BODY CENTER OF MASS TO MINIMAL MOMENT AXIS DISTANCE IS DETERMINANT OF AGE-RELATED EVOLUTION IN STEPPING

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INTRODUCTION

Understanding mechanical phenomena underlying the initiation of gait is essential to better prevent risk of falling. Thus, mechanical variables such as kinematics of the center of mass or whole-body angular momentum evolutions have been demonstrated to be related to anticipatory adaptations of the body while stepping [1,2]. A degradation of these adaptations could therefore reveal an increased risk of falling and has been observed in motor-impaired population [2]. However, in spite of encouraging results, the transfer towards real-time applications for prevention or monitoring is hindered by the complexity of the proposed indicators in both their interpretability and their quantification process. In this abstract, we proposed to test the feasibility of using a mechanical-based index: the distance of the Body Center of Mass (BCoM) to the Minimal Moment Axis (MMA) of the external contact wrench, referred hereafter as $d_{BCoM-MMA}$ [3]. This index should overcome the above-mentioned difficulties while keeping a discriminating nature when comparing young and elderly stepping.

METHODS

15 healthy young (mean age: 25 years old; range: 19-29) and 15 healthy old (mean age: 69 years old; range: 63-77) adults volunteered. They were asked to initiate gait 10 times at a self-selected preferred (Pref) and at a fastest speed (Fast). Each participant performed this stepping and $d_{BCoM-MMA}$ was then obtained at each instant of time using: $d_{BCoM-MMA} = \frac{\|\boldsymbol{F} \times \boldsymbol{M_{BCoM}}\|}{\|\boldsymbol{F}\|^2}$ where $\boldsymbol{F} \times \boldsymbol{M_{BCoM}}$ is the cross product between the external forces and the external moment computed at the BCoM, $\boldsymbol{M_{BCoM}}$ being equal to the variation of the angular momentum ($\boldsymbol{K}$) at the BCOM obtained as described in [5]. Two parameters were then extracted for each trial and each participant: the norm of $d_{BCoM-MMA}$ (d_{norm}) and the value of the Antero-Posterior algebraic distance d_{AP}. Under the hypothesis of normal distribution, t tests were performed to compare the values of the range across groups and across conditions.

RESULTS AND DISCUSSION

Whereas average velocities were close for both groups for the Pref condition, the ranges of the norm and the antero-posterior component of $d_{BCoM-MMA}$ were significantly higher ($p<0.05$) for the group of old adults compared to the group of young adults. On the contrary, for the Fast condition, even if their average velocity was greater, the values of both parameters remained significantly lower for young compared to the old people (Table 1).

This study is the first to quantify the ranges of parameters extracted from $d_{BCoM-MMA}$ during stepping. The values of the ranges are consistent with the ones retrieved during gait of healthy adults. The magnitude of the increase with speed and age is also consistent with the tendency of the distance to be higher for motor-impaired people or in destabilizing situations [5]. Finally, the evolution of the proposed parameters with age is in direct relation with the larger angular momenta exhibited in this population [3]. It therefore confirms that this indicator could be used to monitor gait dynamics in real-time.

CONCLUSIONS

In this abstract we compared stepping instability using the distance between the BCOM and the MMA on old and young population at spontaneous and fast speed. Our results demonstrate that the distance tends to increase for older population at both cadences. This tendency is consistent with the higher instability of older adults during stepping and the distance could be used to quantify it.

REFERENCES

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Table 1: Mean (standard deviations) of the velocities (m/s) and ranges of d_{norm} and d_{AP} in mm for both groups (young and old) and both speed conditions (preferred and fast)

Parameters mean (std)	Pref		Fast	
	Young	Old	Young	Old
Velocity (m/s)	0.7	0.75	1.2	1.0
d_{norm} (mm)	42 (10)	52 (8)	75 (17)	79 (30)
d_{AP} (mm)	73 (15)	90 (18)	126 (22)	145 (50)