Keeping Our Balance: Aging, Attention and the Importance of Visual Feedback

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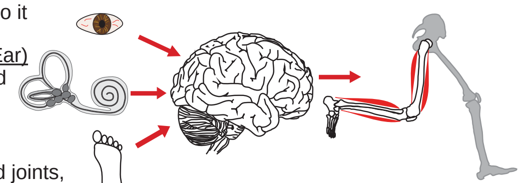
1. INTRODUCTION

Systems for Balance

Vision
See our position in the world and motion relative to it

Vestibular (Inner Ear)
Head orientation and acceleration

Somatosensory
Pressure on feet and joints, body position



Effects of Aging on Balance

With aging, balance declines and there is an increased risk of falls. One in three adults over 65 fall annually with 2.5 million emergency department visits and 25,500 deaths in 2013 [1]

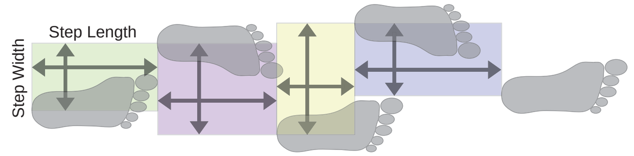
- The quality of sensory information declines with age [2]
- Evidence suggests integration of sensory information changes with age [2]
- Muscle strength declines [3]
- Changes in cognitive function, attention, and decision-making can slow reaction times [2]

Purpose

The goal of this study was to understand how challenges duing walking affect balance in healthy old and young adults.

2. METRICS AND PARTICIPANTS

What do we measure?



Step Variability: Each step is slightly different than the last

- Some variability is good, we adjust our steps to keep our balance
- However, gait variability that is too high can indicate trouble with balance

Step variability ≡ Standard deviation of step length and width over many steps

Participant Characteristics

	Healthy Young	Healthy Old
n	12	10
Age (years)	23.6±3.9	71.0±4.4
Height (m)	1.69±0.25	1.64±0.06
Weight (kg)	70.7±11.3	67.7±9.8
Speed (LL/s)^	1.68±0.19	1.66±0.12
Gender	5M/7F	1M/9F

^Speed determined from overground preferred speed, normalized to leg length (LL)

3. PARTICIPANTS, WALKING CONDITIONS, AND HYPOTHESES

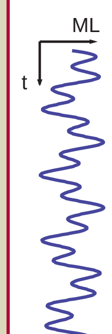
Virtual Hallway

Participants walked on a treadmill while a hallway that moved at the same speed as the treadmill was projected on a screen that filled most of their visual field

Walking Conditions

Participants walked for 3 minutes for each condition [4]

- Normal Walking
- Inaccurate Visual Information
- Dual Task (Counting backwards by 7's)
- Narrow Step Width (Walk on a line)



Inaccurate Visual Information

To give participants inaccurate visual information, we added some unpredictable sideways (medio-lateral) motion to the hallway

- Sideways motion prescribed by a sum of two sine waves added together:
  $ML = 0.175[\sin(.135\pi t) + \sin(.442\pi t)]$ m
- The end of the hallway moved very little relative to the foreground

Hypothesis

We hypothesized that old adults would have more difficulty maintaining their balance than young adults when they were challenged

▸ Old adults will exhibit an increase in variability of step width and step length when challenged

4. STEP VARIABILITY RESULTS

Normal Walking: Young and old adults walked with similar variability

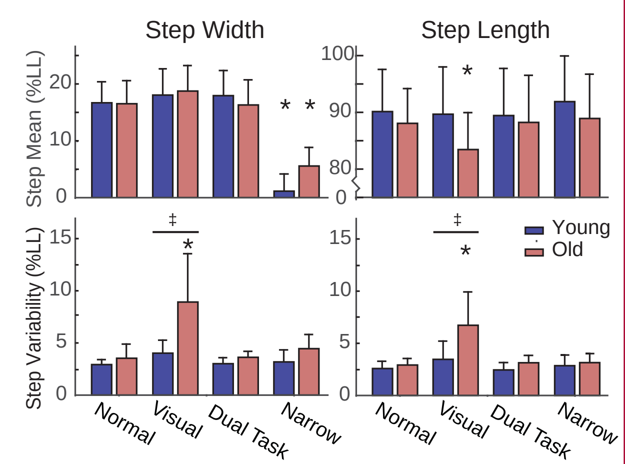
Inaccurate Visual Information: When the hallway provided inaccurate visual information:

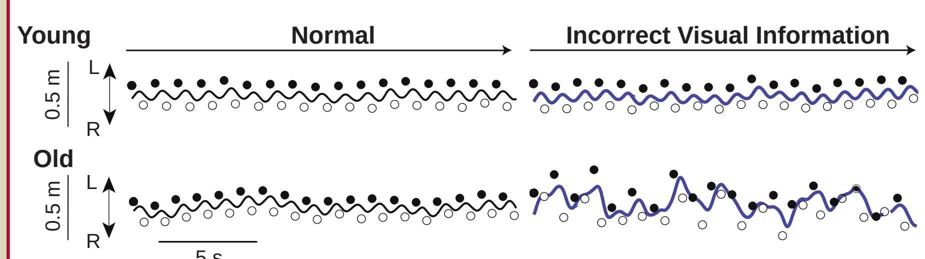
- Old adults had increased step width variability and step length variability (p's <0.05)
- Old adults took shorter steps during this condition (p<0.05).

Dual Task: Neither group was significantly affected by the addition of a dual task.

Narrow Step Width: When walking on a line:

- Neither group had a significant change in step variability
- Old adults tended to walk with wider steps than young adults, but the difference was not significant (p>0.05).





Examples of data we collect from two participants. Dots represent placement of each step and the line shows the motion of the pelvis.

- ● L. Heel at Footstrike
- ○ R. Heel at Footstrike
- — Pelvis

Take home message:
In healthy old adults, good visual information appears to be more important than being able to focus soley on walking or ample space to navigate.

6. CLINICAL IMPLICATIONS

Accurate visual information seems to be paramount to old adults' control of balance during gait. There is some evidence that this may be a compensatory mechanism for age-related deterioration of somatosensory feedback [5] and vestibular function [6].

There is also evidence that old adults may specifically rely on peripheral vision for balance [7], a modality that was particularly challenged in this study.

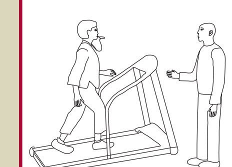
While cognitive dual task paradigms have been used to deliniate fallers [8], we observed only small effects of a secondary cognitive challenge on the gait of healthy old adults.

While there were not significant differences between groups when walking with a narrow step width, old adults appeared to have more difficulty with this task.

7. INTERVENTION

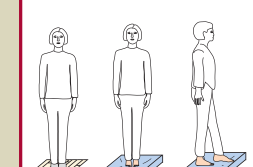
Cranial Nerve Non-Invasive Neuromodulation (CN-NINM)

CN-NINM enhanced walking and balance training combines stimulation via cranial nerves in the tongue with intensive walking and balance rehabilitation exercises.



Walking Training: Participants complete 20 minutes of walking training per session with a focus on:

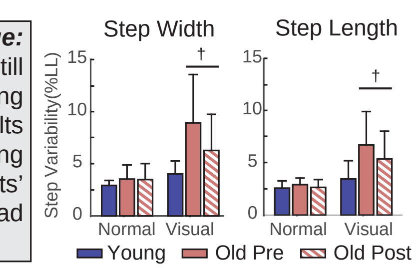
- Symmetric movements
- Correcting any abnormalities
- Improving push-off
- Maintaining good balance



Balance Training: Participants complete 20 minutes of balance training per session while varying:

- Surface: floor or foam
- Footwear: with or without shoes
- Sight: eyes open or closed
- Postion of feet

Take home message:
While we are still recruiting and collecting data, early results suggest that training may reduce old adults' succeptibility to bad visual information.



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Acknowledgments

We would like to acknowledge the Tactile Communication and Neurorehabilitation Lab, Dr. Shawn O'Connor, Mike Schmidt, and Holly Schoenberg.

This research was funded by NIH grants F31AG046945 and F32AG044904 and by a Graduate Award from the Flynn Fund and UW Center for Rehabilitation Engineering and Assistive Technology.