SEX DIFFERENCES IN PLANTAR FLEXION STRENGTH MAY PREDISPOSE MIDDLE AGE FEMALES TO FALLS

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INTRODUCTION

It is well documented that with increased age there are concomitant decreases in muscular mass and strength [1]. Furthermore, gender appears to significantly influence the ability to produce force, with females generally demonstrating lower absolute strength than males across muscle groups [1]. Additionally, it has been documented that elderly females are weaker than males even when strength is normalized for body weight [2].

The risk for fall related injury increases with age, and older females have an increased rate of falls compared to older males [3]. Strength deficits have been implicated as risk factors for falls, with fallers reportedly exhibiting significant plantar flexion weakness compared to non-fallers [4]. While these contributions to the literature are extremely important and relevant to understand how plantar flexor muscle strength is related to falls, there is a vital part of the literature that is lacking. Plantar flexor muscle strength is almost exclusively tested in full knee extension. In this position we are unable to isolate soleus muscle strength. The soleus is a postural muscle; therefore strength deficits could have significant implications on balance and stability. Performing ankle plantar flexion with the knee flexed to 90° minimizes the contribution of the gastrocnemius [5], allowing for isolated soleus muscle function. It is important to understand if sex differences occur when looking specifically at the soleus muscle as it may provide insight into the increased rate of falls in females. Further, it is important to understand if this postural muscle exhibits differences between sexes during middle age as this may indicate that females are predisposed to falls at an earlier age.

If middle aged women demonstrate significant weakness compared to middle aged men, perhaps interventions should be implemented earlier in life. Therefore, the purpose of this study was two-fold. First, to investigate if soleus muscle deficits are apparent in middle age females compared to middle aged males. Secondly, to investigate if plantar flexion strength deficits exist between sexes in the middle aged population.

METHODS

Data was collected from 25 healthy (12 male and 13 female) volunteers (Table 1). Subjects were between 40 and 65 years of age and were free of any unresolved musculoskeletal or neurological disorder by self-report. The test leg was chosen at random (female: 6 right legs, 7 left legs; males: 5 right legs, 7 left legs). Subjects also had to have at least 5° of ankle dorsiflexion with full knee extension as measured with a bi-plane goniometer. This device was used instead of a standard goniometer because it enables proper subtalar joint neutral positioning, which allows for true measurement of talocrural ankle dorsiflexion; and it has higher reliability than a standard goniometer [6].

The Biodex System 3 was used to measure isometric ankle plantar flexion strength with full knee extension (triceps surae) and 90° of knee flexion (soleus). For both measures the ankle position was held constant in maximum available dorsiflexion. Plantar flexion strength data was normalized by body mass to account for differences known to exist in subjects of varying sizes. The Foot and ankle Ability Measure (FAAM) was used to evaluate differences in self-reported function between sexes. Independent sample t-tests were used to compare differences between sexes.
RESULTS AND DISCUSSION

There were no differences in age; however males were significantly larger than females (Table 1). Females were significantly weaker than males in ankle plantar flexion strength with knee extension (Figure 1). They were also significantly weaker in ankle plantar flexion strength with knee flexion (Figure 1). These differences persisted even though strength data was normalized for body mass (Figure 2). There were no significant differences between sex for self-reported rating of function or global rating of function (Table 1).

![Absolute Isometric Plantar Flexion](image)

**Figure 1:** Absolute plantar flexion strength with knee flexion and full knee extension.

The difference between middle aged males and females in absolute plantar flexion strength was expected. It was however, interesting to note that these differences persisted even when normalized for body mass. This was contrary to previous reports in this age group, in which plantar flexion strength deficits did not exist between sexes when normalized for body size [1]. However, our results are similar to reports that elderly females were significantly weaker than elderly males in plantar flexion strength when data were normalized for size [2].

We believe this is the first report to demonstrate that middle aged females are significantly weaker than middle aged males in both soleus and triceps surae isometric muscle strength. Further, this may indicate that these females are predisposed to falls at an earlier age. However, additional data collection, including isokinetic strength, balance, and posture assessment, is needed to truly assess this risk.

**CONCLUSIONS**

Our data indicate that women are weaker than males even when plantar flexion strength is normalized for differences in body size. Further, isolating the soleus muscle revealed significant weakness in females. This has clinical implications for an increased risk of fall in middle aged females, which may be due to postural muscle control deficits.

**REFERENCES**


<table>
<thead>
<tr>
<th></th>
<th>Age</th>
<th>Weight (kg)</th>
<th>Height (m)</th>
<th>FAAM Global (%)</th>
<th>FAAM Function (%)</th>
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<tbody>
<tr>
<td><strong>Male</strong></td>
<td>49.2 ± 7.9</td>
<td>90.1 ± 23.2</td>
<td>1.8 ± 0.1</td>
<td>99 ± 3</td>
<td>98 ± 5</td>
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<tr>
<td><strong>Female</strong></td>
<td>47.8 ± 8.3</td>
<td>66.7 ± 13.3</td>
<td>1.6 ± 0.1</td>
<td>100 ± 0</td>
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<td><strong>p-value</strong></td>
<td>0.67</td>
<td>p &lt; 0.001*</td>
<td>p &lt; 0.01*</td>
<td>0.30</td>
<td>0.35</td>
</tr>
</tbody>
</table>

* denotes statistical significance between males and females.