BIOMECHANICAL ANALYSIS OF FOUR-WHEELED WALKER FOR AN ELDERLY PERSON

[1]Masato Takanokura, [1]Toshihiro Yamauchi
[1]Dept. of Industrial Engineering and Management, Kanagawa University, Japan; email: takanokura@ie.kanagawa-u.ac.jp

INTRODUCTION

Japan goes toward a superannuated society. According to the population projects of National Institute of Population and Social Security Research in Japan, the percentage of the aged population of 65 years and up will reach 25.0% in 2017 [1]. To deal with the superannuated society, the activities of daily living (ADL) have attracted an attention in Japan. Walking is the most important in ADL because a fall of the elderly persons during walking leads to a high possibility of the disuse syndrome. A four-wheeled walker for an elderly person without some disease is a product to assist walking, to carry a baggage, and to take a rest on a street. We analyze the biomechanics of steady walking and step mounting using walkers by an articular angle and torque of a lower limb estimated by a video-based motion-analysis system.

METHODS

The subject was five male students aged 20 to 23 years because we intended developing an analytical method for the biomechanics of elder walking using walkers. Although we used three kinds of walkers as shown in Figure 1 (Mutsumi Medical), we modified the rear wheels to avoid getting them and feet on a force plate by lengthening the wheel axes.

An angle and torque at a hip, a knee, and an ankle joint in a sagittal plane were analyzed by the motion-analysis system (Frame-DIASII, DKH). Reflective markers were attached to ten anatomical landmarks: shoulders, greater trochanters, knees, ankles, and toes. The marker position was estimated by using the DLT method from images filmed by four digital-video cameras of 60 fps (GR-DV5000, Victor). The angle was estimated from the marker positions. Ground reaction force was measured by force plates (9286A, Kistler) and charge amplifiers (9865E1Y28, Kistler). Torque was estimated by the inverse dynamics from the marker positions and ground reaction force.

We formed a floor of 3.6m by a force plate and aluminum floorboards for steady walking. The subject walked at a natural speed with the walker on the floor. We formed a step of 17cm by two force plates, floorboards, and a curb for step mounting. The subject first lifted up front wheels onto the step and then mounted the step along with the walker by lifting up rear wheels. He mounted with a load of 5kg on a basket of the walker and without a load.

(a) Careman (b) You-mate GXN (c) Oscar-mini

Figure 1: Four-wheeled walkers for elderly person.

RESULTS AND DISCUSSION

Figure 2 illustrates flexion torque at hip during steady walking. The ANOVA demonstrated that the main effect of the walker was significant ($F(3,12)=10.67$, $P<0.01$). *Post hoc* analysis showed that the walkers reduced flexion torque at hip ($P<0.01$). Extension torque was not varied. Torque at knee showed similar results. The walkers reduced plantarflexion torque at ankle. The subject supports the body weight not only by the lower limb but by the upper limb through the handgrip of the walker. Articular torque of the lower limb did not depend on the structure of the walker because it went forward at a constant speed during steady walking. Walking using the walkers caused a smaller extension angle at hip, a larger flexion angle at hip, and a larger dorsiflexion angle at ankle.

Figure 3 shows flexion torque at hip during step mounting. The ANOVA demonstrated that the main effects of the walker ($F(2,8)=10.62$, $P<0.01$) and the load ($F(1,8)=12.10$, $P<0.01$) were significant. *Post hoc* analysis showed that the walker "Careman" with a load of 5kg caused larger torque. Torque to hip extension, to knee flexion and extension showed similar results. The handgrip of Careman is positioned just above the rear wheels. The larger moment caused by force to push down the handgrip is necessary to lift up the front wheels because the moment arm is shorter than the other walkers.

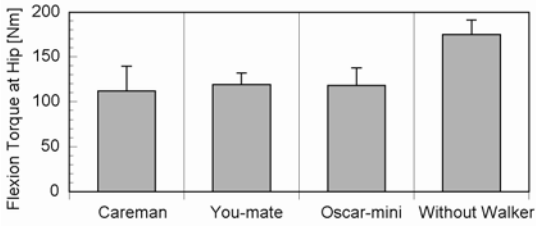

Figure 2: Flexion torque at hip during steady walking.

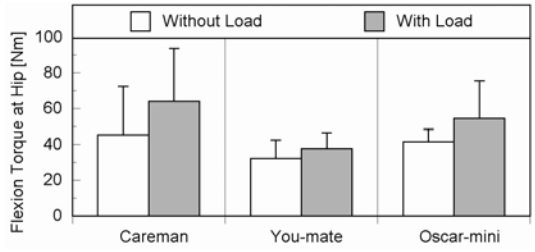

Figure 3: Flexion torque at hip during step mounting.

CONCLUSIONS

During steady walking, the walkers reduce articular torque of the lower limb. During step mounting, torque depends on the structure of the walker and the load on the basket.

REFERENCES

1. National Institute of Population and Social Security Research. *Population Projects for Japan: 2001-2050*, 2002.