EVALUATE THE POTENTIAL CONTRIBUTIONS OF SWING LEG TO THE STABILITY OF BODY DURING SINGLE FOOT SUPPORT PHASE OF WALKING

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INTRODUCTION

Evaluation of the stability of the body during walking is critical to understanding the mechanisms of balance control. However, the current evaluation index, which is used in biped robot control [1], is not applicable to measurements of the stability of the human body. A critical limitation of this index is that it uses the stability index of the support leg to represent the stability of the whole body while neglecting the contribution of the swing leg. The purpose of this study, therefore, was to evaluate the contribution of the swing leg to the stability of whole body during the single-foot support phase of walking using an energy-work approach.

METHODS

A simplified five-segmental sagittal model of human body during single-foot support phase of walking is shown in Fig. 1.

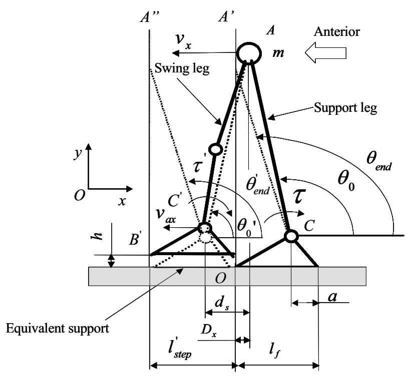

Fig. 1: A 5 links model of human body during single foot support phase of walking.

Although the swing leg does not provide support to the body during swing, the foot of the swing leg can move downward/ forward to touch the ground and form a new support, if a forward perturbation is imposed to the body. After foot touchdown, plantarflexion torque can be generated by the ankle joint to prevent forward rotation of the body. Consequently, the swing leg holds the potential to support the body and this could contribute to the stability of whole body.

We used an equivalent support to estimate the contribution of the swing leg to the stability of human body. The equivalent support consisted of a foot and a leg (without knee flexion) and could provide the same functional contributions to the stability of the body as the actual swing leg would after it touched down, as Fig. 1 shows.

After perturbations, the kinetic energy of the mass of the body transforms into two parts: one of them is the increment in potential energy of the mass when the human moves from its initial position A to the final position A"; the other one is the energy absorbed by the ankle joints, including the ankles of the supporting leg and the swing leg after it touches the ground. This corresponds to when they generate plantar-flexion torques to prevent forward rotation of the body. Thus, we define the stability reserve of the human body during a single foot support phase as

$$S^b_{anterior} = W - (E - (P_{end} - P_0)) \text{ (J)} \qquad (1)$$

where E is the kinetic energy of the human body at the initial position or after perturbations. P_0 and P_{end} are potential energies of the mass at initial and final positions. W is the energy absorbed by the ankle joints of the supporting and swing leg after touchdown.

RESULTS AND DISCUSSION

The stability reserve of the human body during the single support phase is shown in Fig. 2. The center of mass moved from Dx =1.8 (after the toe off the ground) to -.3 (before the heel touches with the ground). The stability reserve of the whole body was large before the foot of the swing leg touched the ground. This is consistent with the actual stability of the human body during walking.

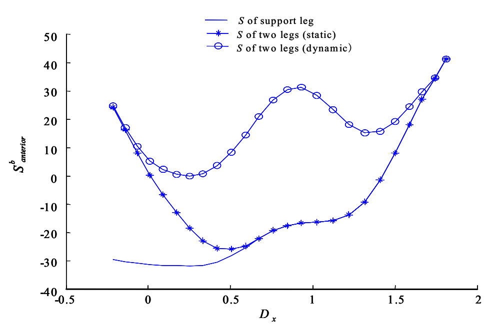

Fig. 2: The stability reserve of human body during single foot support phase. The D_x has been normalized by the length of foot.

CONCLUSIONS

The swing leg potentially contributes to the stability of the body and should be involved in the evaluation of the stability during walking.

REFERENCES

1. Furuta T. et al. *Robotics and Autonomous System,* **37**, 81-10, 2001.

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