Ankle Strength and Stiffness Predict Range of Motion During Walking in Older Adults

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Introduction

• Falls responsible for 40% of nursing home admissions
  (Guideline for the Prevention of Falls in Older Persons, 2001)

• Studies focusing on lower extremity vulnerability show weakness in the ankle dorsiflexors and lack of flexibility of ankle plantarflexors increase risk of falling. (Hylton, 2003)

• Ankle stiffness or weakness could lead to foot drop during walking, impairing the ability to clear obstacles and increasing the risk of falling
Foot Drop

• Obligation of ankle during swing phase is 90° of dorsiflexion (DF)
• Foot drop: Deficit in ankle dorsiflexion during swing phase of walking
  • Stiffness = \( \frac{\Delta \text{ Torque}}{\Delta \text{ Angle}} \)
  • Dorsiflexor Strength
• Lack of floor clearance = Tripping and falling
Purpose

• To associate strength of the dorsiflexor muscles and plantarflexor stiffness to ankle motion during the swing phase of walking in older women.

• To test the relationship between a novel ankle strength to stiffness ratio score and ankle range of motion during the swing phase of walking in older women.
Subjects

Inclusion Criteria:
- Women Age 65-80 yr
- Independent living
- No walking aids

Exclusion Criteria:
- History of heart rhythm abnormalities, heart attack, stroke
- Severe osteoporosis or severe arthritis
- Neurological/cognitive disorders

Table 1. Subject descriptive characteristics

<table>
<thead>
<tr>
<th>Subjects (n=16)</th>
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<tbody>
<tr>
<td>Age (yr)</td>
<td>71.8</td>
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<tr>
<td></td>
<td>4.2</td>
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<tr>
<td>Height (m)</td>
<td>1.60</td>
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<tr>
<td></td>
<td>0.06</td>
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<tr>
<td>Mass (kg)</td>
<td>64.5</td>
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<tr>
<td></td>
<td>9.3</td>
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<tr>
<td>% Body Fat</td>
<td>39.0</td>
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<tr>
<td></td>
<td>9.3</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>25.3</td>
</tr>
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<td></td>
<td>3.7</td>
</tr>
</tbody>
</table>

Table 1. Subject descriptive characteristics
Methodology

Visit 1
Habituation

Visit 2
Data Collection

Visit 3

Anthropometrics

Strength

Stiffness

Gait Analysis

3 Days

Strength

Stiffness

Gait Analysis

~ 1 Week

Body Composition
Methodology: Strength & Stiffness

- Cybex Dynamometer
- Maximal voluntary contraction of the dorsiflexors
- Resistive torque of relaxed plantarflexor (PF) muscle measured from 105-75° of ankle flexion
- 30 Seconds Rest between each trial
Methodology: Gait Analysis

- Kistler Gaitway Treadmill
- Ankle ROM measured with electrogoniometer
- Subjects walked at:
  - 50 m·min⁻¹
  - Self-selected maximum speed
- Smaller angle means better ROM
Measures

- **Strength of DF** – Peak torque during maximal voluntary contraction

- **Passive stiffness (of PF)** = \[\frac{\Delta \text{Torque}}{\Delta \text{Angle}}\]

- **Strength:Stiffness ratio** = \[\frac{\text{Max torque of the DF}}{\text{Stiffness of the PF}}\]

- **Ankle ROM** - Measured with an electrogoniometer during treadmill walking

- **% Body Fat** – Whole-body air-displacement plethysmography (BodPod)
Passive Stiffness

Muscle Length (Ankle Angle)

Resistive Torque (Nm)

Stiffness
Statistics

- Median DF strength PF stiffness scores used to separate subjects into groups

- Analysis of:
  - ‘Strong’ vs. ‘Weak’
  - ‘Stiff’ vs. ‘Flexible’

- Differences between groups were assessed using one-way ANOVA

- Strength of association between variables compared using Pearson correlation

- Statistical significance set at $P < 0.05$
Figure 1. Relationship between dorsiflexor strength and ankle angle.

$r = -0.47, P = 0.03$
Figure 2. Relationship between plantarflexor stiffness and ankle angle.
Figure 3. Relationship between ratio of DF strength to PF stiffness and ankle angle.
Figure 4. Relationship between DF strength and treadmill speed.

* = P < 0.05
Figure 5. Relationship between treadmill self selected speed and percent body fat.  * = P < 0.05
Conclusion

• Dorsiflexor weakness is related to foot drop in older adults.

• Stiffness of plantarflexors is not related.

• Ratio of strength to stiffness was the strongest predictor of ankle ROM.

• Strong dorsiflexors, stiff plantar flexors, and a low percent body fat were all related to higher self-selected walking speeds.
Thank You!

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Undergraduate Research Conference

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Participating Subjects