Musculoskeletal Simulation of Human Stance Postural Control for External Forces

When humans are subjected to external forces, they use their ankles and hips to balance themselves. It is called ankle strategy when only ankle movements are used, and hip strategy when hip movements are also used. These postural control strategies are used differently depending on the magnitude of the external force, but it is known that they are also used differently among individuals even when the magnitude of the external force is the same. How postural control strategies are used can be used as indicators, such as predicting falls. However, it is unclear how differences in any of the parameters between individuals will affect the way postural control strategies are used. We investigate that through forward dynamics simulations using musculoskeletal models and human experiments.

We first stood a musculoskeletal model (Fig. 1) using a neural controller model and moved the support surface in various directions [1]. We succeeded maintaining a standing posture of the musculoskeletal model for support surface translations, and the characteristics of the muscle responses were consistent with those of human responses in a previous study. This confirmed the usefulness of our models for simulating human postural control for external forces. Then, postural control simulations for a backward support surface translation were performed with varying degrees of muscle mass, sensory noise and muscle tone [2]. The results confirmed that muscle mass and muscle tone could influence postural control strategies. Human experiments have also confirmed the tendency of muscle tone to influence postural control strategies [3].

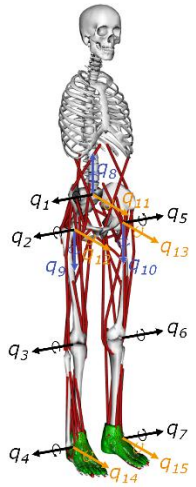

Figure 1.
Musculoskeletal model.

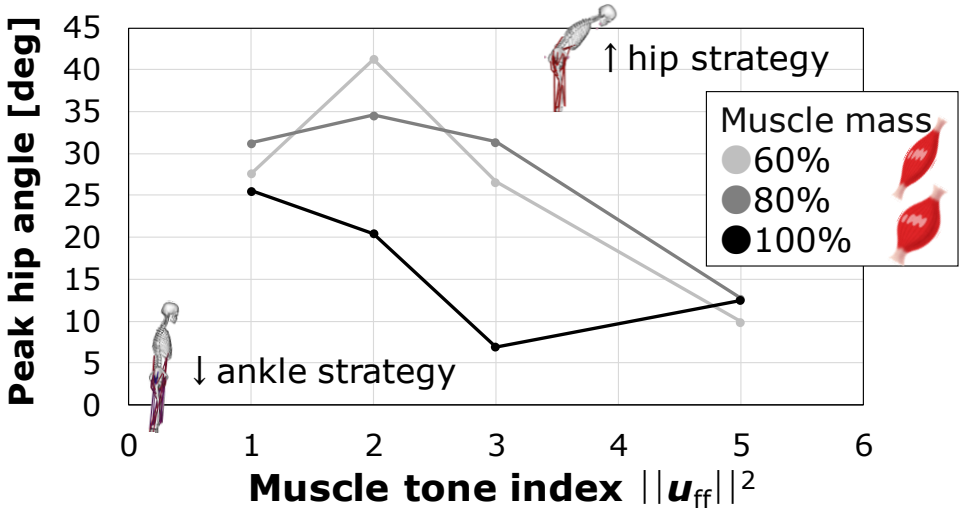

Figure 2. The relationship between the muscle tone index ||uff||2 and the postural control strategy index, peak hip angle. When the muscle tone is large, ||uff||2 is large. When the postural control strategy is close to the hip strategy, the peak hip angle is large. The graphs were lower on the right shoulder, resulting in the postural control strategy leaning towards the hip strategy when muscle tone was greater.

Keywords: postural control strategy, musculoskeletal model, forward dynamics simulation

References:

[1] K. Kaminishi, P. Jiang, R. Chiba, K. Takakusaki, and J. Ota, "Postural control of a musculoskeletal model against multidirectional support surface translations," PLoS One, vol. 14, no. 3, p. e0212613, 2019.

[2] K. Kaminishi, R. Chiba, K. Takakusaki, and J. Ota, "Investigation of the effect of tonus on the change in postural control strategy using musculoskeletal simulation," Gait & Posture, vol. 76, pp. 298-304, 2020.