

Determining foot shape and size for boot last design

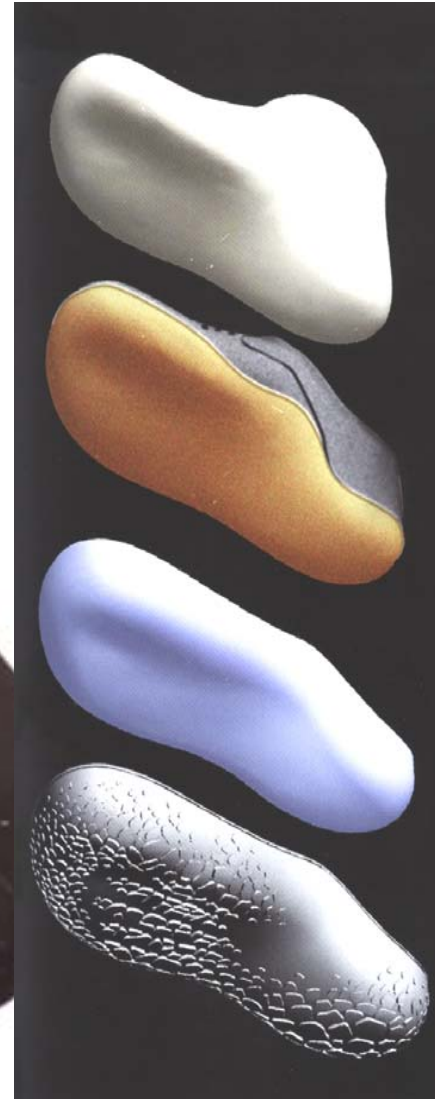
L Mac Duff, K Bredenkamp, H Nolte
Banff 2007



Characterization of feet



- Form
- Fit
- Function



Content

Anthropometric linear database

Analyses of database to determine changes in population

Fit evaluations of the boot

Investigations of fit and function of the boot

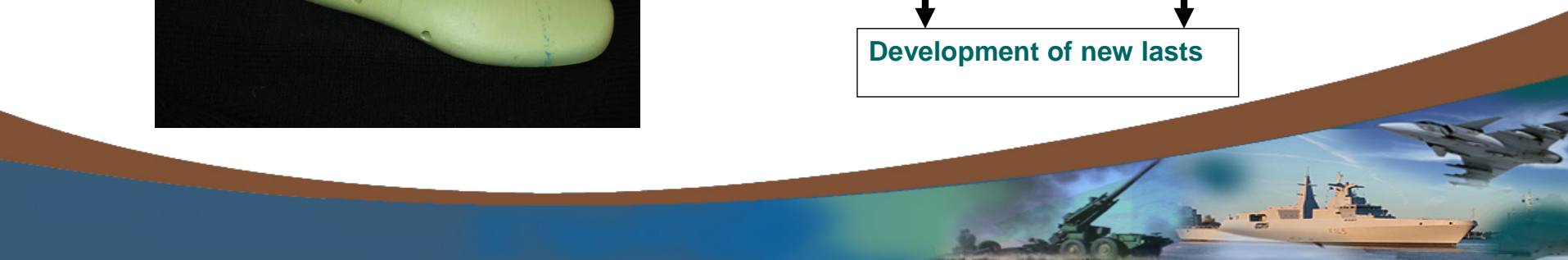
- Pressure data
- Biomechanical analysis
- Subjective complaints
- Clinical examination
- Anthro data

Pilot study - 3D scanner data

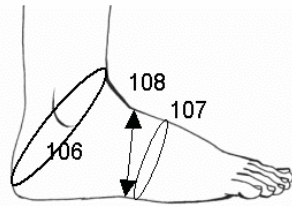
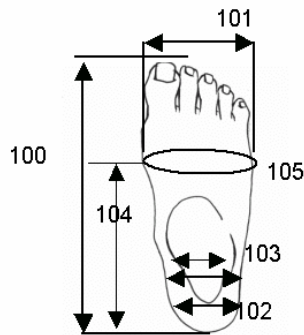
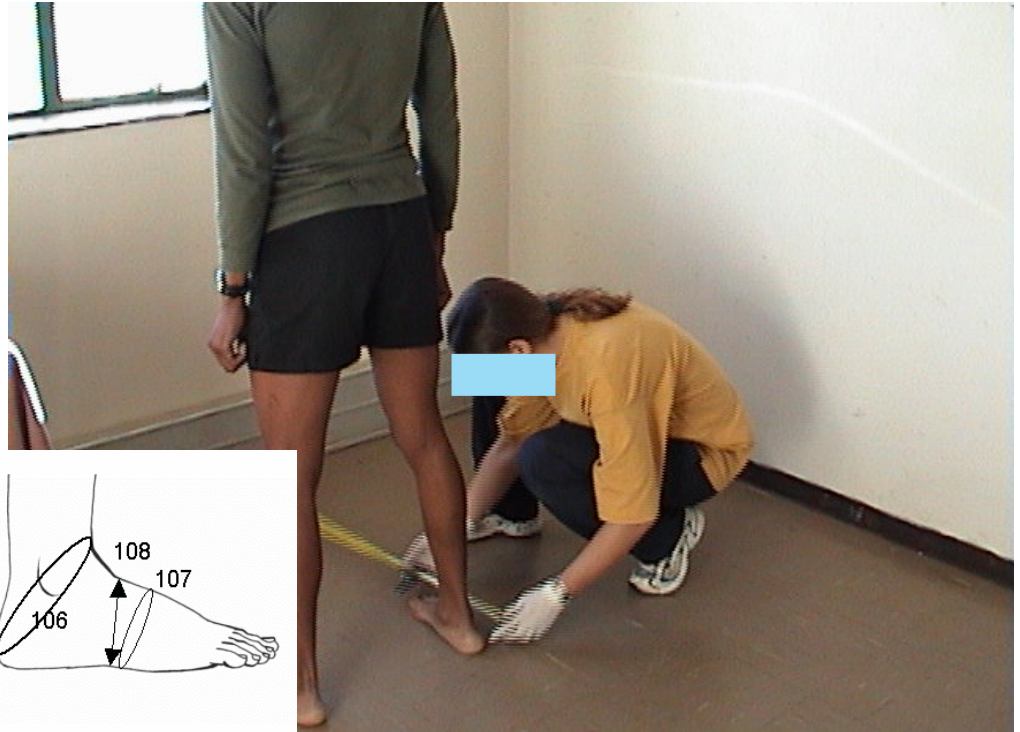
3D scanner data
Characterize foot forms

Development of new lasts

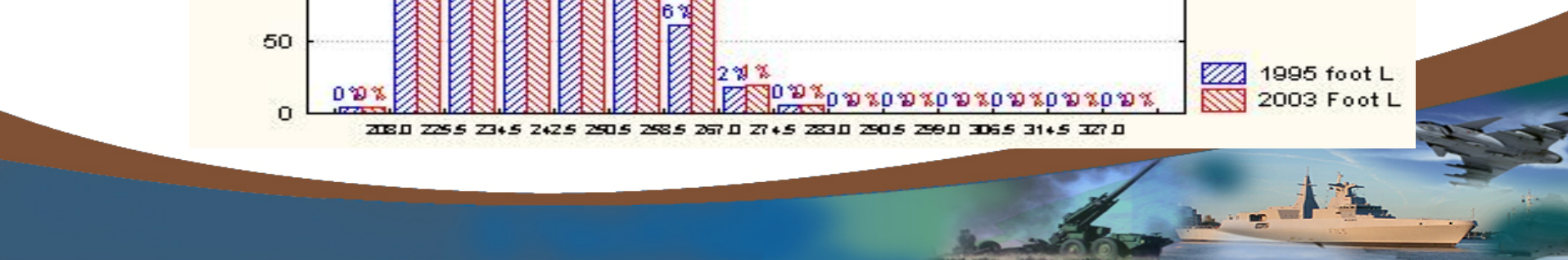
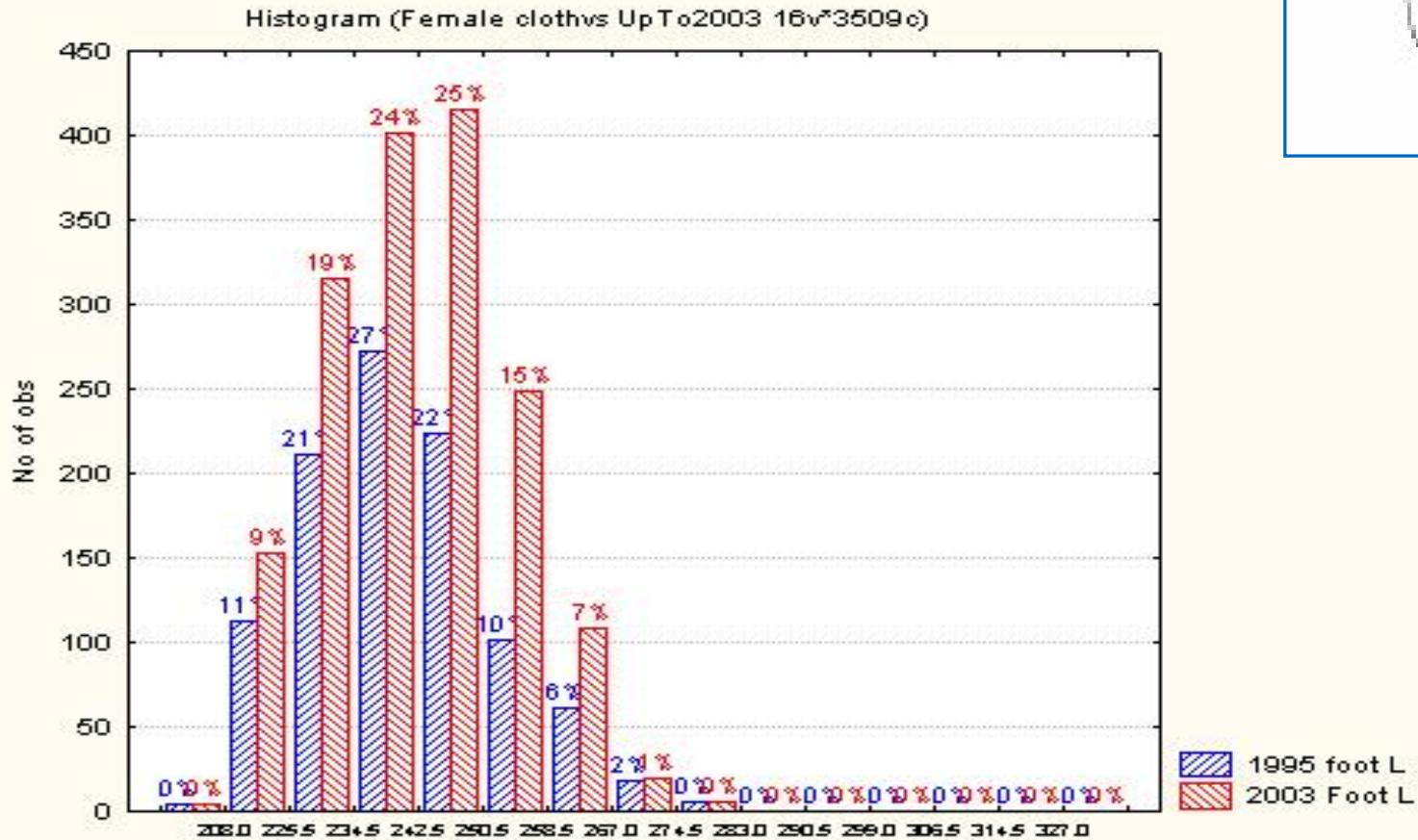
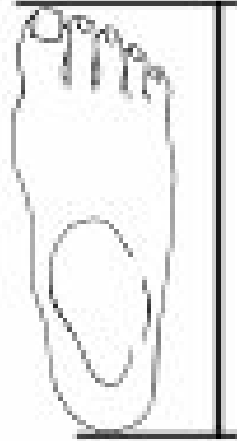
Shock attenuation evaluation + prediction methods – modeling



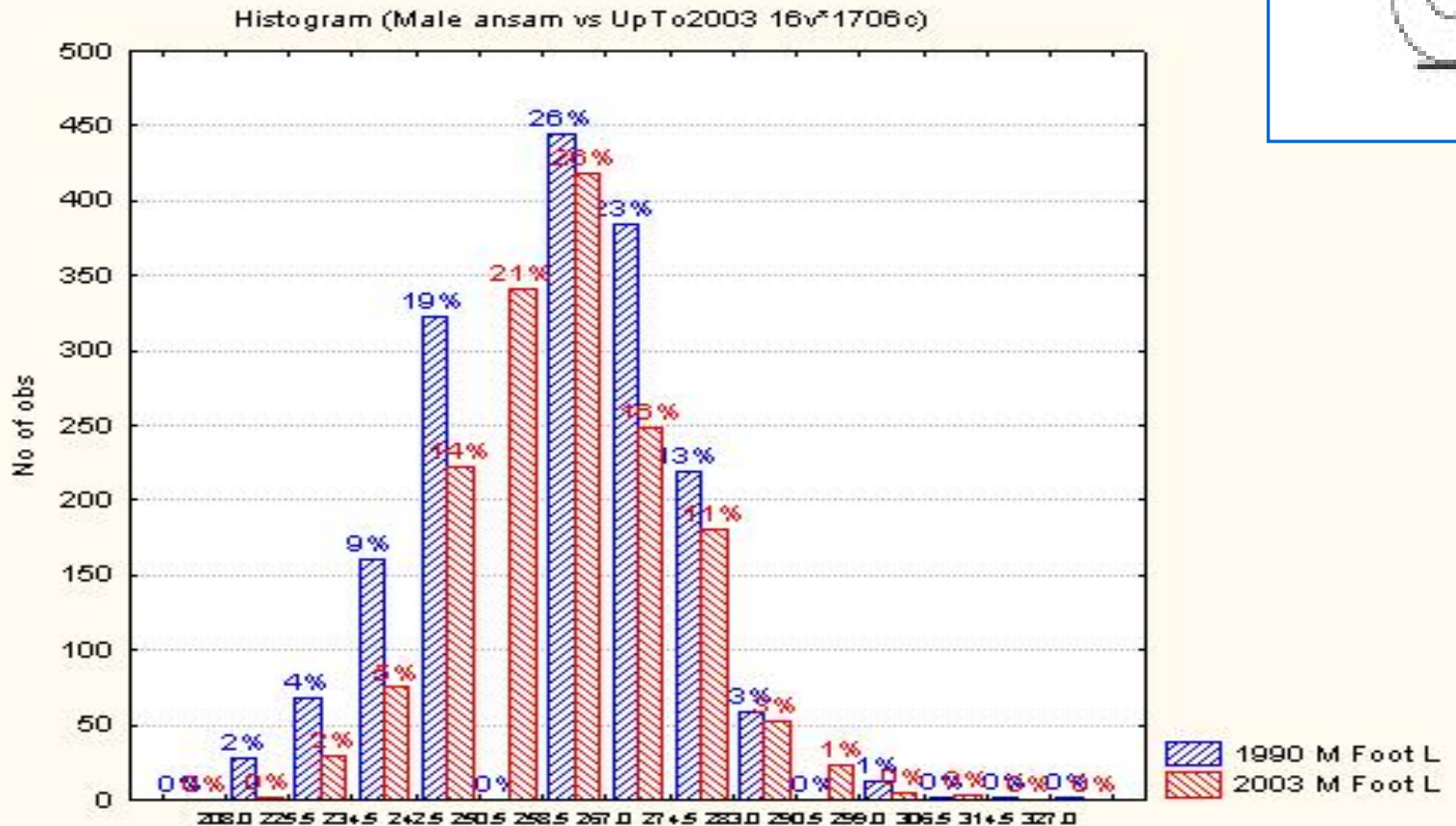
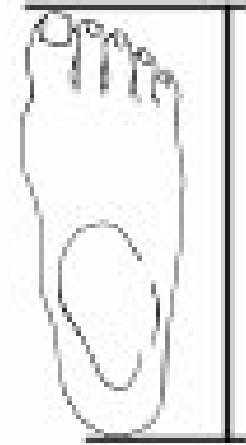
Anthropometry analyses for changes in user population and size allocation predictions



Changes in Anthropometry FEMALES : foot length

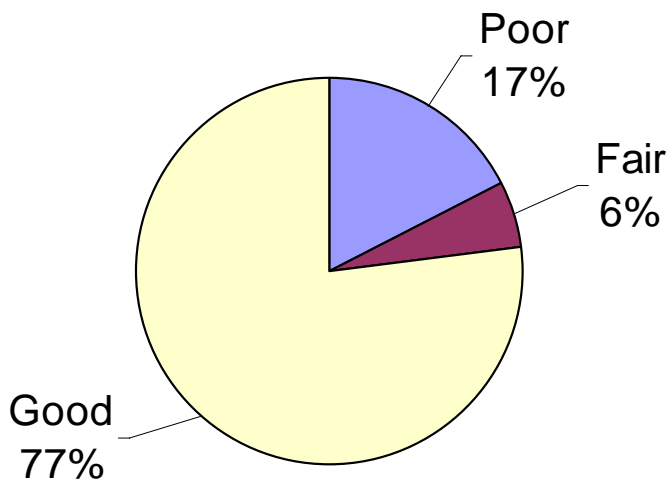


Changes in Anthropometry MALES : foot length

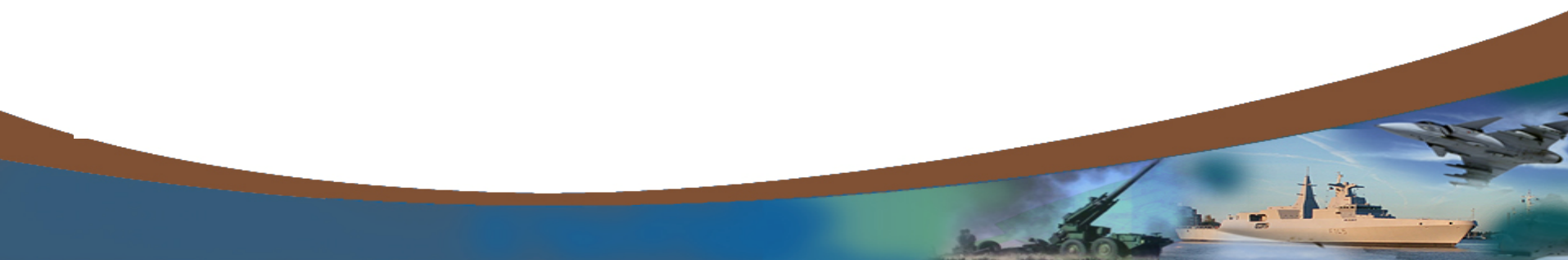
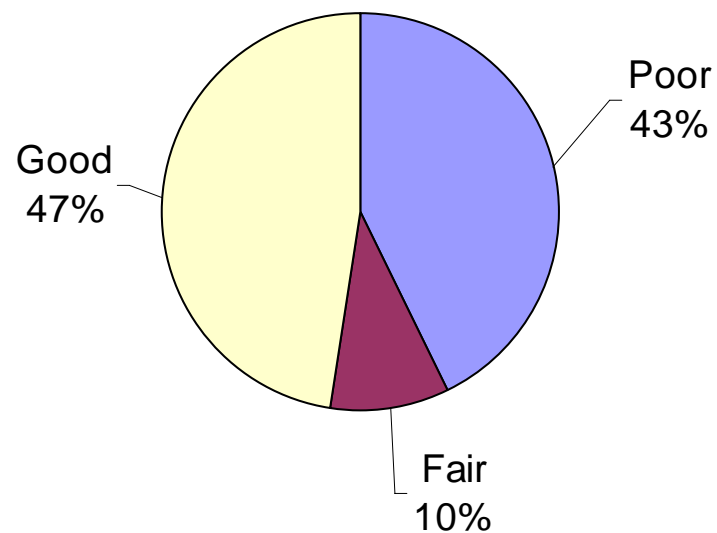


Fit evaluation rating for boots

Boot fit evaluations for males

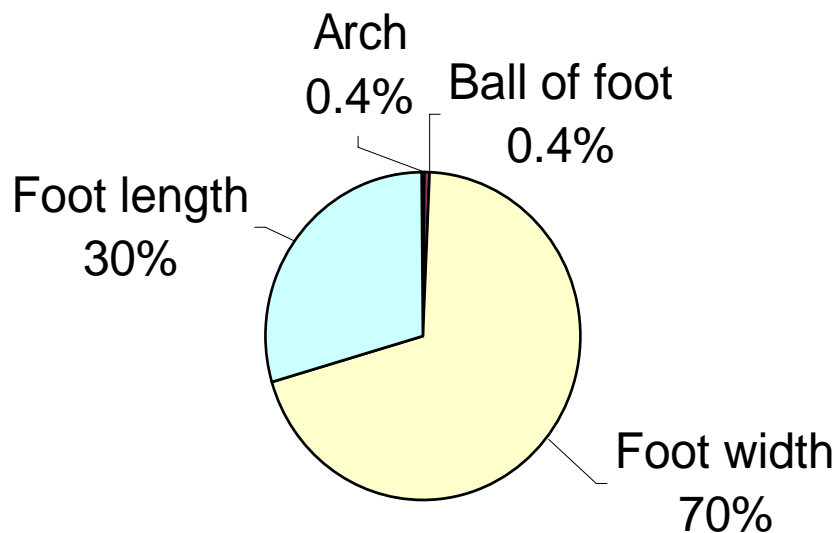


Boot fit evaluation for females

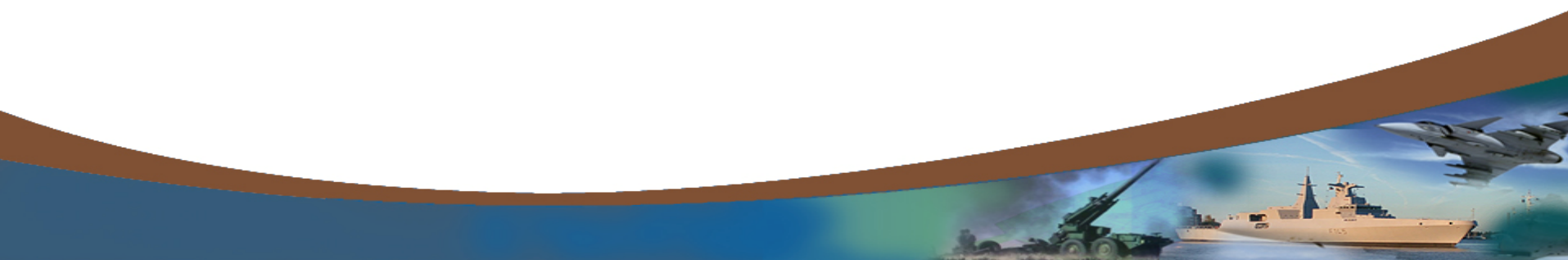
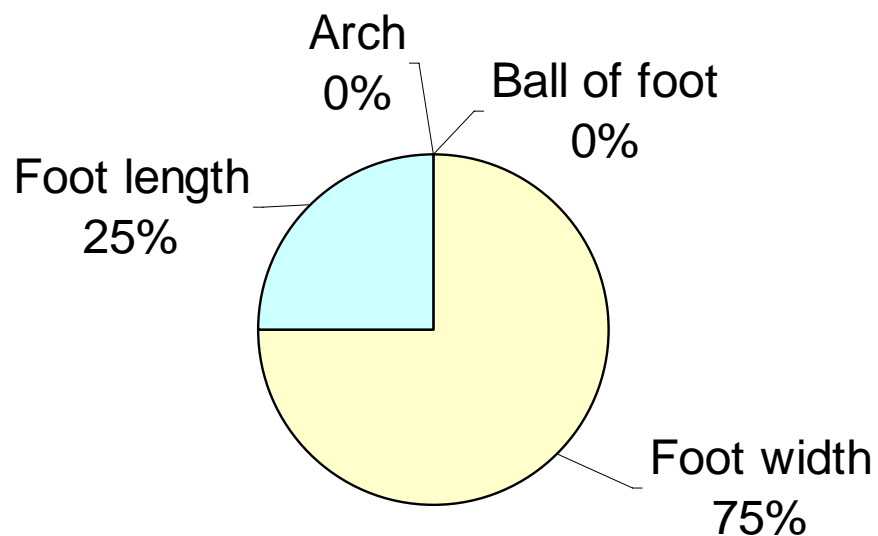


Region of foot - poor fit

Males

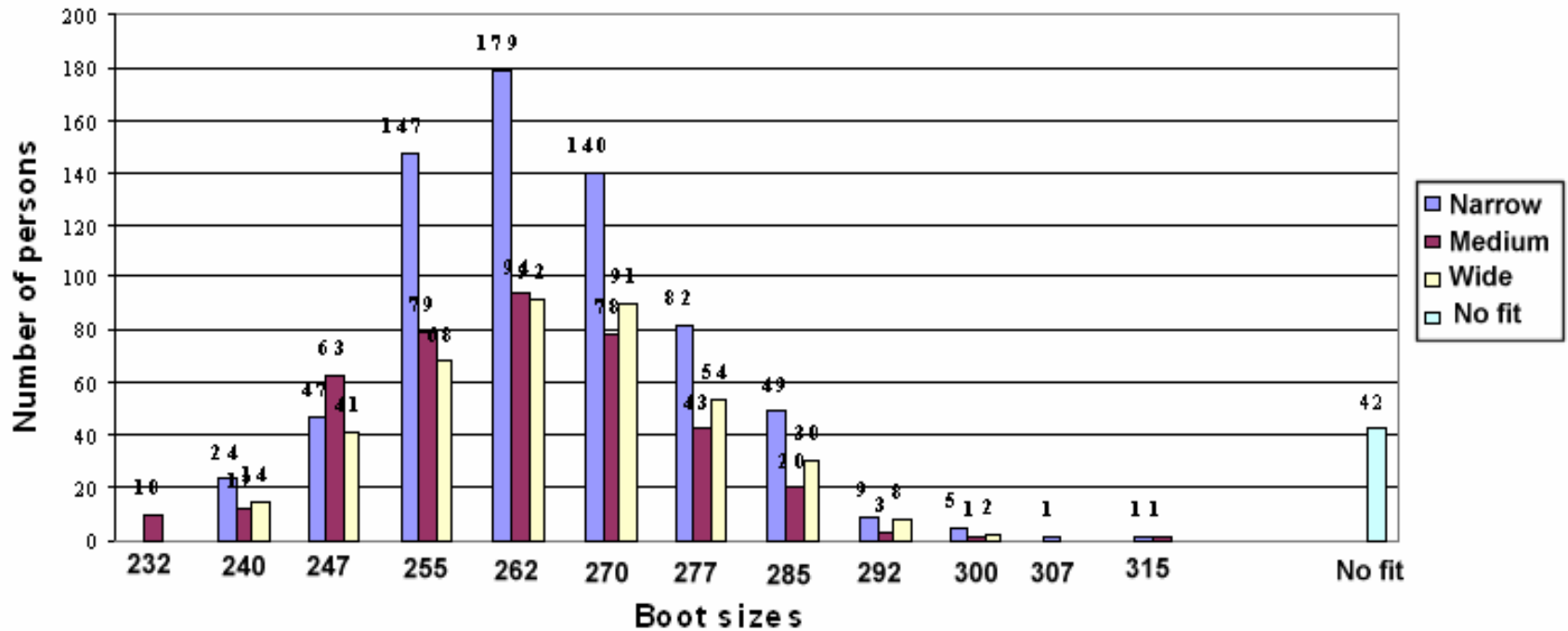


Females



Findings

Shoe and Boot issue distribution - 2e Semester 2001 for a sample of 1530 SANDF personnel



- Design and development
- Size prediction

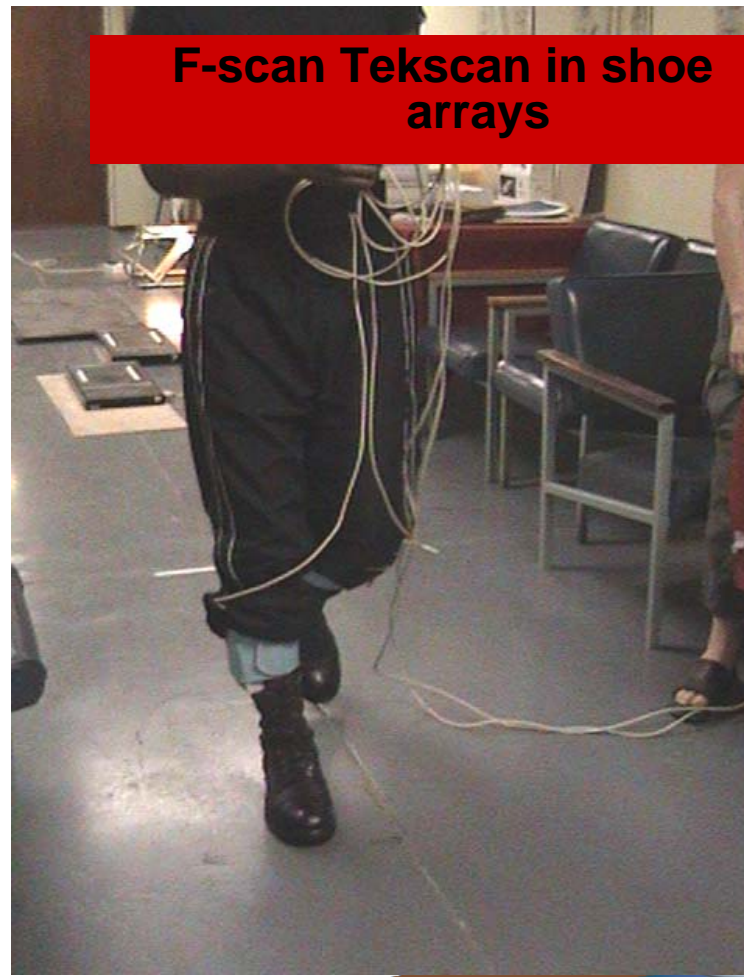


Investigations of fit and function

- Anthropometric measurements (linear and circumferential)
- Clinical measurements (leg length, calcaneus angles)
- Foot impressions (arches)
- Barefoot and in boot pressure
- Boot size reported

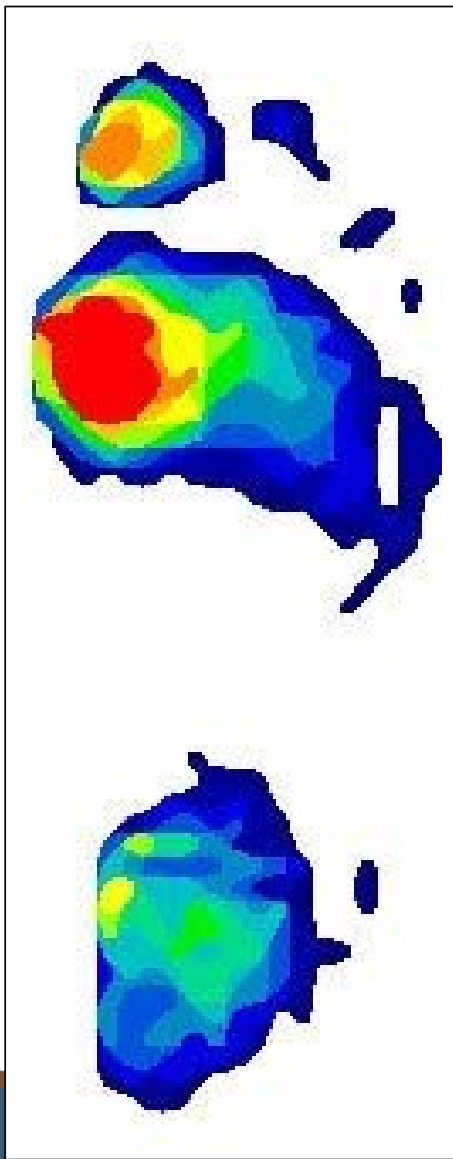


Pressure data capture

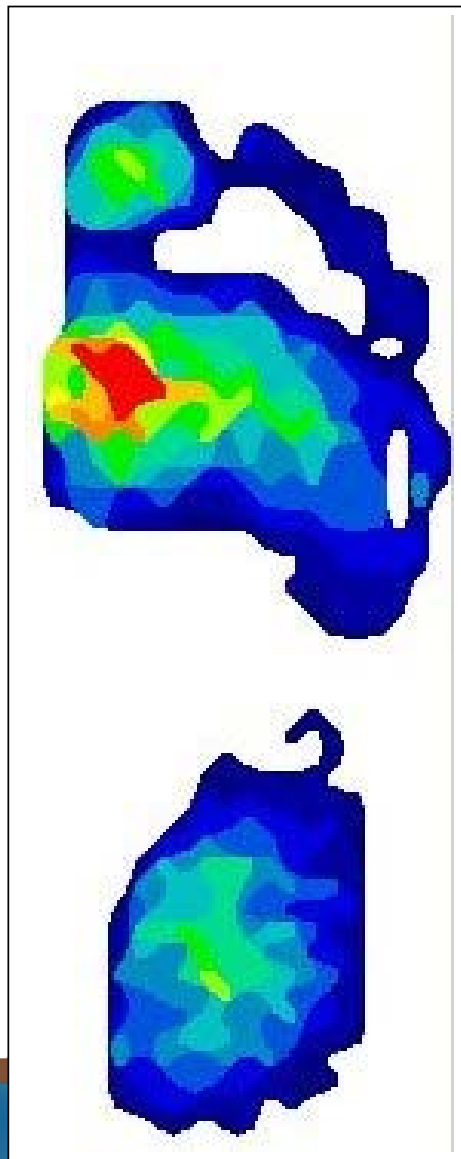


Foot pressure scans

Boot without inners



Boot with inners



Findings

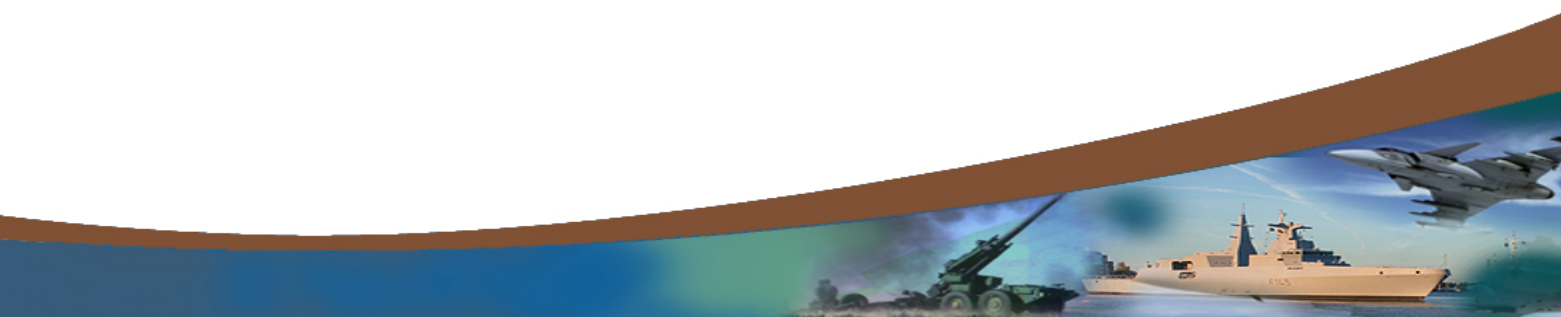
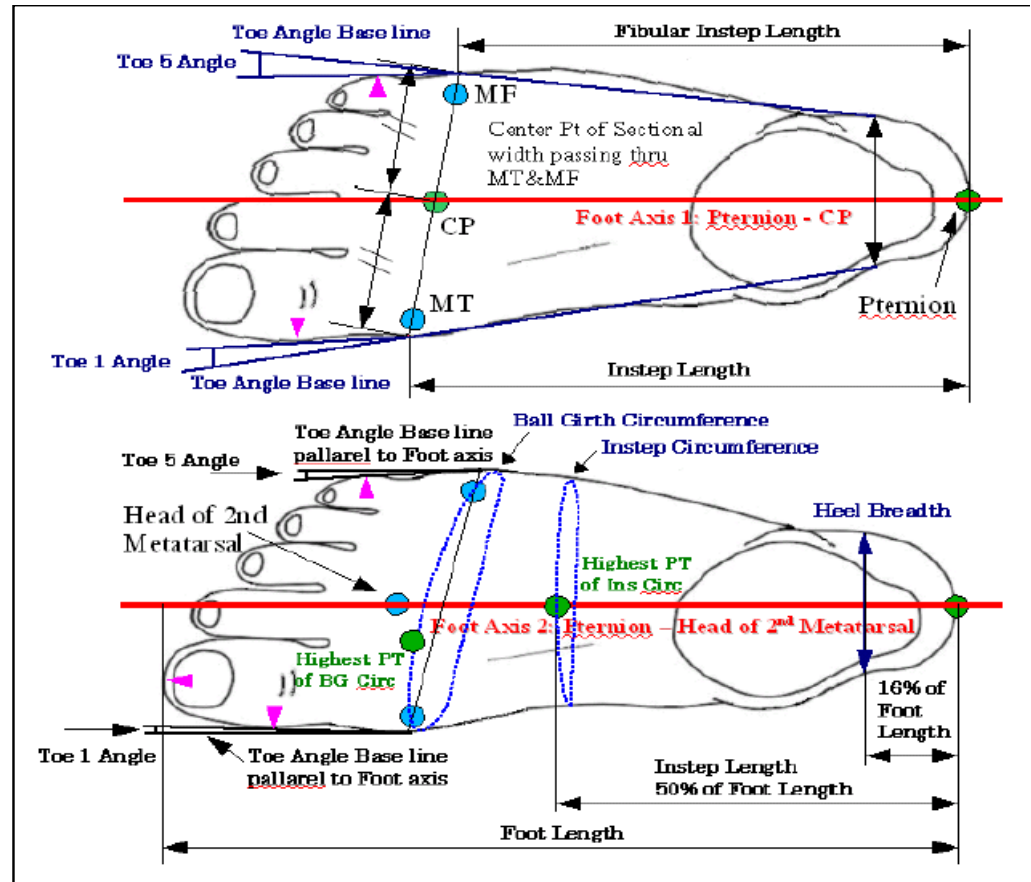
- Measurements as screening tool picked up potential clinical problems
 - Leg length discrepancies with low back discomfort
 - Arch problems lack of support
 - Predisposition of foot injuries (joint angles)
- Size allocation mismatch
- Narrow last needed
- Form data needed
- Pressure hot spots on top of great toe, under MT #1 + 2 and heel, lat of foot width
- Inner soles improve pressure hot spots –
 - Determine actual attenuation



Pilot study using InFoot scanner

Variable

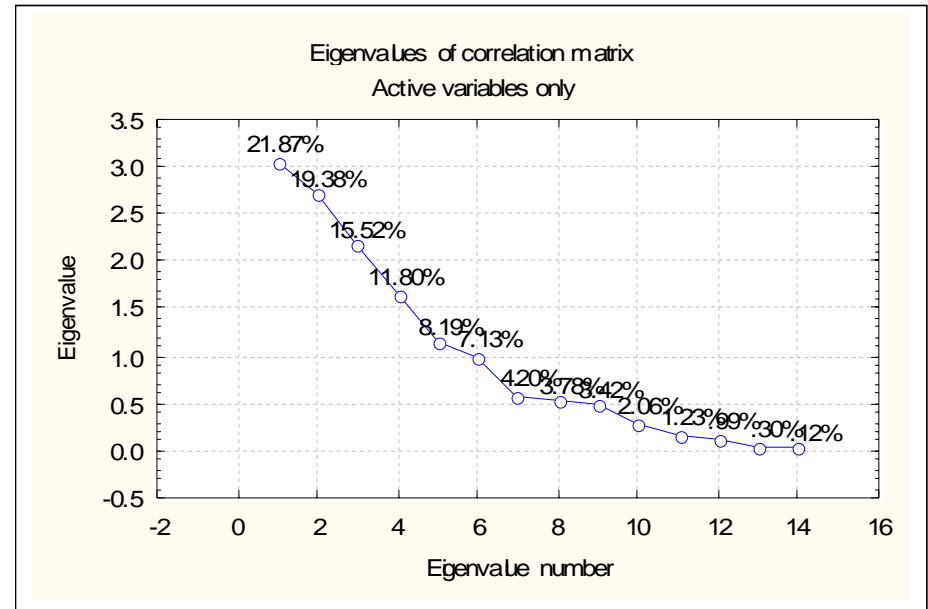
- RFoot length
- RBall Girth circ
- RFoot breadth
- RInstep circ
- RHeel breadth
- RInstep length
- RFib Instep length
- RHt Ball Girth
- RHt Instep
- RToe #1 angle
- RToe #5 angle
- RHt Toe #1 joint
- RHt of Toe #5 joint
- RHt navicular
- RHt Sphyrion fib
- RHt sphyrion
- RHt lateral Pt latmall
- RHt med Pt med mall
- RArch length
- RAngle of heel bone



Female PCA

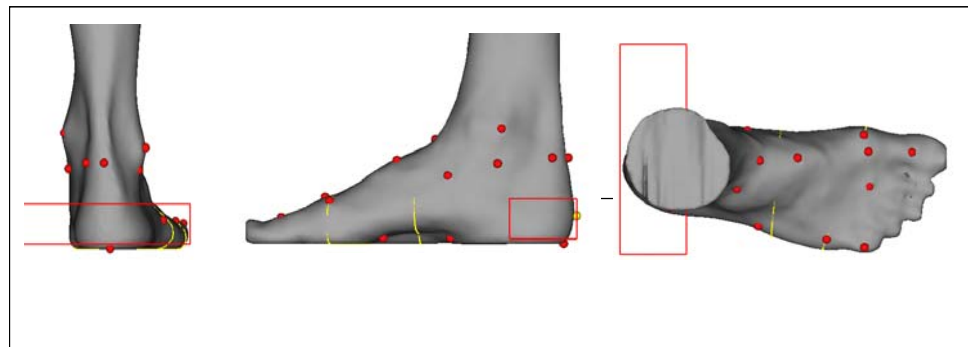
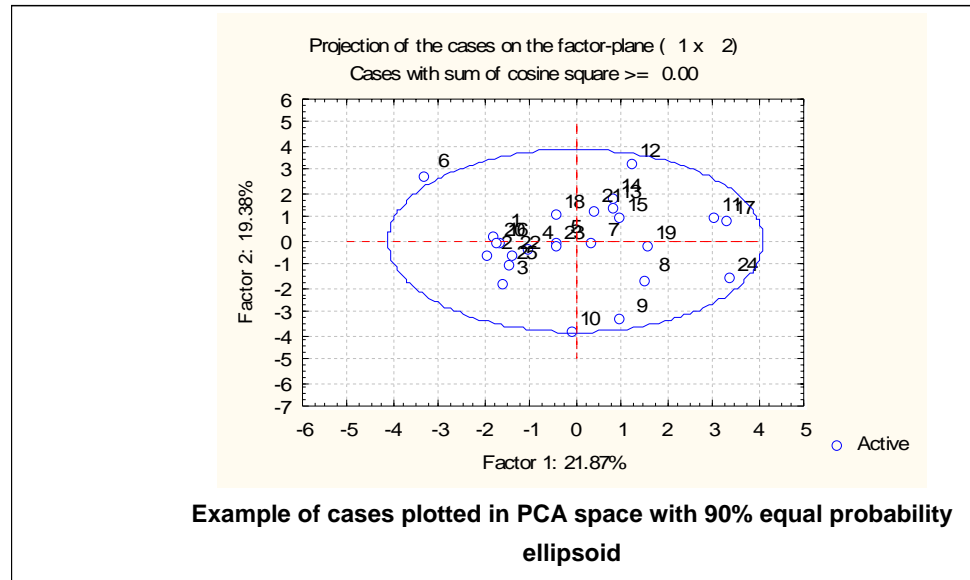
- Factor 1 describes instep circumference, heel breadth as well as metatarsal and 1st toe height
- Factor 2 describes a foot form that includes foot breadth, ball circumference and 1st toe angle
- Factor 3 describes lateral malleolus height
- Factor 4 describes the little toe height as a characteristic foot form identifier.

Females



Case selection for females

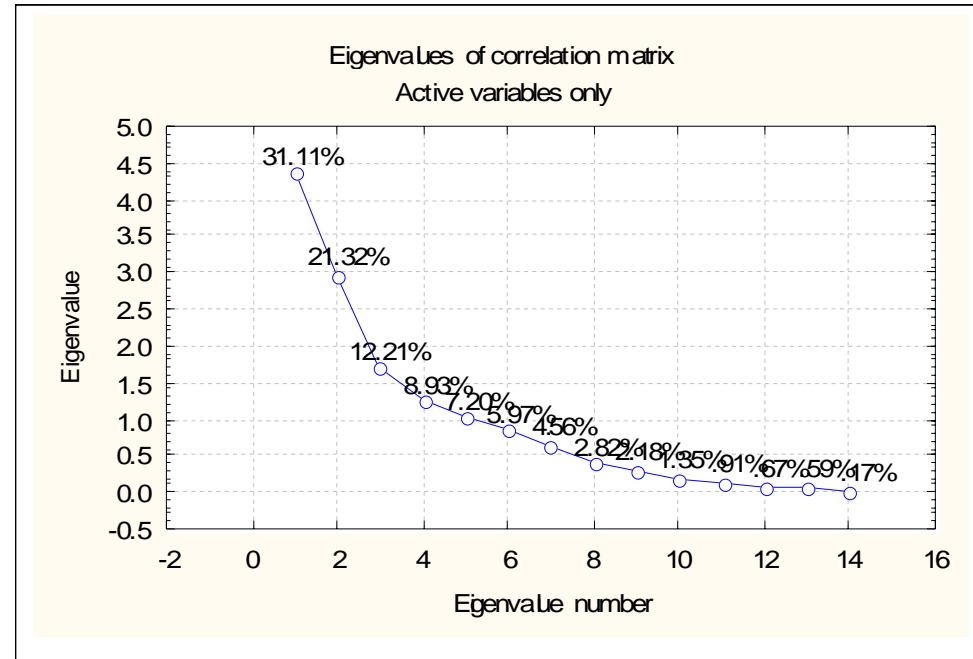
Female



Male PCA

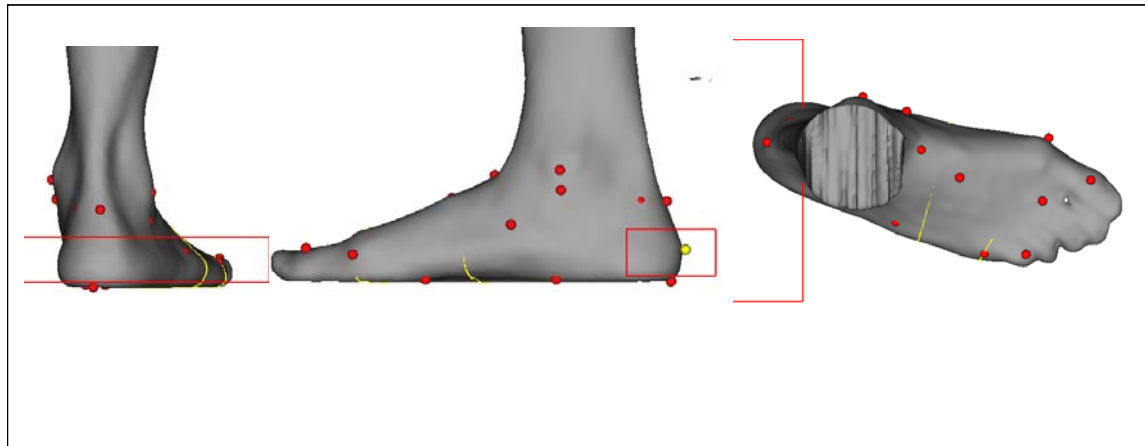
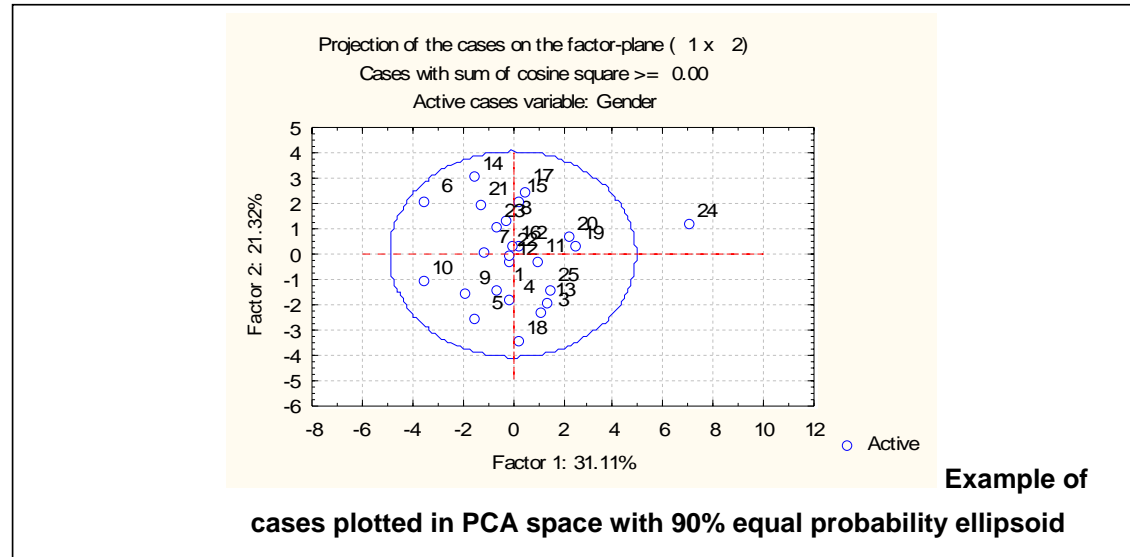
- Factor 1 represents a foot width and circumference variable which includes foot breadth, ball and instep circumference and 5th and 1st toe heights
- Factor 2 represents foot and malleoli height variable which includes metatarsal height, 5th toe angle as well as medial and lateral malleoli heights
- Factor 3 represents foot length (including instep and foot lengths) and 1st toe angle
- Factor 4 represents foot arch length and the angle of the heel bone

Males

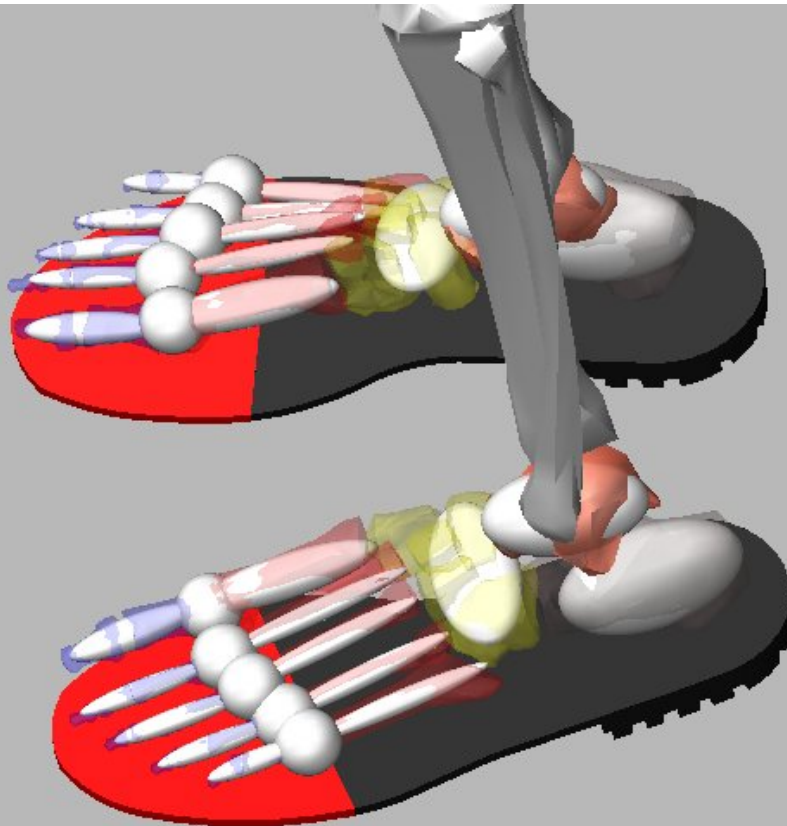


Case selection for males

Male



Evaluate and predict shock attenuation of footwear system



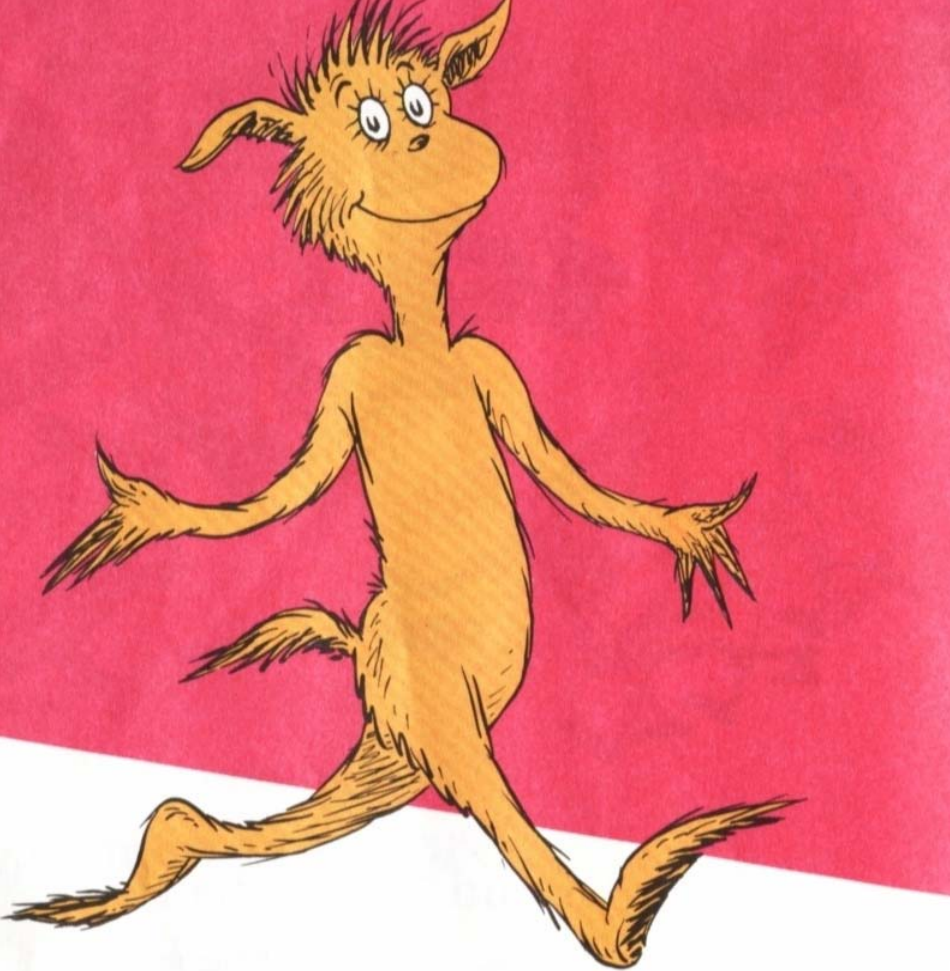
- Qualisys movement data captured for walking and jumping in boots
- Captured GRF with tekscan (validate with force plate)
- Modelled detailed foot model in LifeMOD
- Input available properties of shoe (assumptions made)
- Run model to predict loads
- Changed shoe properties to predict impact on shock attenuation



Future work

- **Conduct a survey of the user population to characterize the foot forms**
- **Improve the biomechanical foot model's biofidelity**
- **Build up database on boot sole and inserts properties as inputs to model**
- **Provide recommendations using the anthropometric and biomechanical databases to optimize design**
- **Evaluate boots for acquisition process**





Left foot.

Right foot.

Feet. Feet. Feet.

Oh, how many feet you
meet!

Dr Seus