SOLEUS FASCICLE STRAIN DURING WALKING IN YOUNG AND OLD ADULTS:
INSIGHT INTO AGE-RELATED GAIT DEFICIT

1 Fausto A. Panizzolo, 1Daniel J. Green, 2 David G. Lloyd, 1 Jonas Rubenson
1 School Of Sport Science, Exercise and Health, The University of Western Australia
2 School of Physiotherapy and Exercise Science, Griffith University

INTRODUCTION
Gait in older adults is associated with loss of function and exercise capacity [1]. A consequence of this is that older adults have a reduced gait speed, higher incidence of falls, and a higher expenditure of metabolic energy during walking compared to younger adults. Although this has been confirmed by several studies [2,3], a clear understanding of the underlying muscular mechanisms behind gait impairment in older adults is still unresolved.

Several studies have reported alterations in the architectural characteristics of skeletal muscle linked with ageing, such as reductions in pennation angle and fascicle length. In addition, aging has shown to affect passive muscle contractile characteristics as well as tendon stiffness [4]. These changes in muscle-tendon properties can have implications on the force and power potential produced by the muscle and muscle efficiency [5,6], and may be the underlying source for altered gait performance.

The primary locus of gait impairment in older adults has been suggested to reside at the ankle joint. Studies have indicated that out of the lower limb joints, the ankle shows the largest reduction in power production [7]. The resulting gait in older adults displays a shift from ankle-based to hip-based power production. Surprisingly, however, few studies have investigated the in vivo behaviour of the muscle’s crossing the ankle joint that may be linked to these deficits [8].

For these reasons, the aim of this study was to investigate how ageing affects fascicle strain in the soleus muscle during walking. The soleus muscle has been chosen because it represents the dominant source of mechanical power for walking [9].

METHODS
Data from eight young male subjects (24 ± 3.0 yrs; mean ± SD) and preliminary data from two older male subjects (both 65 yrs) have been collected. Subjects were asked to walk on an instrumented treadmill (Bertec, Columbus, OH, USA) at their preferred walking speed (~ 1 m/s) and at speeds above and below their preferred speed. Preferred speeds were established on the treadmill by allowing the subject to freely alter the speed with 0.05 m/s increments. During the trials ground reaction forces were collected at 2000 Hz synchronously with B-mode ultrasound images of the soleus muscle (Telemed, SonoBlaster 128, Lithuania; 60-80 Hz) and electromyography recordings from the soleus, gastrocnemius and tibialis anterior muscles. Ultrasound images were manually digitized (ImageJ, http://rsb.info.nih.gov/ij/) to obtain fascicle length, while ground reaction forces were used to define the gait cycle (from heel strike to heel strike) and stance/swing phases. A minimum of five gait cycles per subject were analyzed. Gait cycles were normalized to 101 points and average data for the young and old adult groups were compiled (MATLAB, The MathWorks Inc., USA)

RESULTS AND DISCUSSION
The range of fascicle length measured is presented in Table 1. The behavior of soleus fascicle strain during a gait cycle is presented in Figure 1. The length of the fascicle was normalized to the length at heel strike (L0), to offer a better evaluation of the fascicle behavior during taking into account individual variation in absolute fascicle lengths.

Table 1: Values represent the maximal and minimal fascicle length in the two groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Fascicle length (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Max</td>
</tr>
<tr>
<td>Young</td>
<td>33.6 ± 3.9</td>
</tr>
<tr>
<td>Old</td>
<td>37.3 ± 1.6</td>
</tr>
</tbody>
</table>

Interestingly the overall pattern of soleus fascicle strain in the two groups is similar. Initially the fascicles shorten just after heel strike, followed by a stretching phase during the first half of stance and a more rapid shortening phase in the latter half of stance as the ankle undergoes plantarflexion. The shortest muscle lengths occur immediately after the toe off event (respectively 63% and 65% of the cycle, for old and young). Fascicles primarily lengthen throughout the swing phase, although moderate shortening occurs just prior to heel strike in the young group. These results are in accordance with those reported in [8], and with a similar study where the authors investigated the behavior of the soleus muscle during walking in young adults [10].
The main difference between the groups is the magnitude of strain during the cycle; length changes are much smaller in the age group compared to the younger adults (13% and 35% of the initial length at heel strike, respectively). Interestingly, a similar reduction in muscle strain has been observed for the gastrocnemius lateralis muscle in older subjects [8].

One possible explanation for the observed difference in muscle fascicle behaviour is that the lower strain present in older reflects a reduced amount of work and power produced at the ankle, in accordance with [8]. Alternatively, or in conjunction with the previous statement, the soleus muscle in older adults may operate with less strain due to an increase in the amount of stretch experienced in the Achilles tendon. Reduced muscle strain could be beneficial for older adults, allowing the muscle to operate on a narrow range of the force-length curve, perhaps representing an adaptive mechanism to accommodate weaker muscles.

**CONCLUSIONS**

Preliminary data indicate that a reduction in soleus muscle fascicle strain is present during walking in older adults compared to young adults. This shift in fascicle strain may reflect a loss in power producing capacity at the ankle joint, or adaptations of the muscle-tendon architecture itself. Additional data from a larger sample, combined with measurements of joint kinetics (moments, power and work) will help elucidate the changes that occur in the soleus muscle during walking in older adults and to further clarify their mechanisms.

**ACKNOWLEDGEMENTS**

This research was supported by National Heart Foundation grant G09P4469 awarded to J.R, D.J.G and D.G.L.

**REFERENCES**