Altered Balance Control in Older Adults with Mild Cognitive Impairment During Obstacle-Crossing

Shiuan-Huei Lu[1,2], Yi-Chun Kuan[1,2], Tung-Wu Lu[1,3]
[1] Department of Biomedical Engineering, National Taiwan University, Taipei, Taiwan
[2] Department of Neurology, Taipei Medical University Shuang-Ho Hospital, New Taipei City, Taiwan
[3] Department of Orthopedic Surgery, School of Medicine, National Taiwan University, Taipei, Taiwan
Email: d08548005@ntu.edu.tw

Summary

Mild cognitive impairment (MCI) is an intermediate stage between normal aging and dementia. Cognitive decline in MCI leads to problems with memory, executive function, attention, and motor coordination—critical components for maintaining balance and safe mobility. Biomechanical methods employed during obstacle-crossing, including toe-obstacle clearances and the kinematic strategies using pelvis-leg apparatus, are critical for identifying fall-related risk factors. However, no studies have explored dynamic balance control during obstacle-crossing in MCI. The study aimed to quantify balance control by calculating the inclination angle (IA) and the rate of change of IA (RCIA) during obstacle-crossing. Eighteen older adults with MCI and 18 healthy controls crossed obstacle, with kinematic and forceplate data collected. Compared to healthy controls, the MCI group exhibited compromised balance control, especially during weight transfer, indicating an increased risk of balance loss. Regular monitoring for increased IA and RCIA during obstacle-crossing may help assess fall risk in this population.

Introduction

MCI is a transitional stage between normal age-related cognitive decline and dementia. Cognitive decline in MCI leads to problems with memory, executive function or attention, affecting instrumental activities of daily living [1] and increasing fall risk, especially during obstacle crossing. Obstacle-crossing requires precise end-point control while maintaining whole-body balance. Previous studies showed altered spatiotemporal parameters and joint kinematics in MCI during obstacle-crossing [2]. However, no studies have explored whole-body balance control to provide insights into the IA of the body's center of pressure (COP) to center of mass (COM) vector and the RCIA during obstacle-crossing in MCI. Therefore, this study aimed to assess the whole-body balance control in MCI during obstacle-crossing.

Methods

Eighteen patients with MCI and 18 healthy adults participated in the study. All the experiments and procedures were carried out following the World Medical Association Declaration of Helsinki. Each participant walked at the preferred speed on a 10-meter walkway and crossed an obstacle at 10, 20, 30% of their leg length. Thirty-nine infrared retro-reflected markers were placed on anatomical landmarks to track the motion of the segments [2], measured using an 8-camera motion analysis system while the ground reaction forces (GRF) were simultaneously measured using three forceplates. Spatiotemporal and endpoint parameters, COM-COP IA and RCIA in sagittal and frontal planes were extracted. A two-way mixed-design analysis of variance (ANOVA) was performed to analyze the effects of between-subjects and within-subjects on all calculated variables.

Results and Discussion

In the sagittal plane, patients with MCI exhibited increased posterior IA with increased posterior RCIA during double-limb support (DLS), and increased posterior IA when the trailing toe was above the obstacle, and increased anterior RCIA at trailing limb crossing, toe-off, leading limb crossing, and trailing toe-off, compared to the Control group (Figure 1). In the frontal plane, patients showed greater IA at trailing limb crossing, toe-off, leading limb crossing, and heel-strike, as well as increased magnitudes and ranges of RCIA without an IA large enough for maintaining the dynamic stability of the COM during DLS.

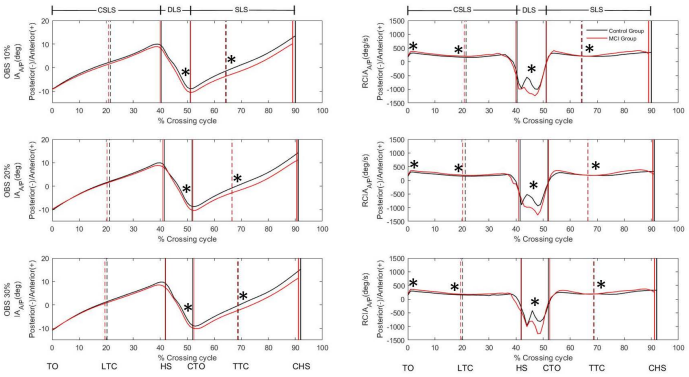

Figure 1: Ensemble-averaged curves of COM-COP IA (left column), and RCIA (right column) in the sagittal plane over a crossing cycle when crossing obstacles of three different heights in MCI and healthy controls; * indicates a significant group effect.

Conclusions

This study is the first to investigate the whole-body balance control, in terms of COM–COP IA and RCIA in patients with MCI when crossing obstacles of three different heights. The current results suggest that MCI adopt altered balance control strategies during obstacle crossing. This may come at the cost of compromised COM–COP control, potentially due to limited cognitive resources, thereby increasing fall risk. Assessing whole-body balance control strategies could aid in the early detection of compromised obstacle-crossing abilities in patients with MCI.

Acknowledgments

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References

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