A FEASIBILITY STUDY FOR THE INVERTED PENDULUM MODEL APPLICATION IN POSTURAL SWAY, FALLING AND WALKING

[1]Hueseok Choi and [1, 2]Youngho Kim

[1]Department of Biomedical Engineering, Graduate School, Yonsei University,

[2]Institute of Medical Engineering, Yonsei University; email: younghokim@yonsei.ac.kr

INTRODUCTION

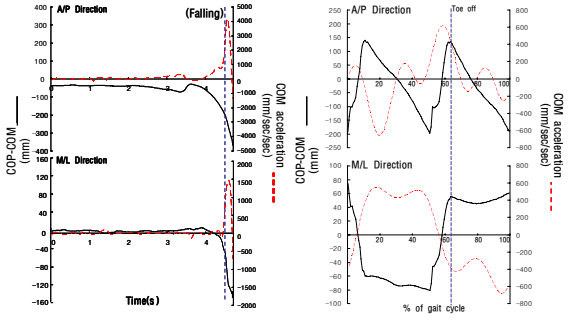
The inverted pendulum model is most widely used to characterize the postural control. In this model, the postural control is defined by the relation between the whole body COM and the COP. The whole body COM is regulated through movement of the COP under the feet. Especially, the difference between the COP and the whole body COM, (COP-COM), was highly correlated to the horizontal acceleration of the whole body COM during postural sway and was reported as the 'error' of the postural control system and provided important insight into the postural control mechanism [1,2,3]. Recently, Corriveau et al. [4] has been shown that the root mean square (RMS) error of the (COP-COM) is greater in the elderly with neurological impairments compared with the healthy. In this study, we analyzed the relationship between the whole body COM and the COP in postural sway, falling and walking. Moreover, we investigated the feasibility of the inverted pendulum model application in postural sway, falling and walking.

METHODS

Using the three-dimensional motion analysis synchronized with three force plates, the inverted pendulum model was applied to four different movements (quiet standing, intended postural sway, falling and walking) in twenty healthy volunteers who have no musculoskeletal problems and balance disorders in order to investigate the relationship among COP, COM and the horizontal acceleration of the body. We also performed the cross-correlation analysis between (COP-COM) and the horizontal acceleration of the body.

RESULTS AND DISCUSSION

The features of (COP-COM) resembled the inverse form of the acceleration of the whole body COM. The cross correlation coefficients between (COP-COM) and the horizontal acceleration of the whole body COM were -0.96±0.02 in the A/P direction and -0.95±0.03 in the M/L direction. As a result of cross correlation, (COP-COM) had quite high negative correlations with the horizontal acceleration of the whole body COM in both A/P and M/L directions. This result shows that (COP-COM) can be directly related to the horizontal acceleration of the whole body COM in postural sway based on the inverted pendulum model. Also, the features of (COP-COM) resembled the inverse form of the acceleration of the whole body COM before falling occurs. The cross correlation coefficients between (COP-COM) and the horizontal acceleration of the whole body COM were -0.92±0.06 in the A/P direction and -0.89±0.13 in the M/L direction before falling occurs, also, once falling occurs, the cross correlation coefficients between (COP-COM) and the horizontal acceleration of the whole body COM were 0.81±0.05 in the A/P direction and 0.77±0.24 in the M/L direction. As a result of cross correlation, (COP-COM) had quite high negative correlations with the horizontal acceleration of the whole body COM in both A/P and M/L directions before falling occurs, but high positive correlations were found in both A/P and M/L directions once falling occurs. In addition, during walking, (COP-COM) had low negative correlations with the acceleration of the whole body COM as -0.21±0.12 in the A/P direction, whereas high negative correlations were found as -0.87±0.11 in the M/L direction. This result shows that (COP-COM) can be directly related to the horizontal acceleration of the whole body COM before falling occurs based on the inverted pendulum model.



(a) falling (b) gait.

Figure 1: (COP-COM) and the acceleration of the whole body COM

CONCLUSIONS

This study investigated the feasibility of the inverted pendulum model application in postural sway, falling and walking using the 3D motion analysis system synchronized with three force plates. Results revealed that the correlation between (COP-COM) and the acceleration of the whole body COM based on the inverted pendulum model can be used to determine the postural stability in falling. Furthermore, a better understanding of biomechanical challenges and new method imposed on whole body dynamic stability during locomotion will provide an opportunity to reduce the incidence of falls in the elderly through early detection and intervention.

ACKNOWLEDGEMENTS

This research project was supported by the Sports Promotion Fund of Seoul Olympic Sports Promotion Foundation from Ministry of Culture, Sports and Tourism.

REFERENCES

1. Winter DA, et al., *Gait and Posture*. **l3**:193-214, 1995
2. Morasso PG, et al., *Human movement Science*. **18**:759-767, 1999
3. Winter DA, et al., *Journal of Neurophysiol*. **80**:1211-1221, 1998
4. Corriveau H, et al., *Archives of Gerontology and Geriatrics*. **39**:163-177, 2004