Functional reserves of older and younger adults when negotiating stairs of different configurations

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Introduction - Background

- A high percentage of falls occur on staircases, particularly during descent
- Cost of treatment to NHS in UK is ever increasing as the population age

Aim

- Investigate different measures of difficulty in order to identify a stair configuration which is easier for older adults to negotiate
- Within the same parameters, identify configurations which are particularly challenging and therefore pose a high fall risk

- Causes may be multi factorial

  Relating to:
  - Balance
  - Strength
  - Range of motion
  - Handrail use
  - Foot positioning

- Focus of this presentation will be **joint function reserves**

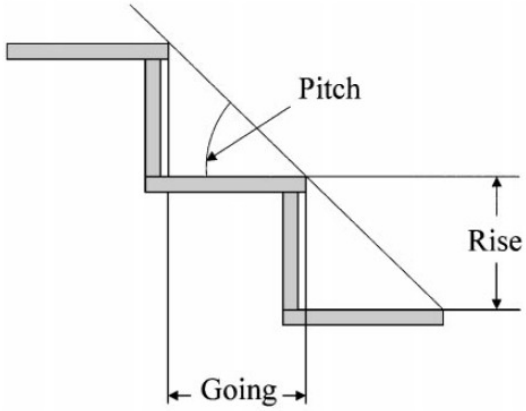
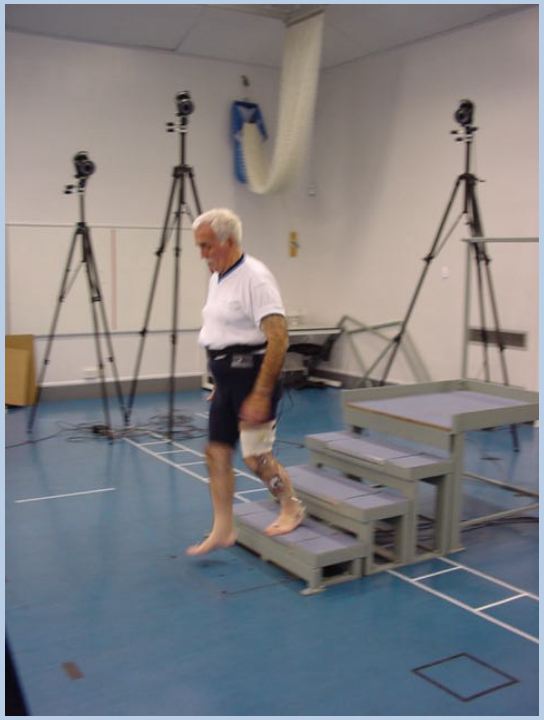


Fig. 1. Simple stair geometry.

Stair Negotiation project @ MMU



Expected Outcomes:

Better Stair Design

Increased Functional Reserves

Reduction of falls and accidents

Stair Safety-specific Training Programme

Specific

Focused

Individualised

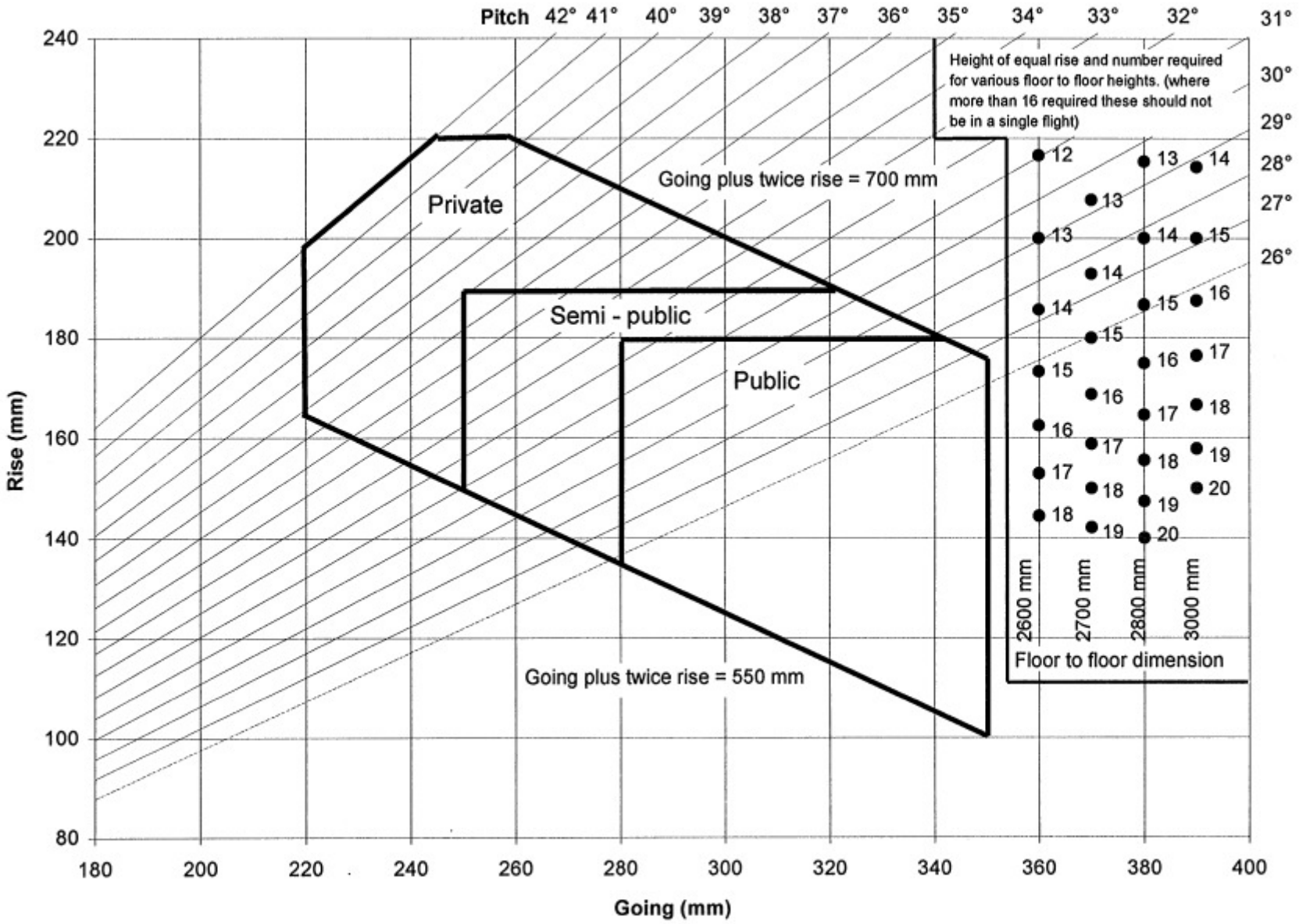


Fig. 2. Acceptable stairs based on the relationship between rise and going.

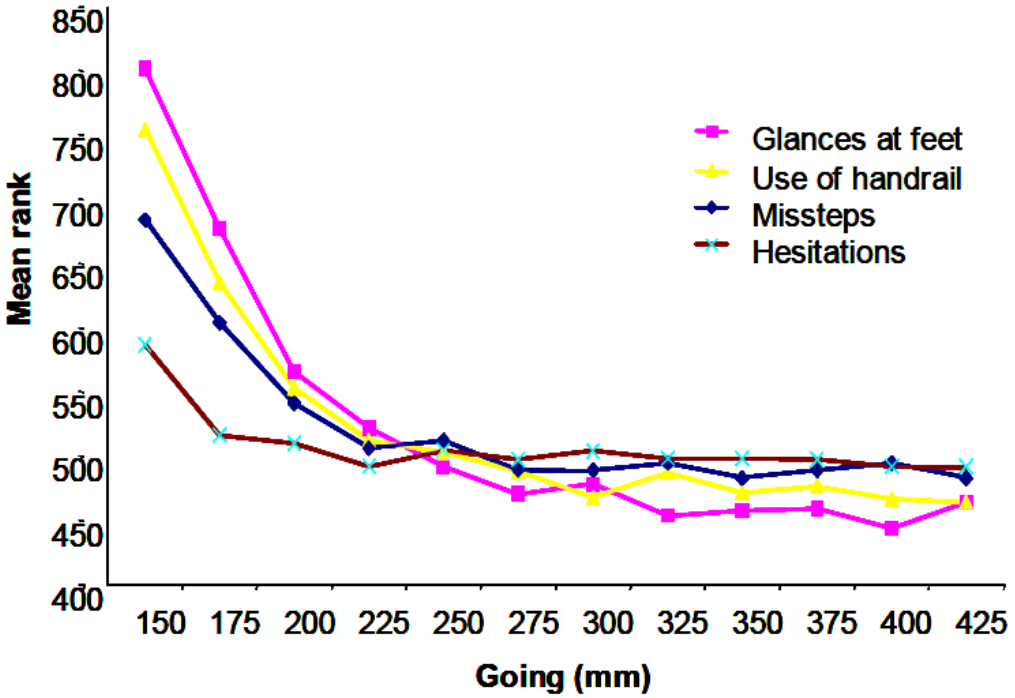
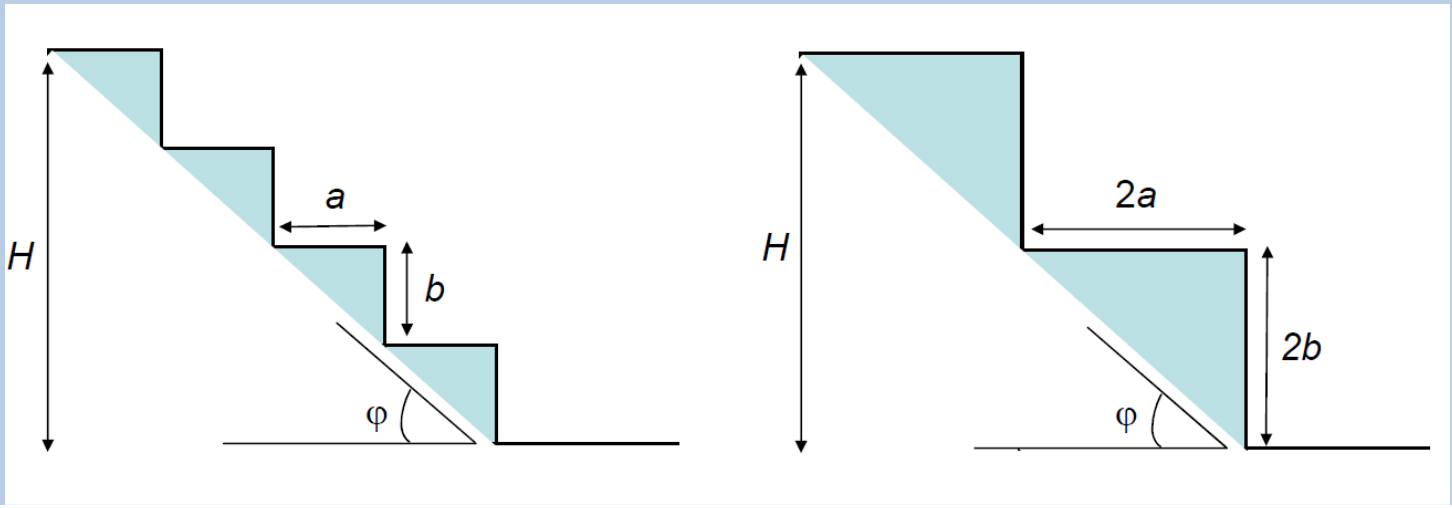
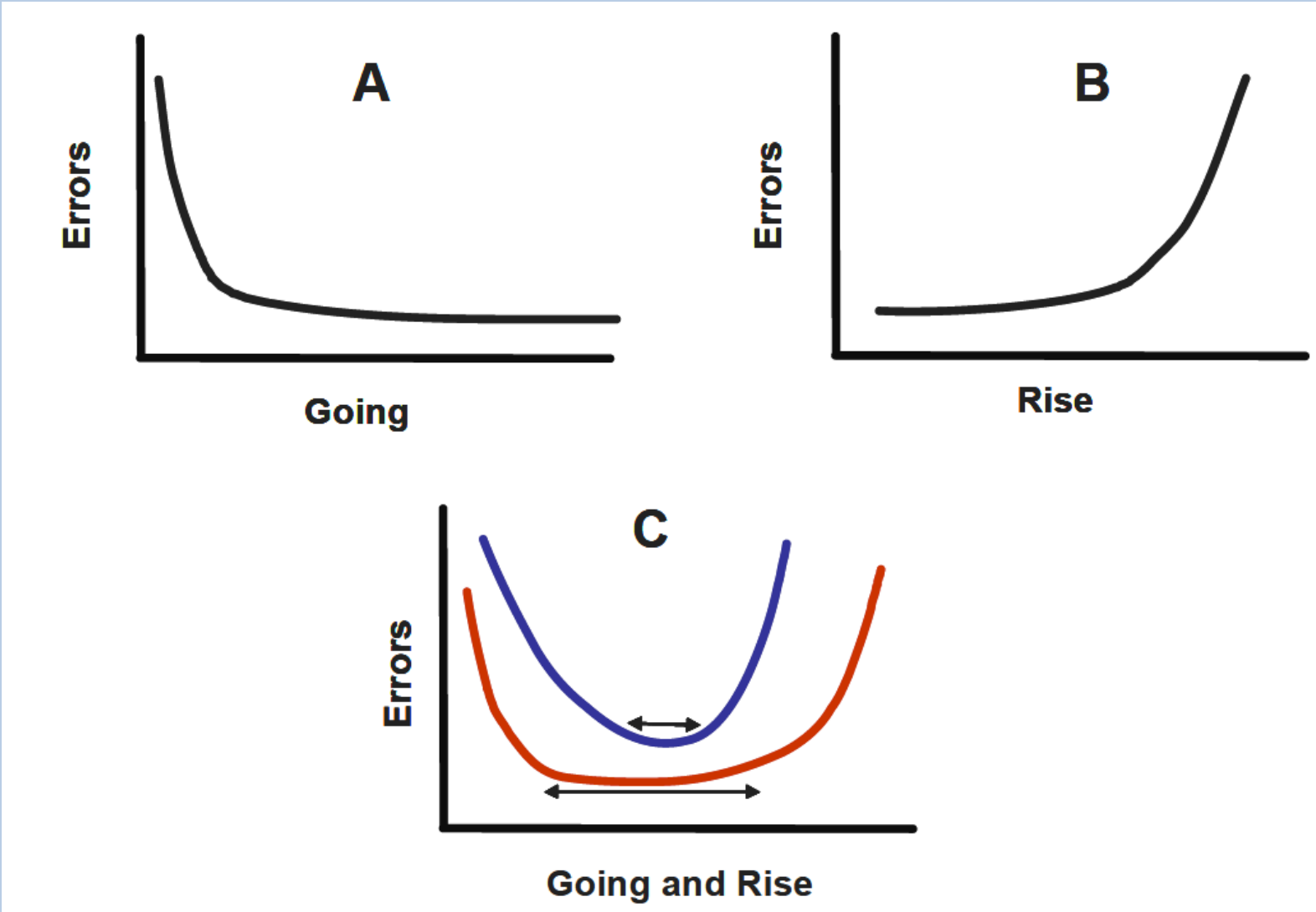


Fig 1. Problems associated with stair descent as a function of going with a constant rise




A
Errors
Going
B
Errors
Rise
C
Errors
Going and Rise

Introduction – Joint Function Reserves

- Joint function reserve = % of maximum strength
- Higher reserve = closer to limits = increased risk
- Main muscle groups of interest
  - Ankle plantarflexors
  - Knee extensors
- Measured moments of ankle and knee joints
- Ascertained maximum ability
- Compared to measure on stairs

Methods - Dynamometer

←Ankle set up

Knee set up →

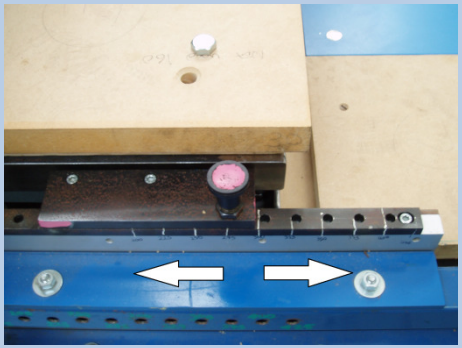
- Ankle and Knee
- 4 velocities
- Concentric and Eccentric
- Matched speed and muscle action to stairs

Methods - Staircase

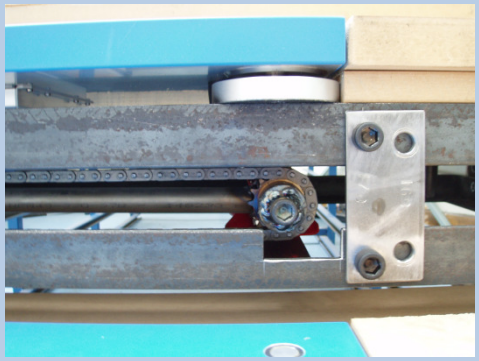
Equipment

- 7-step staircase
- Adjustable rise and going
- 4 embedded force plates

Going adjustment



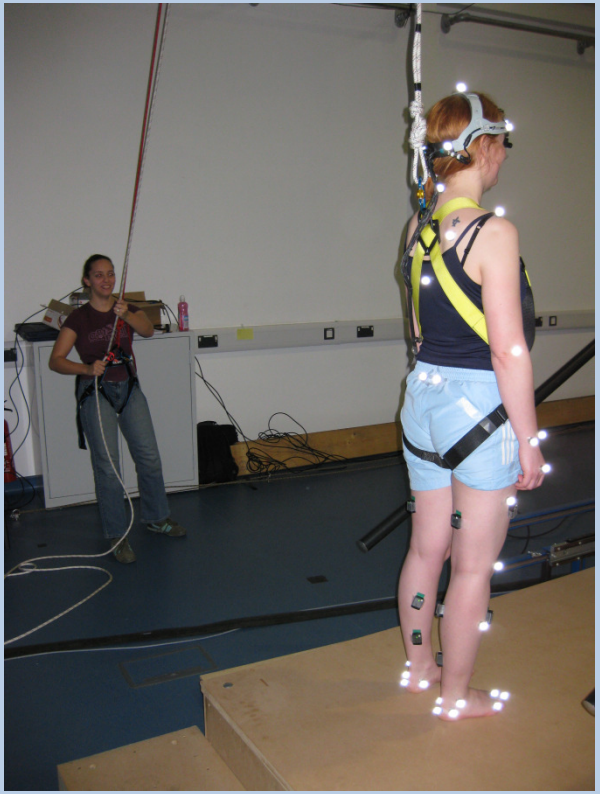
Rise adjustment



Methods - Staircase

Set-up

- 43 reflective markers
- 10-camera optoelectronic system



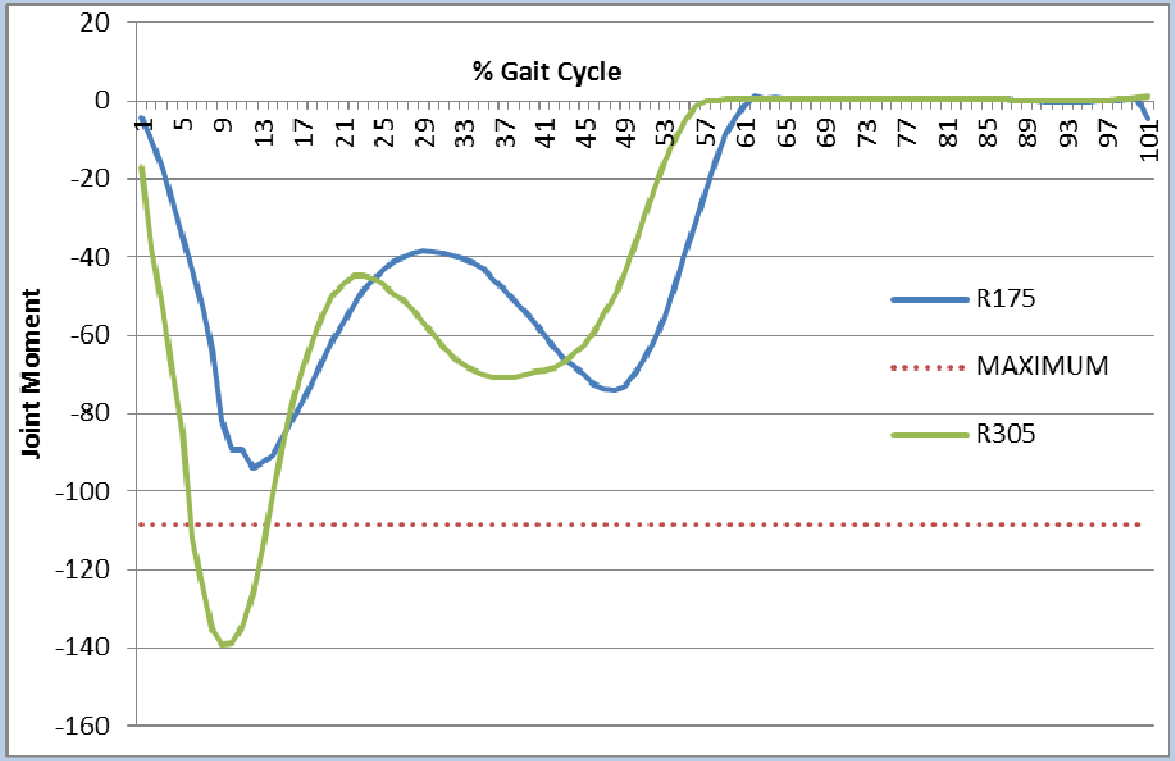
- Harness and belay

GOING	RISE
325 mm	305 mm
325 mm	225 mm
325 mm	175 mm
275 mm	175 mm
225 mm	175 mm
175 mm	175 mm

Protocol

- 6 configurations; ascent & descent
- Standing start and finish
- Self-selected strategy and velocity

Representative Graph



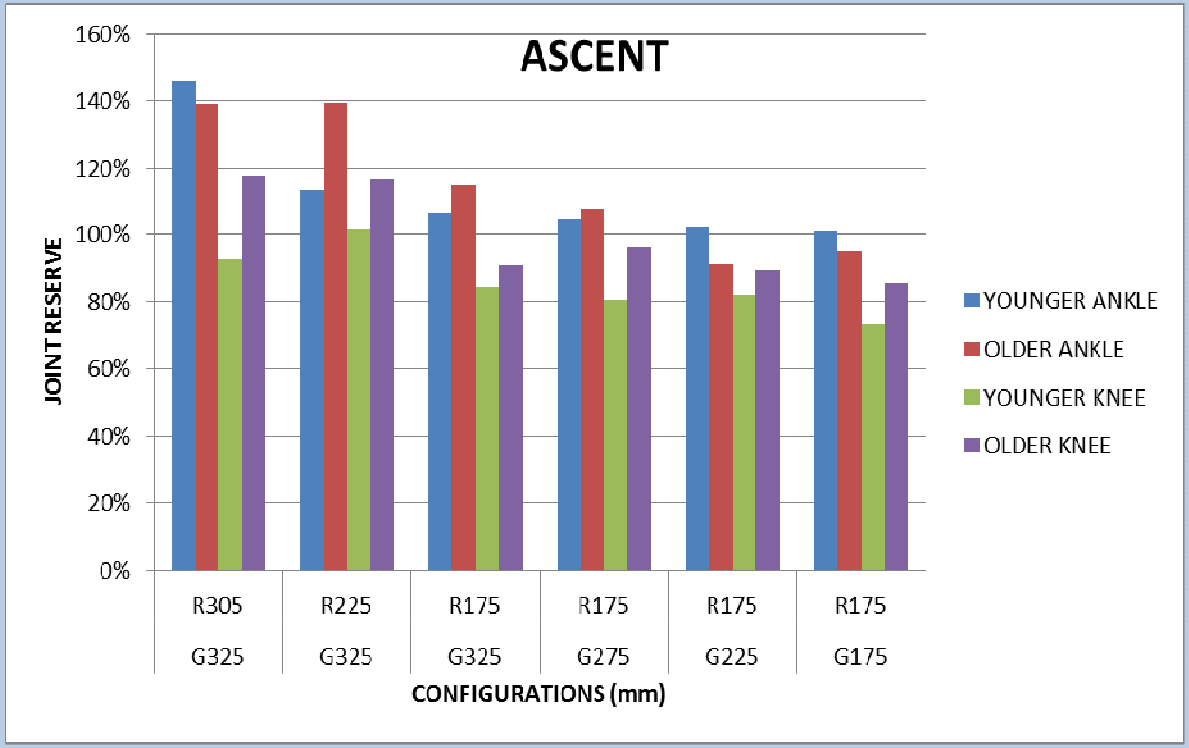
- Ankle moment
- One subject
- Two conditions

- Lower rise within voluntary maximum measured ability
- Higher rise exceeds voluntary maximum measured ability
- Possibly due to a less constrained movement on the stairs compared to the dynamometer

Results - Ascent

Ankle

- Step height has significant effect
- Going has no significant effect
- Currently the sample size does not allow us to say whether age has an effect



Knee

- Step height has significant effect
- Going has no significant effect
- Age does have a significant effect

Conclusion - Ascent

- With regards to strength reserves at the knee and angle, stairs with a rise of 175 mm are less taxing for both older and younger adults to negotiate than stairs with rises of 225 mm or 305 mm.

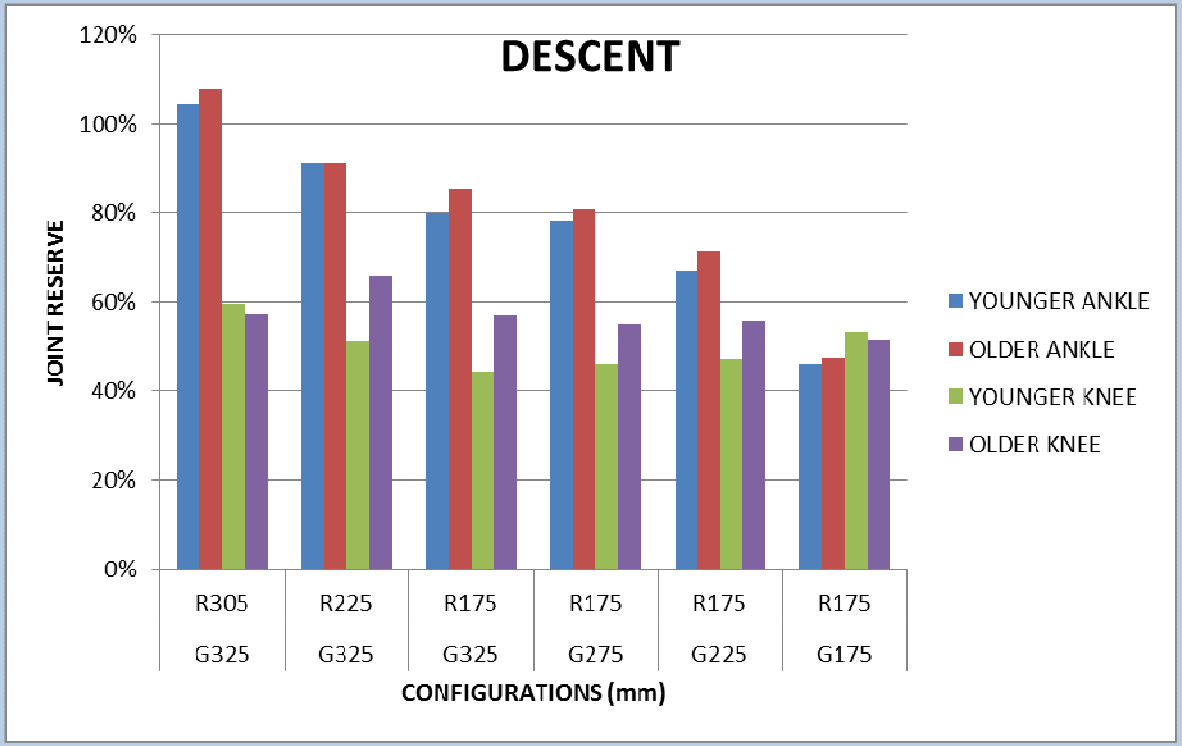
- Changing the going of the step between 325 mm and 175 mm has no significant effect on the strength demands.

- Older adults consistently use a higher percentage of knee strength at all configurations.

Results - Descent

Ankle

- Step height and going both significantly affect strength demands
- Currently the sample size does not allow us to say whether age has an effect



Knee

- Cannot say whether age or configuration have significant effect
- Younger remains between ~45% and ~60% of maximum
- Older stays between ~50% and ~65% of maximum

Conclusion - Descent

- Ankle angle strength reserves were found to be significantly higher with a riser height of 305 mm than either of the lower rises.
- There was no significant difference of ankle reserve, between a rise of 225 mm and 175 mm although there was a decreasing trend.
- A going of 175 mm produced significantly lower reserves than any other configuration.
- Older adults consistently use a higher percentage of ankle strength at all configurations.

Conclusion

- Based on joint reserves alone the configuration of choice to reduce the demand on the muscles and improve safety would be a **rise of 175 mm** and a **going of 175 mm**.

- However, due to observable changes in strategy (particularly in descent) there is likely other functional parameters which are challenged by this configuration.

- Investigations into other factors such as balance, foot positioning/trajectory and joint angle patterns, will help to identify which configuration is least challenging and therefore safer for adults to negotiate.

Acknowledgements