.2</td>
<td>28</td>
</tr>
<tr>
<td>70</td>
<td>46.6</td>
<td>25</td>
</tr>
</tbody>
</table>
Track design investigation
What can be done for cross falls at the tracks

Track surface
grades from
surveyed data

Track surface
grades existing

Track surface
grades improved
Track design investigation
What can be done for cross falls at the tracks

Mt Gambier track surface grades design drawing 5135 by GRSA
Track design investigation
Continuity of a track path

First order

Second order
Track design investigation
Continuity of a track path and lateral dynamics
Track design investigation
Continuity of a track path and lateral dynamics

Cessnock and Wentworth Park tracks size comparison
Track design investigation
Straight to bend path types in GRNSW tracks

Grafton
305 m start

Richmond
535 m start

No transition (N)

Part transition (P)
Track design investigation
Straight to bend path with proper Euler transition

Hypothetical track design with minimal centrifugal acceleration jerk (plan view)

Greyhound run video for hypothetical track with minimal centrifugal acceleration jerk (greyhound view)
Track design investigation
Rate of rotation (yaw rate) of greyhounds for Richmond 400 m starts immediate bend
Track design investigation
The Gardens starting box alignment

Old boxes alignment

New boxes alignment (proposed)

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Starting boxes realignment options for 400 m start
Track design investigation
Mt Gambier starting box alignment

- Maximum transitional rate of rotation

<table>
<thead>
<tr>
<th>Boxes alignment for distance start</th>
<th>Rate of rotation (rad/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing 512 m</td>
<td>2.63</td>
</tr>
<tr>
<td>Improved 512 m</td>
<td>1.73</td>
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Track design investigation
Alternative design options for Tweed Heads

Tweed Heads track design proposed by club

Tweed Heads design developed by UTS

<table>
<thead>
<tr>
<th>Track design</th>
<th>Jerk magnitude (m/s²)</th>
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<tbody>
<tr>
<td>Alternative design Option C</td>
<td>0.42</td>
</tr>
<tr>
<td>Alternative design Option B</td>
<td>0.72</td>
</tr>
<tr>
<td>Alternative design Option D</td>
<td>1.1</td>
</tr>
<tr>
<td>Alternative design Option A</td>
<td>1.69</td>
</tr>
<tr>
<td>Richmond</td>
<td>5.5</td>
</tr>
<tr>
<td>Wentworth Park</td>
<td>10.5</td>
</tr>
</tbody>
</table>
Track design investigation
Alternative design options for Tweed Heads

Tweed Heads design developed by UTS

Tweed Heads design developed by UTS with extended straight start

Tweed Heads design developed by UTS