EFFECT OF BALANCE RECOVERY TASK DIFFICULTY ON STEPPING VELOCITIES FOR FORWARD, SIDEWAYS AND BACKWARD LOSS OF BALANCE DIRECTIONS

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INTRODUCTION

Several studies have shown that both age and loss of balance direction affect balance recovery following small and medium postural perturbations [1]. However, it is only recently that this has also been shown for large postural perturbations at the threshold of balance recovery where avoiding a fall is not always possible.

We demonstrated that the maximum lean angles from which participants could be suddenly released and still recover balance using a single step were 32% greater for younger (YA) than older (OA) adults [2]. Maximum lean angles were also 23% and 31% greater for forward leans than for sideways and backward leans, respectively. Finally, the age related reduction in maximum lean angles was 41% smaller for backward leans compared to the other lean directions.

More importantly, we demonstrated that knee extension power (r^2=63-72%) was the best clinical predictor of the maximum lean angles in all three directions [3]. Similarly, the best experimental predictors of the maximum lean angles in all three directions were mean (r^2=62-84%) and maximum (r^2=63-84%) step velocities at the maximum lean angles [4]. However, these strong associations do not show a true cause and effect relationship.

If declines in lower extremity muscle power and stepping velocities are responsible for this decreased ability to recover balance with age and lean direction, stepping velocities should increase as the balance recovery task becomes more difficult. The purpose of this study was thus to determine the effect of the incremental initial lean angles on the mean and maximum step velocities for forward, sideways and backward loss of balance directions.

METHODS

Data from 16 YA (22.9±3.1yrs) and 16 OA (68.1±5.8yrs), who participated in experiments to determine the maximum forward, sideways and backward lean angles from which participants could be suddenly released and still recover balance using a single step, were used [2].

Using 3 force platforms (OR6-7, AMTI, Newton MA), 2 load cells (FD-2 and MC3A, AMTI, Newton MA) and 3 optoelectronic position sensors (Optotrak, NDI, Waterloo ON), we obtained initial lean angles, mean step velocities (step length divided by step time) and maximum step velocities (maximum first derivative of foot position).

Unconditional growth linear regression models [5], which take into account both intra and inter individual variances, were used to determine the effect of initial lean angle on mean and maximum step velocities for each lean direction.

RESULTS AND DISCUSSION

As expected, both mean and maximum step velocities increased with the incremental initial lean angles in all three lean directions (Figure 1):

- For mean step velocity, the linear regression analyses resulted in model R^2 explaining 72-92% of the variability.
- For maximum step velocity, the linear regression analyses resulted in model R^2 explaining 68-92% of the variability.
- Linear regression analyses grouping all lean directions together resulted in model R^2 explaining 75% and 74% of the variability for mean and maximum step velocities, respectively.

CONCLUSIONS

Therefore, in healthy adults, stepping velocities did increase as the balance recovery task became more difficult for forward, sideways and backward loss of balance directions. The association between declines in lower extremity muscle power, declines in stepping velocities and the decreased ability to recover balance with age and loss of balance direction is thus very strong.

However, to truly confirm a cause and effect relationship, one would have to determine if an intervention aimed at improving lower extremity muscle power could improve stepping velocities and thus improve forward, sideways and backward maximum lean angles. Alternatively, one could determine if a lack of intervention would result in a natural decline in lower extremity muscle power, an associated decline in stepping velocities and thus a decline in forward, sideways and backward maximum lean angles.

REFERENCES

1. Maki BE, et al. *J Biomech* **29**(3), 343-353, 1996.
2. Telonio A and Smeesters C. 31st Annu Meet Am Soc Biomech, Stanford CA, Aug 22-25 2007.
3. Telonio A, et al. 4th N Am Congr Biomech, Ann Arbor MI, Aug 5-9 2008.
4. Telonio A and Smeesters C. 4th N Am Congr Biomech, Ann Arbor MI, Aug 5-9 2008.
5. Singer JD and Willett JB. *Applied longitudinal data analysis: modeling change and event occurrence*, Oxford University Press, New York NY, 2003.

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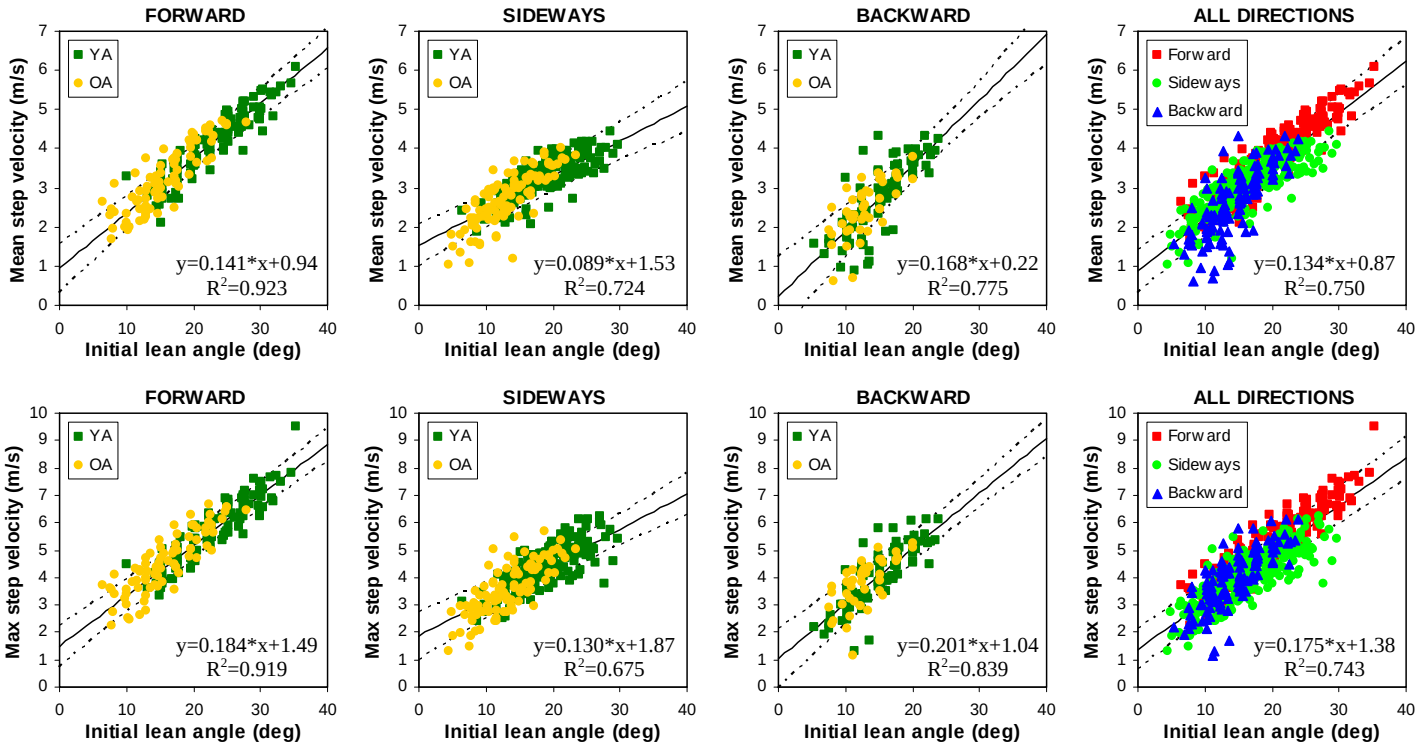

Figure 1: Effect of the forward, sideways and backward incremental initial lean angles on the mean and maximum step velocities for younger (YA) and older (OA) adults. Mean ± standard deviation regression lines are shown for each lean direction and for all lean directions together.