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

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If I'd asked people what they wanted, they would have said a faster horse

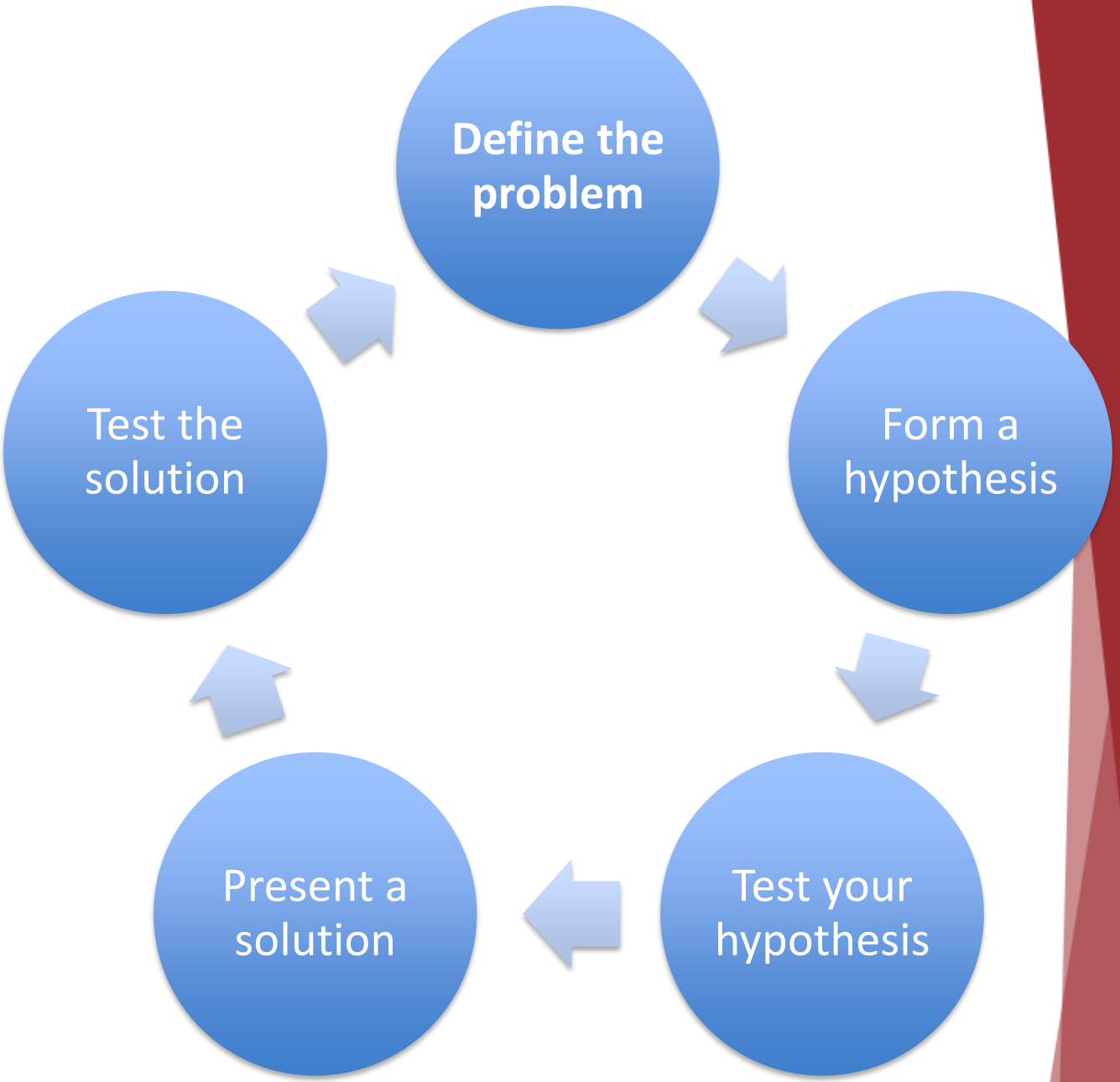
- Henry Ford

Briefly about me

- Station Officer ACT Fire & Rescue (12yrs)
- PhD in occupational physiology (heat stress)
- Honours degree Biomechanics
- Bachelor & Masters Education

Overview

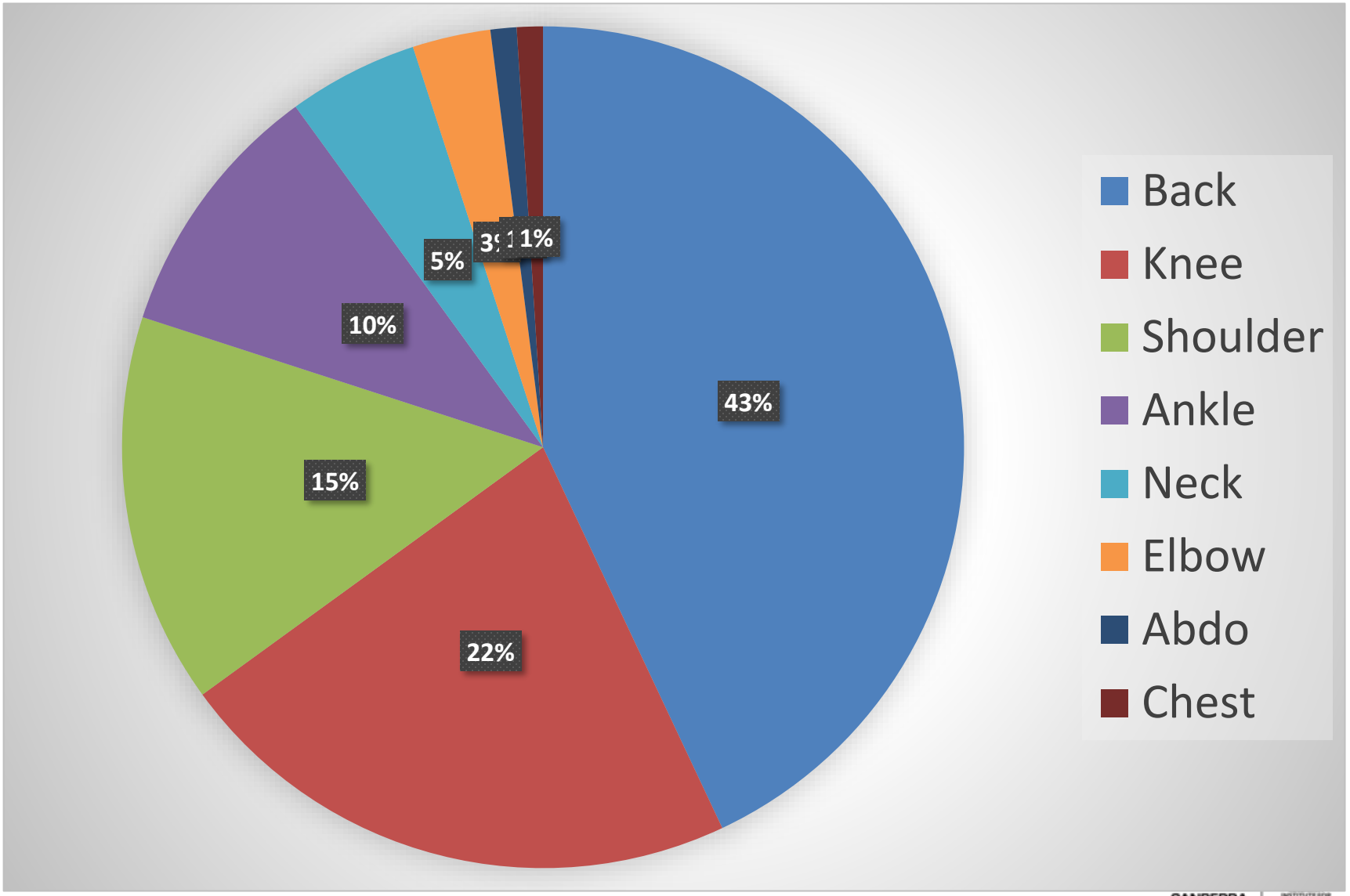
- Define the problem
  - Collect meaningful data
  - Understand/Interpret data
- Form a hypothesis
  - Understand the human
  - Establish a likely cause
  - Critically analyse the literature
- Test the hypothesis – Lab testing
- Critically analyse the data – present a conclusion
  - Rule hypothesis in / rule out



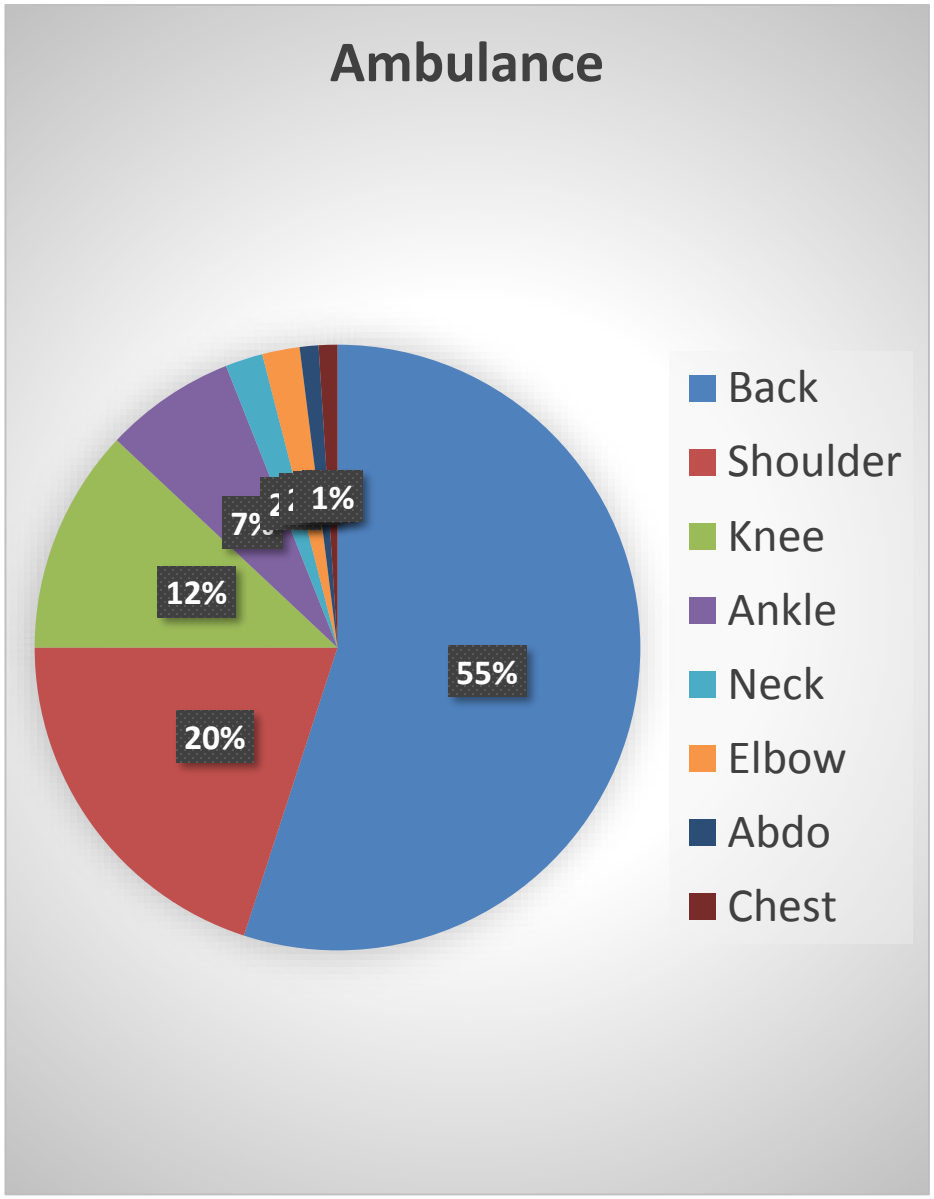
Defining the Problem – Data tells part of the story

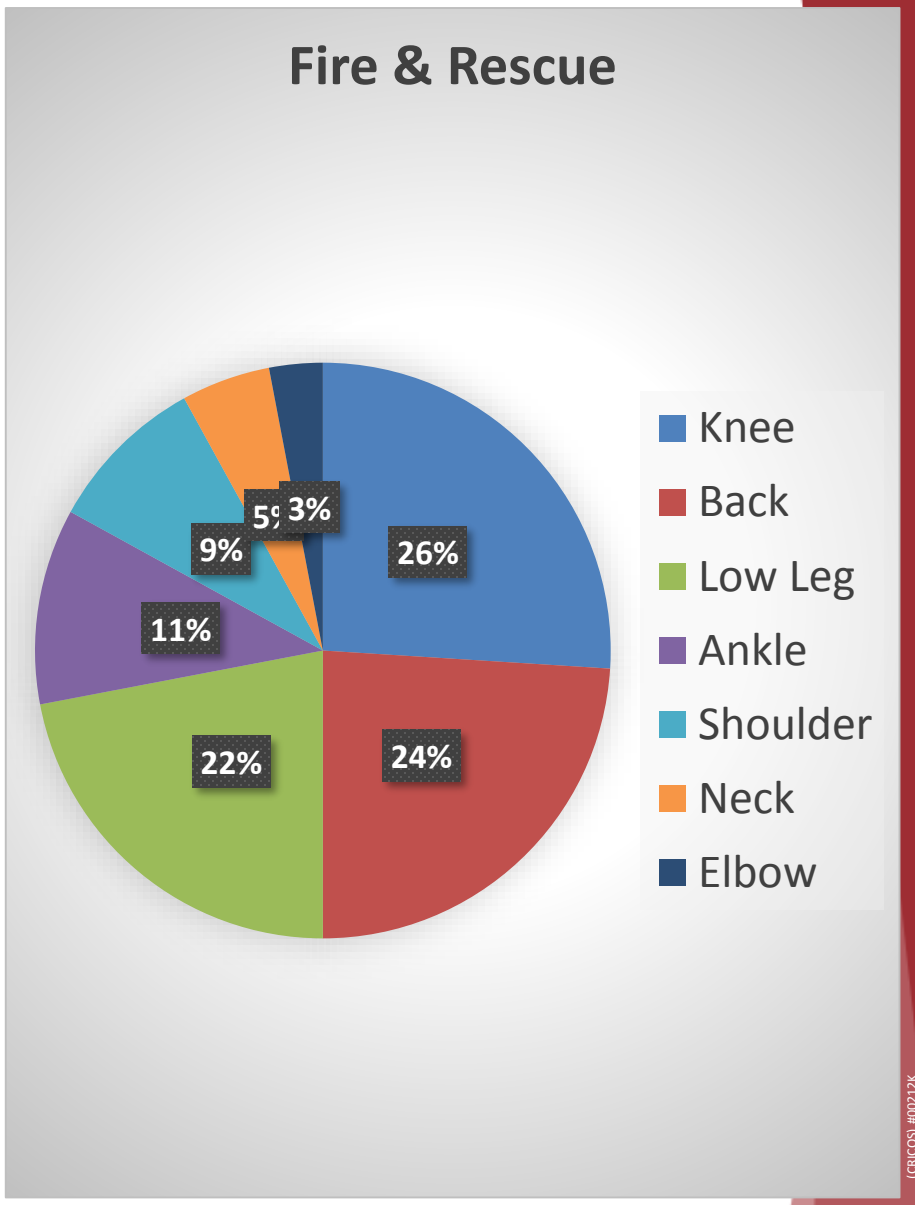
Soft Tissue Injury Costs (average per claim) – ACT ESA Ops Staff		
Total Claims	541 - Average age 40.2 years	
	Males	392 (41.0 yrs)
	Females	149 (37.0 yrs)
Lost Work Time	3291.8 (5.9) weeks	
Cost to Date	$5,143,038 ($9,216)	
Predicted Future costs	$3,551,771 ($6,365)	

ACT ESA – All Agency Injury Profile



By Individual Agency





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

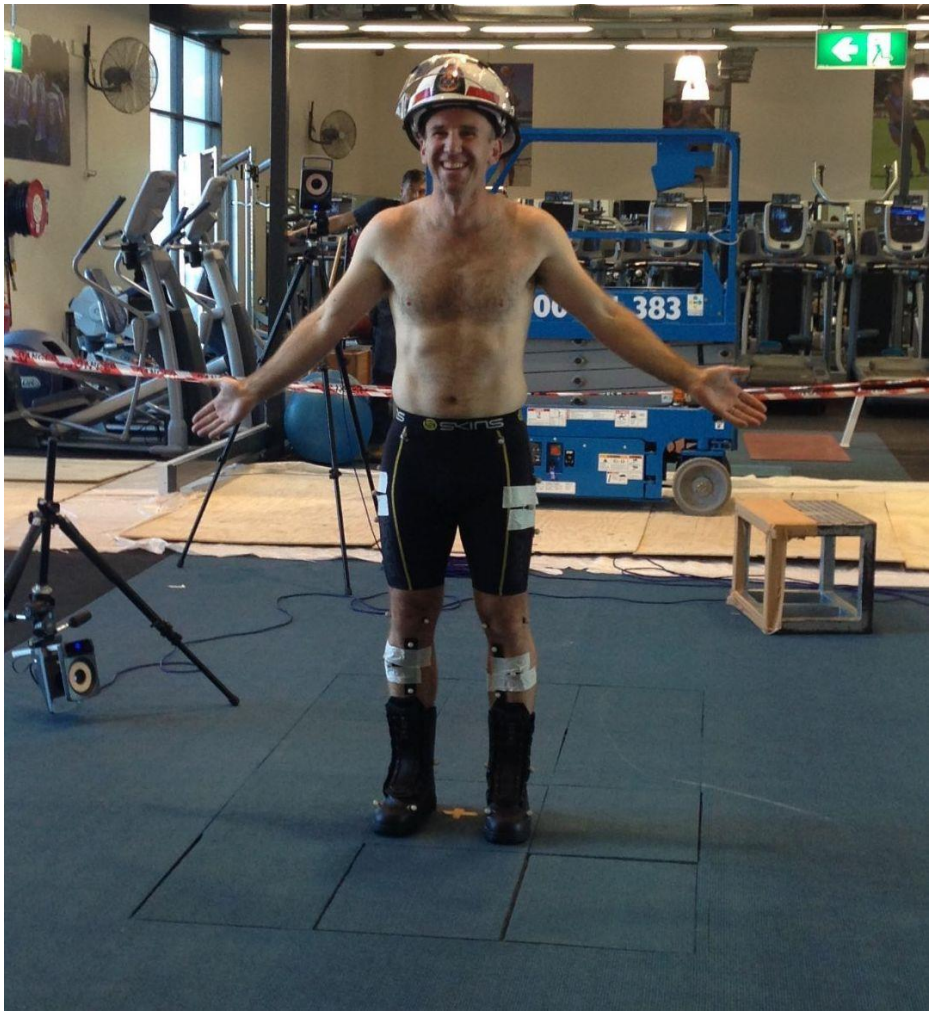
- Reduced force attenuation
  - Higher Ground reaction forces
- Greater lumbar loading
- Increased prevalence of lower body injuries

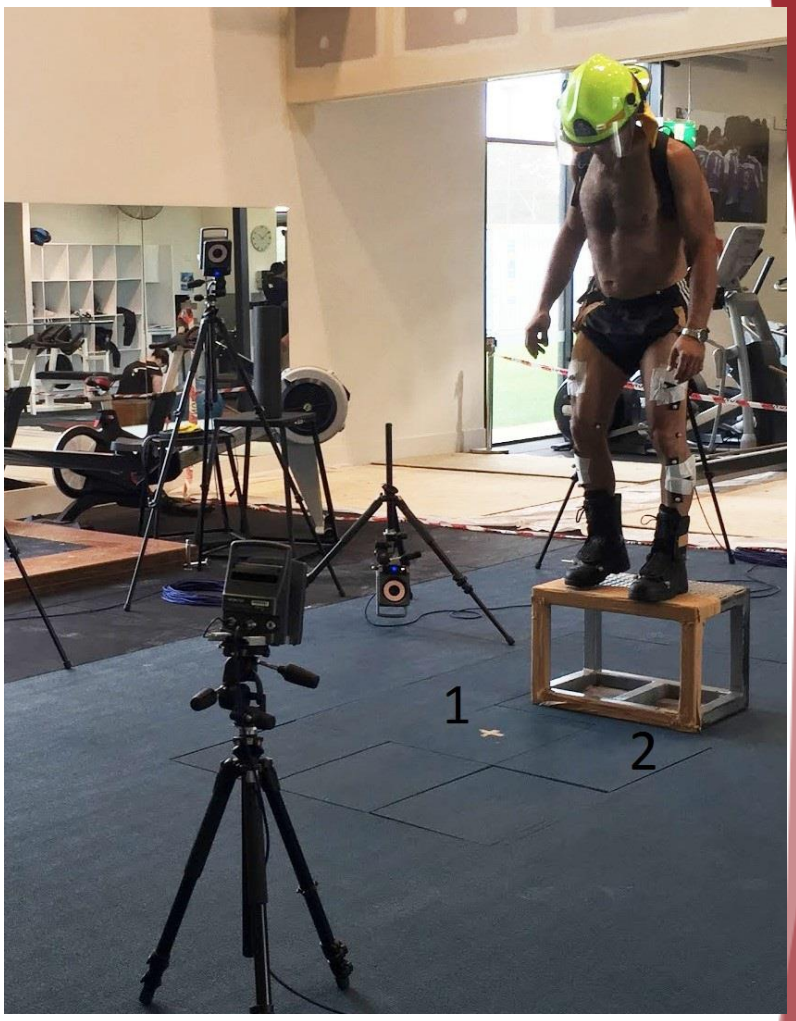
Testing Methodology

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





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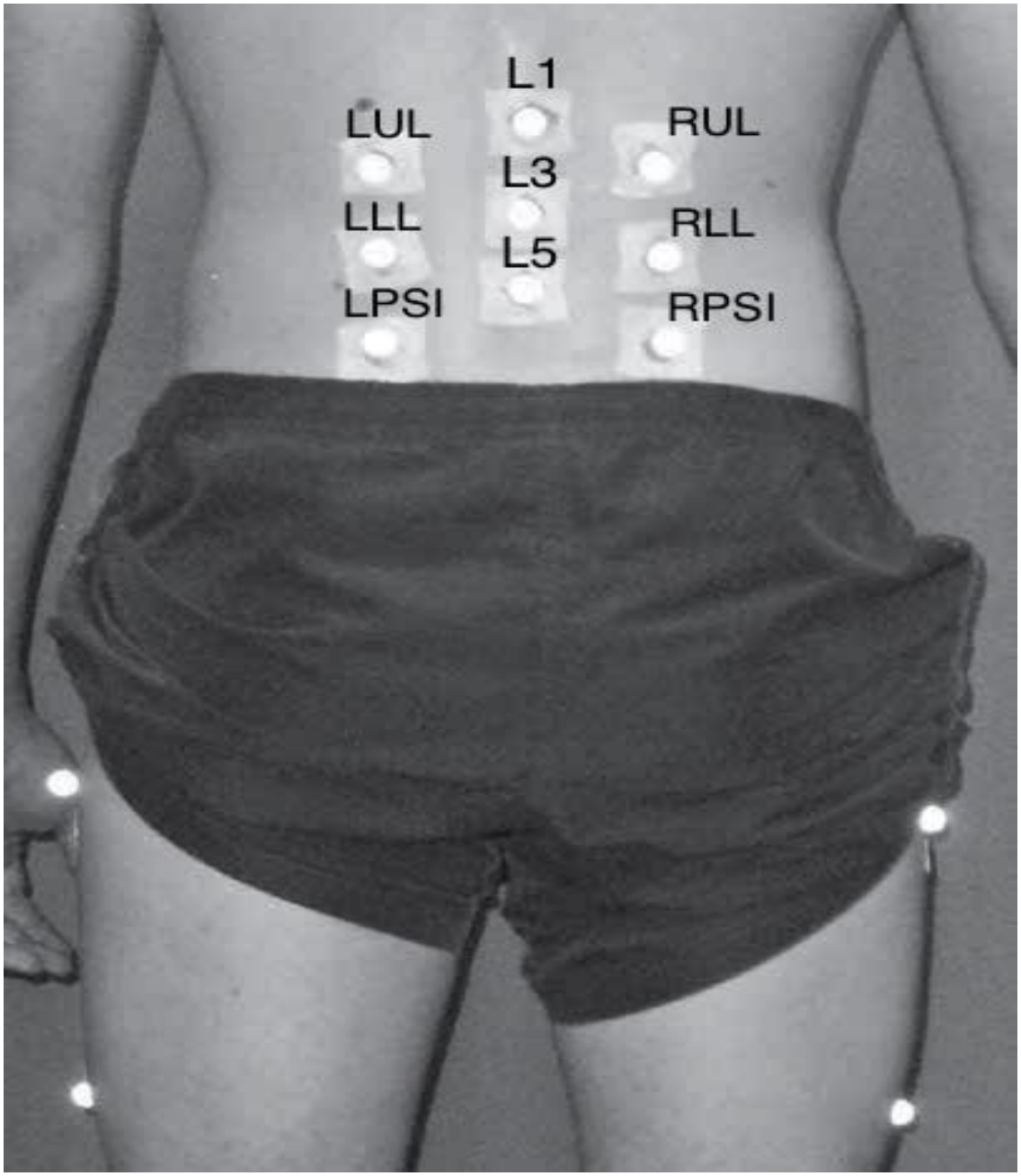

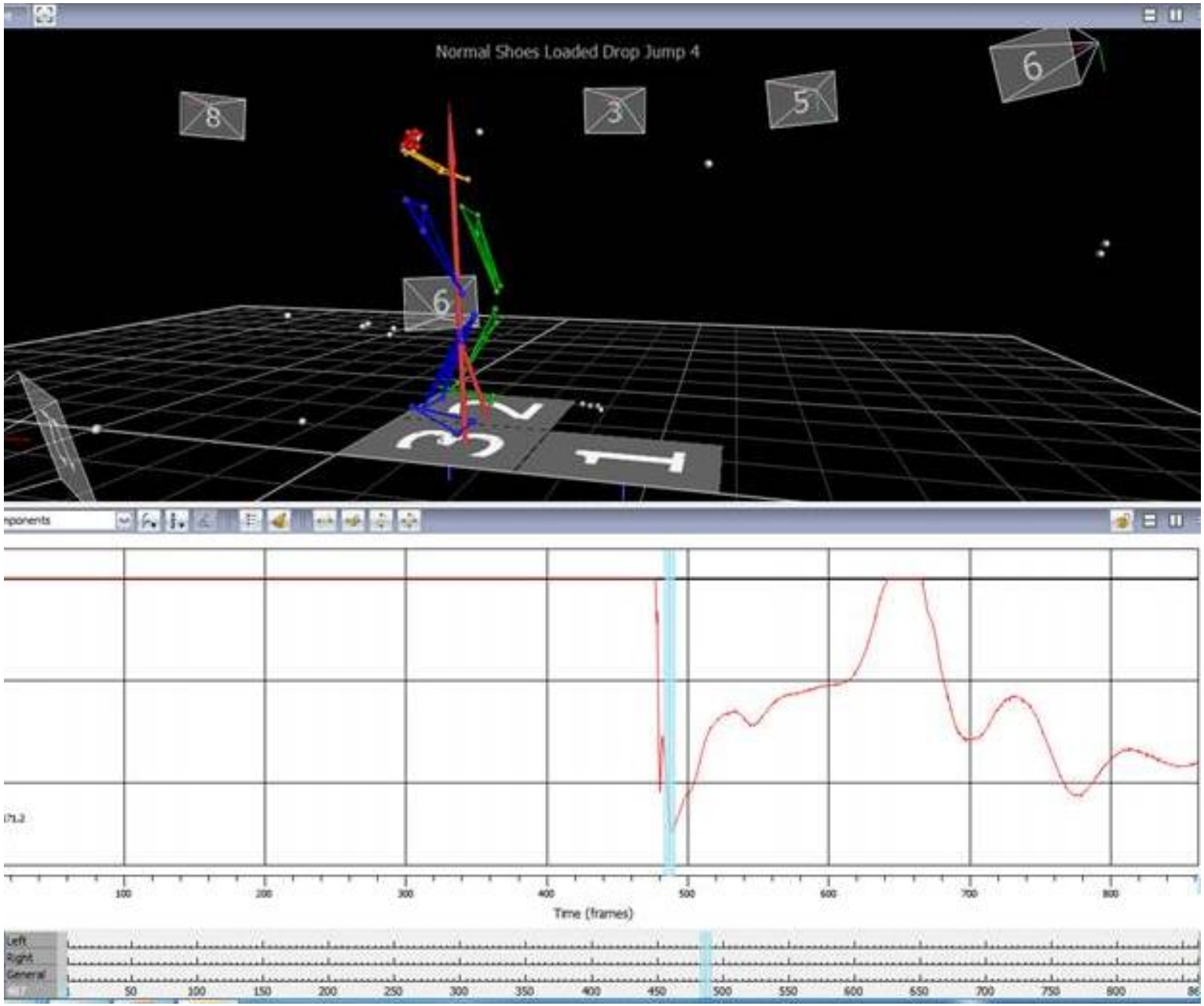

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Key Results

Contents lists available at ScienceDirect

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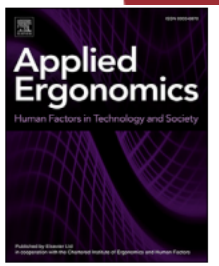

Ankle restrictive firefighting boots alter the lumbar biomechanics during landing tasks

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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) BW vs 2.40 (0.58) 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

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