Upper and lower body contributions to stability during very slow walking

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I. Introduction

During gait, both the lower and upper body can contribute towards gait stability. Typically investigated at walking speeds between 0.6 and 2.0 m/s, these strategies include step placement and centre of pressure excursions of the lower body [1] and upper body momentum [2]. While foot placement seems to be the dominant strategy at these speeds [3], same relative contributions might not hold at very slow speeds, especially in the mediolateral direction. The goal of the current study is to investigate mediolateral gait stability at very slow speeds and the contributions of the upper and lower body towards maintaining that stability.

II. Methods

We determined the gait stability of eight healthy subjects walking at 0.1, 0.3, 0.5 and 0.6 m/s and a self selected speed from an open-source gait dataset [4]. We computed the extrapolated centre of mass (XCoM) and the average minimum margin of stability (MoS) as the distance between the XCoM and center of pressure (CoP) [5]. Changes with speed in the lateral CoP and trunk centre of mass (CoM) motion at the minimum MoS event were evaluated to investigate the contributions of the lower and upper body, respectively. Data was non-dimensionalized with respect to body mass, leg length, and gravity.

III. Results

The mediolateral MoS and its contributing components changed linearly with gait speed (Fig. 1). The MoS increased at a rate of 0.055 m per m/s (slope: 0.061, $R^2 = 0.79$). MoS components at the minimum MoS event decreased with gait speed, with the XCoM (slope: -0.17, $R^2 = 0.88$) decreasing at a rate 1.2 times greater than that of the CoP (slope: -0.14, $R^2 = 0.96$). The trunk CoM lateral position also decreased at a steeper slope than XCoM (slope: -0.29, $R^2 = 0.84$).

IV. Discussion

As gait speed decreased, the trunk amplitude increased, causing greater excursions of the XCoM that were not compensated by a corresponding increase in the CoP, causing a lower MoS at slower speeds.This lower MoS suggests that the uncompensated larger trunk amplitudes decreased gait stability at slower speeds. Although it is unclear whether the increased trunk amplitude is the result of passive dynamics or active control, both have important implications for the control of balance, especially at the very slow speeds of individuals with gait impairments.

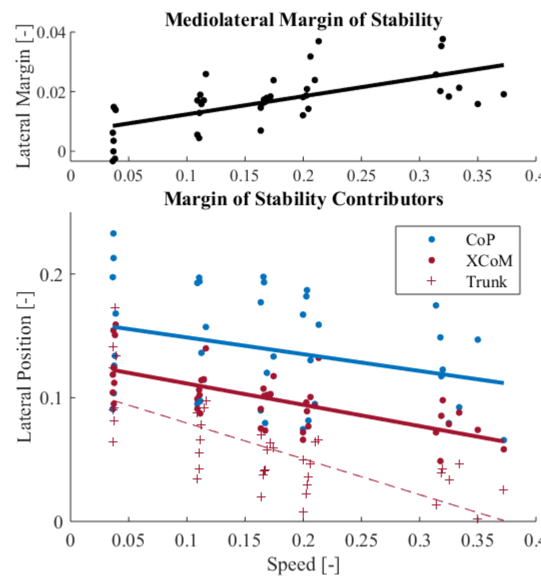

Fig. 1. Linear trends of the margin of stability and the factors that affect it with gait speed, all trends are were statistically significant ($p < 0.05$). The margin of stability is greater at faster speeds. The lateral position of the contributors decrease with speed with the XCoM decreasing at a faster rate than the CoP.

References

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