

Modeling of standing postural control in Parkinson's disease patients

Patients with Parkinson's disease (PD), a neurodegenerative disorder, exhibit abnormal posture, a characteristic standing posture, in addition to impaired postural control. Increased muscle tone, which is steady muscle activity, has been suggested as a cause of abnormal posture. However, it is difficult to measure muscle tone in the standing posture, and the relationship between muscle tone and postural abnormalities has not been clarified in detail. Abnormal posture causes dysphagia and back pain, and greatly affects quality of life. It is important to elucidate the mechanism of abnormal posture in order to establish a treatment for abnormal posture. Therefore, we aim to elucidate the mechanisms of abnormal posture and postural dysregulation in PD by performing forward dynamics simulations of postural control using a computer model.

In our previous study, we investigated the hypothesis: "In patients with PD, the abnormal posture is a static standing posture with small local center of gravity sway in response to increased muscle tone" using a computer model. Using the computer model and standing data from actual PD patients, we estimated muscle tones of various magnitudes (Fig. 1). The posture with the smallest center of gravity sway was calculated using an optimization method for the estimated muscle tones. The calculated posture and the center of gravity sway in the standing posture were compared with the posture and center of gravity sway of actual PD patients. The results showed that the difference between the posture and the center of gravity sway was the smallest at higher muscle tone than that of normal subjects (Fig. 2). This indicates that the posture with the smallest sway of center of gravity at higher muscle tone than that of the normal subjects is close to the actual standing data of PD patients, and their sway of center of gravity is also close to that of the normal subjects. These results are consistent with the hypothesis, and suggest that the posture in which the center of gravity sway is locally smaller in PD patients at increased muscle tone may be an abnormal posture [1].

Keywords: Parkinson's disease, Abnormal posture, Muscle tone

References

- [1] Y. Omura et al., "Analysis of the Relationship Between Muscle Tones and Abnormal Postures in a Computational Model," The 45th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, July 2023.

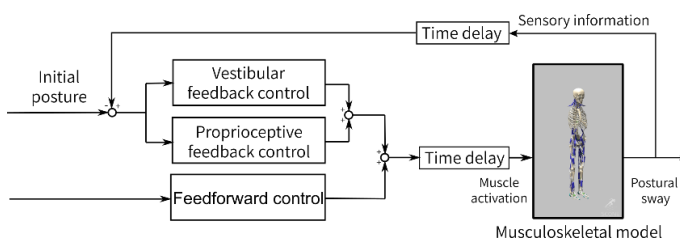


Figure 1. Computational model. The model consists of feedforward control representing muscle tones and feedback control using proprioceptive and vestibular information. In addition, time delays due to information transmission and muscle activity are considered.

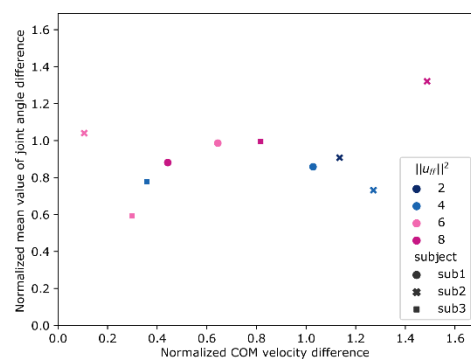


Figure 2. Normalized average values of the joint angle difference and normalized differences of the average COM velocity between simulation and experimental results for each subject. $\|u_{ff}\|^2$ represents the magnitude of whole-body muscle tone. The closer to the origin, the closer the posture and sway are to the experimental values.