PRESERVED STRIDE-TO-STRIDE CONTROL IN HEALTHY ELDERLY DESPITE INCREASED LOCOMOTOR VARIABILITY

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1. Motivation

Healthy elderly walk with more variability and are locally more unstable than young [1]. Healthy young exploit redundancy to help regulate variability [2,3] in walking [4]. Here we determined if healthy elderly exploit redundancy in the same way as young subjects, in spite of increased biological noise [5].

2. State of the Art

Increased gait variability prospectively predicts increased fall risk in the elderly [6]. It remains critical to determine if these observed variability increases indicate deleterious changes in locomotor *control*.

3. Own Approach

Many strategies can achieve walking on a treadmill at speed v. One strategy is to maintain ~constant speed at each step [4]. All combinations of stride length (L_n) and time (T_n) that equally achieve this goal (i.e., $L_n/T_n = v$) define a "Goal Equivalent Manifold" [3,4]. Only deviations perpendicular to the GEM (δ_P) are "goal relevant" since only they affect speed (v) [4].

17 healthy young and 17 healthy older adults walked on a treadmill for 2 trials of 5 min each at each of 5 speeds [1]. We computed time series of stride lengths (L_n), stride times (T_n), stride speeds ($S_n = L_n/T_n$), and of δ_T and δ_P fluctuations relative to each GEM [4].

We computed means and standard deviations for each variable. We used Detrended Fluctuation Analysis (DFA) [4,7] to compute an exponent, α, that quantifies the degree of statistical persistence. Smaller α indicate more frequent/rapid *corrections* of stride-to-stride deviations and therefore greater *control* [7].

4. Current Results

Elderly subjects took slightly shorter ($p = 0.021$) and faster ($p < 0.001$) steps, but still walked at the same preferred *speeds* ($p = 0.569$) [1]. Our elderly exhibited significantly greater variability ($p < 0.05$) than our young subjects for all stride variables (Fig. 1), and also for both δ_T and δ_P fluctuations (not shown).

However, these elderly exhibited *no* differences from young ($p = 0.836$) in how they corrected (α) stride-to-stride deviations (δ_T and δ_P) relative to the GEM (Fig. 2). All subjects rapidly corrected ($\alpha < 0.5$) "goal relevant" δ_P fluctuations, while allowing "goal irrelevant" δ_T fluctuations to persist ($\alpha >> 0.5$) (Fig. 2).

5. Best Possible Outcome

These healthy elderly exploited the available [T_n, L_n] redundancy to maintain ~constant walking speed at each stride just like young subjects (Fig. 2). They exhibited the same degree of stride-to-stride *control* [4,7] in spite of their increased variability. Thus, while increased variability may be *one* factor that helps predict fall risk, increased variability alone may not always indicate degraded neuromuscular control. We emphasize these were *very healthy* elderly who did not (yet) walk slower than our healthy controls.

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References

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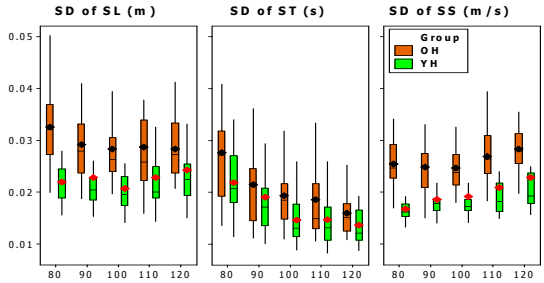

Fig. 1: Standard deviations of stride length (SL), time (ST), and speed (SS) for young (YH) and older (OH) subjects, across walking speeds (%PWS).

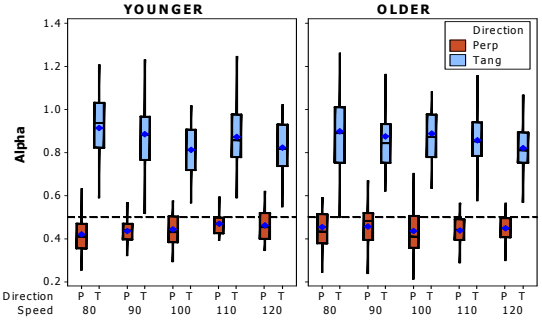

Fig. 2: DFA Alpha (α) exponents for both groups for fluctuations tangent (δ_T: "Tang") and perpendicular (δ_P: "Perp") to the GEM, across walking speeds (%PWS).