SEPARATING THE INFLUENCE OF AGE AND SPEED ON GAIT VARIABILITY

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INTRODUCTION

Gait variability has been correlated with fall risk in the elderly (Maki 1997). Older adults exhibit higher gait variability and walk slower compared to healthy young adults (Öberg 1993), but the cause of this higher variability is unclear. Slower walking is more variable in healthy young adults (Öberg 1993, Dingwell 2006). Thus, increased variability in older adults may result from simply walking slower. Alternatively, this higher variability may arise from other age-related changes, such as decreased range of motion and/or strength. This can be tested by comparing young and older adults and controlling for speeds.

Using self-selected speeds overground allows comparison between speeds, but makes it difficult to compare across subjects or groups (Öberg 1993). Interpolating variability at a fixed walking speed allows comparison between groups (Moe-Nilssen 2005), but ignores differences between individuals. Here, we quantified gait variability in both young and older adults at multiple controlled speeds, to test whether higher variability in older adults can be attributed to walking speed alone.

METHODS

Eighteen healthy older adults (age 72±6) and 17 height- and weight-matched young adults (23±3), with no orthopedic or neurological conditions, participated with informed consent. Each walked for 5 minutes on a Woodway treadmill at 80, 90, 100, 110, and 120% of preferred walking speed (PWS) (Dingwell 2006), twice at each speed. The order of presentation was randomized. VICON was used to measure motion of the trunk, pelvis, and left leg. Custom MATLAB routines were used to determine temporal-spatial gait measures, 3D joint and trunk angles, and trunk velocity. Bilateral leg strength and passive range of motion were also measured, and used to derive a composite score for strength and ROM each, using the 1st principal component from principal component analysis.

Variability of leg joint and trunk angles, and trunk velocity were quantified at each speed as MeanSD, the average of the stride-to-stride variability over the gait cycle (Dingwell 2006). The two groups and 5 speeds were compared using a repeated-measures ANOVA, with an α of $0.05 \div 18 = 0.0028$.

RESULTS AND DISCUSSION

The PWS of older adults were no different from young adults (1.29 ± 0.13 m/s, $p = 0.86$). Older adults had lower strength and ROM scores ($p < 0.001$).

Older adults exhibited higher variability at all speeds for trunk roll ($p < 0.001$). Stride time ($p < 0.02$), step length ($p < 0.005$) and trunk pitch ($p < 0.03$) trended toward the same. If 2 statistical outliers from young adults were removed, the variability of knee flexion/extension angle ($p < 0.01$), trunk velocity in anterior-posterior ($p <0.02$), and mediolateral ($p < 0.05$) directions also exhibited a similar trend. Walking speed significantly affected the variability of stride time, hip abduction/adduction angle, knee varus/valgus angle, knee internal/external rotation, and all trunk motions ($p < 0.002$). The ankle motions were not significantly affected by age or speed.

These age-effects were no longer significant when the composite Strength and/or ROM were used as covariates in an ANCOVA model, in stride time variability ($p > 0.11$), step length variability ($p > 0.09$), MeanSD of trunk pitch ($p > 0.018$) and roll ($p > 0.01$).

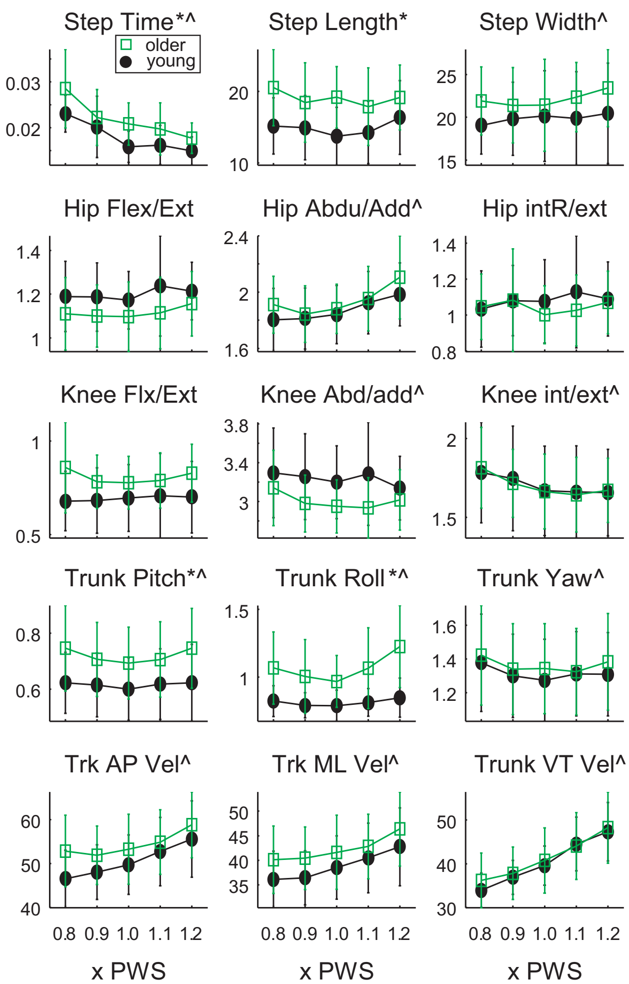

Figure 1: Variability vs. Speed. * denotes age effect; ^ denotes significant speed effect. Units: Stride Time in [s], Step length/Width in [mm], angles in degrees, and velocities in [mm/s]. AP, Anterior-posterior; ML, medio-lateral; VT, vertical.

Older adults exhibited higher variability regardless of walking speed. These differences could be attributed to their lower strength and/or flexibility. Our results agree with previous literature. Strength training and stretching interventions have reduced fall risk in some older adults (Faber 2006). Strength training also had a small, but significant reduction of gait variability (Hausdorff 2001).

Increased variability in the elderly may also come from changes in motor control. More work is needed to understand how aging affects motor functions during gait.

SUMMARY/CONCLUSIONS

This is the first comprehensive study that directly separated the issue of age-related differences in variability and the effects of walking speed. Age-related differences in variability were found regardless of walking speed. Loss of muscle strength and flexibility can explain these differences.

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