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.
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 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

<table>
<thead>
<tr>
<th>GOING</th>
<th>RISE</th>
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<tbody>
<tr>
<td>325 mm</td>
<td>305 mm</td>
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<tr>
<td>325 mm</td>
<td>225 mm</td>
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<tr>
<td>325 mm</td>
<td>175 mm</td>
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<td>275 mm</td>
<td>175 mm</td>
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<td>225 mm</td>
<td>175 mm</td>
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<td>175 mm</td>
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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.

• A going of 175 mm produced significantly lower reserves than any other configuration.

• There was no significant difference of ankle reserve, between a rise of 225 mm and 175 mm although there was a decreasing trend.

• 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