Boot design and injury risk – presenting a new system for injury management

Dr Anthony Walker$^{1,2}$, Dr Wayne Spratford$^2$

$^1$ ACT Fire & Rescue, Canberra, Australia
$^2$ UC RISE, University of Canberra, Canberra, Australia
If I’d asked people what they wanted, they would have said a faster horse

- Henry Ford
Briefly about me

• Station Officer ACT Fire & Rescue (12yrs)

• PhD in occupational physiology (heat stress)

• Honours degree Biomechanics

• Bachelor & Masters Education
Overview

• Define the problem
  • Collect meaningful data
  • Understand/Interpret data

• Form a hypothesis
  • Understand the human
  • Establish a likely cause
  • Critically analyse the literature

• Test the hypothesis – Lab testing

• Critically analyse the data – present a conclusion
  • Rule hypothesis in / rule out
Define the problem

Form a hypothesis

Test your hypothesis

Test the solution

Present a solution
Defining the Problem – Data tells part of the story

<table>
<thead>
<tr>
<th>Soft Tissue Injury Costs (average per claim) – ACT ESA Ops Staff</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Claims</strong></td>
</tr>
<tr>
<td><strong>Males</strong></td>
</tr>
<tr>
<td><strong>Females</strong></td>
</tr>
<tr>
<td><strong>Lost Work Time</strong></td>
</tr>
<tr>
<td><strong>Cost to Date</strong></td>
</tr>
<tr>
<td><strong>Predicted Future costs</strong></td>
</tr>
</tbody>
</table>
ACT ESA – All Agency Injury Profile

- Back: 43%
- Knee: 22%
- Shoulder: 15%
- Ankle: 10%
- Neck: 5%
- Elbow: 3%
- Abdo: 1%
- Chest: 1%
Discussion points

• The bulk of ambulance soft tissue injuries are upper body injuries
  – Ambulance officers do a lot of lifting?
  – Recruited for technical skill not physicality
• The bulk of firefighter soft tissue injuries are lower body injuries
  – Recruited for physicality in addition to technical skill
  – Why?
• Females in this data set get injured earlier?
  – Disproportionate rates of injury (28%)?
The Problem – lower body injuries in firefighters, are boots a factor?

- Firefighters walk on hot surfaces
- Firefighters work in environments where sharp objects may penetrate the sole of the shoe.
- Firefighters carry heavy objects which may impact their feet if dropped
- Firefighters were suffering ankle injuries from “rolled ankles” on unstable surfaces
- Firefighters walk in chemicals and water
- When firefighters kneel, pants “ride up” exposing lower leg to fire
Our Hypothesis – Is the solution the best one?

**Minimum standards ISO 20345:**
- Height of upper 185mm (8.5-10 shoe)
- Toecaps shall be incorporated
- Penetration resistance to 1100N
Our Hypothesis

All of the design requirements lead to increased rigidity of the boot. This may result in

- Altered Landing Mechanics
  - Reduced plantar flexion
  - Change in force distribution

Leading to

- Reduced force attenuation
  - Higher Ground reaction forces
- Greater lumbar loading
- Increased prevalence of lower body injuries
Testing Methodology

Testing completed at University of Canberra Biomechanics lab – ACT Govt supported honours project.

- VICON Motion Capture System
- Force plates

- 20 male firefighters
- Landing tasks analysed – stepping, landing from firetruck
  - boots compared with neutral shoe
Key Results

Ankle restrictive firefighting boots alter the lumbar biomechanics during landing tasks

Vy Vu, Anthony Walker, Nick Ball, Wayne Spratford

a Discipline of Sport and Exercise Science, Faculty of Health, University of Canberra, Canberra, Australia
b University of Canberra Research Institute for Sport and Exercise, University of Canberra, Canberra, Australia
c Australian Capital Territory Fire and Rescue, Canberra, Australia
Results

Compared with a neutral shoe….

• Wearing Structural Firefighting Boots resulted in a **43% Reduction** in plantar flexion on landing.

• Wearing Structural Firefighting Boots resulted in a **54% Increase** in lumbar flexion.

• Wearing Structural Firefighting Boots resulted in a **12% Increase** in ground reaction forces.

\[ 2.14 \ (0.65) \ \text{BW} \ \text{vs} \ 2.40 \ (0.58) \ \text{BW} \]
Where to now?

- Collect good data and learn how to read it!
- Factor the human into any design changes
  - What is the possible impact of the change on the Firefighter?
- Design changes to boots should be considered to Increase the resilience of the firefighter
  - Consider
    - Less ankle restriction (height & structure)
    - Greater sole flexibility
    - Less weight

- Can we design one boot to be used for everything?
Thankyou

Contact details
Dr Anthony Walker
University of Canberra Research Institute for Sport & Exercise
University of Canberra
ACT, Australia
Anthony.walker@canberra.edu.au
(+61) 412 313 870
Twitter: Walks547