EFFECT OF INCLINED SUPPORT SURFACE ON POSTURAL STRATEGY DURING PLATFORM TRANSLATION

Jun Kawano, Shin-Ichiro Yamamoto

Graduate School of Engineering and Science, Shibaura Institute of Technology

mf14018@shibaura-it.ac.jp

ABSTRACT

There are many attempts to investigate the attitude control change during standing. Previous studies have reported that postural coordination patterns change as a function of translation frequency. In addition, the state of the support surface to change the relationship between the nervous system and the musculoskeletal system. Thus the state of the support surface is also important in the standing position. However, the effect of inclined support surface that cannot be perceived on postural strategy was not clear. Therefore, the purpose of this study is to investigate the influence of inclined support surface that cannot be perceived on postural strategy during platform translations. In addition, to experiment in the eye open (EO) and eye close (EC) to account for visual information, eight healthy young adults (21.5±0.5y) participated in this study. Participants maintained their balance in stance during support surface translations in the anterior–posterior direction at two different frequencies (0.2 and 0.8[Hz]) and at three different base of support condition (LV: Level, TD: Toe Down, TU: Toe Up). For the kinematic data at slow frequency, subjects stood the platform depending on the movement of platform itself, while at fast frequency subjects fixed their head and center of mass (COM) in space. The ankle moment and electromyogram (EMG), which influenced in every different condition of frequency and visual information, were changed during the perturbation of the motion platform. The angle of motion platform was small enough so that subjects could not be perceived. These results suggested that angle of motion platform changed involuntarily the stable posture control strategy.

1. INTRODUCTION

Human bipedal stance is inherently unstable, because a large body mass is located high above a relatively small base of support. Therefore, an advanced facility of the postural-control system is required for maintaining upright posture. Humans are able to select distinct strategies depending on task requirements.

Buchanan et al. [1] examined the effect of frequency of sinusoidal platform translation on postural movement. They demonstrated that support surface allowed subjects to remain in upright stance and ride the platform with little motion about the ankles, knees, or hips for slow translation frequencies. For fast translation frequencies, a different postural pattern emerges, with the head and upper trunk fixed in space relative to the moving platform with extensive motion about the ankles, hips, and knees. They suggested that fixing the head in space was important to remove the visual scene oscillation produced by the translating support surface, thus allowing vision to aid in high frequency postural control. Therefore human upright posture is maintained by the central nervous system via integration of complex afferent and efferent control signals, bases on body orientation and motion information, which are provided by the vestibular, visual and somatosensory systems.

On the other hand, Sasagawa et al. [2] investigated the active stabilization mechanism by inclined surface on quite standing. As a result, they found EMG activity change as a function of support surface conditions, indicating that increased (decreased) passive contribution required less (more) extensor torque generated by active muscle contraction. From this reason, it is important to assess the effect of support surface condition on postural strategy. However previous studies examined principally linear motion of body segments and, in a number of cases, had a limited range of experimental perturbations. Therefore, it is performed by adding the perturbation by changing the support surface experiments, then the angle of the support surface has a large range. This angle is therefore subject was perceptible, because the subject is using optional control strategy.

Therefore, the purpose of this study is to consider the effect of the attitude control strategy standing posture when the addition of dynamic disturbances under conditions varied to the extent that cannot be perceived in the subject the base of support.

2. EXPERIMENT

2.2 Method

Eight healthy young adults (21.5±0.5y) participated in this study. No subject had a prior history of neurologic disease at the time of testing that could affect to the ability to perform the experiment. Both knee joints of the subject were fixed at the lower limb joints fixed brace for analysis by an inverted pendulum model for two-degree-of-freedom by ankle and hip. Kinematic data was collected using motion analysis with 7 high precision infrared cameras (HWK-200RT camera, Motion Analysis, USA) at a sampling frequency of 200 Hz using 18 reflective markers. Eighteen kinematic reflective markers were placed on the skin overlying the base of the third metatarsal, lateral malleolus, lateral condyle of the femur, greater trochanter of the femur, acromion process of the scapula, top of head and back of the head. The center of mass (COM), hip and ankle joint angles were calculated from the kinematics data. Meanwhile, a force plate (9286A, KISTLER, JAPAN) and a force sensor recorded at a sampling frequency of 1000 Hz. Electromyography (EMG) signals of tibialis anterior (TA), medial gastrocnemius (MGAS), soleus (SOL), rectus femoris (RF) and biceps femoris (BF) of right lower limb were recorded at sampling frequency of 1000 Hz. Subjects were exposed to external platform perturbation (anterior-posterior direction) at two different frequencies (0 (quiet standing (QS)), 0.2 and 0.8 Hz) by a movable platform (MB-150, COSMATE, JAPAN) with a translational displacement of 50mm. At that time, the support base surface changed Lavel (LV), Toe-Up (TU) and Toe-Down (TD). The angle of support surface is 1.5 degree which is small enough so that subject was imperceptible. Furthermore, subject's vision (eyes-closed (EC) and eyes-opened (EO)) was manipulated. In addition, installing the parallel bars (P-2, MUTSUMI MEDICAL, JAPAN) to allow for safety in the subject.

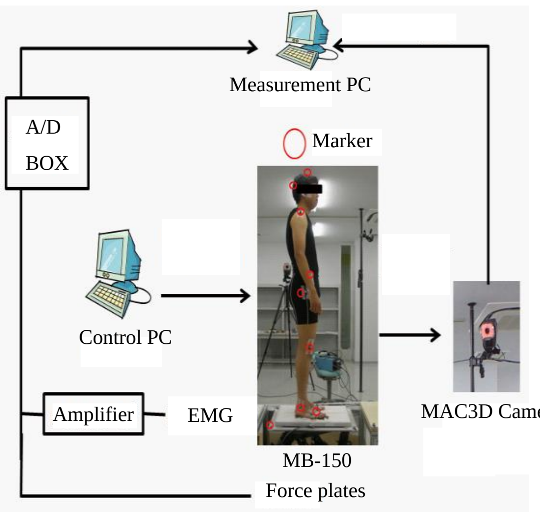

Fig.1 System configuration

2.2 Date Analysis

The methods for data on analyzing applied for the attitude control to the disturbance after stability: cross-correlation function for each of the parameters after five cycles; calculating a correlation coefficient from Cross-Correlation Function (CCF) analysis, the peak value Correlation Coefficient: CC, corresponding to it time shift: TS.

3. RESULTS AND DISCUSSION

A typical example of the stick picture, head amplitude and relationship of ankle and hip angle are shown in Fig.1.2.3. Head movement at 0.2 frequency moves as well as the movement of the motion base (MB). In 0.8 frequency subject tends to fix the head in the space. In addition, negative correlation between ankle angle and hip angle was observed in the disturbance of a high frequency. In the translation disturbance of 0.2 frequency from these above the attitude control strategy swings in the same manner as in the head and the movement of the MB. A posture control strategy for fixing the head in 0.8 frequency. These results were observed regardless of the change of the platform. Accordingly, our results support the Buchanan's reports that fixing the trunk and the head segment relative periodic disturbances in the space. [1]

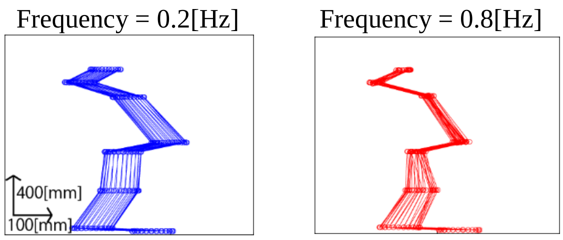

Fig.1 stick picture

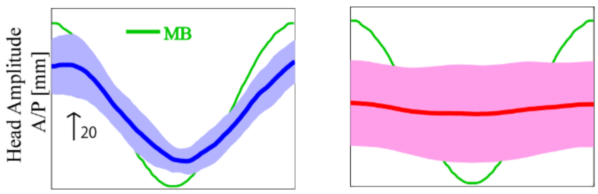

Fig.2 Head amplitude

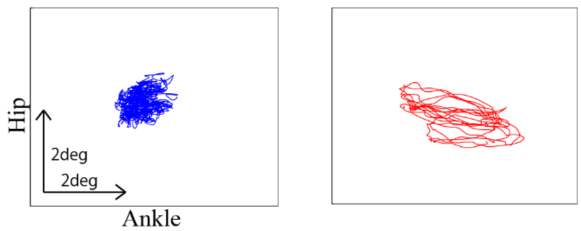

Fig.3 Relationship of ankle angle and hip angle

Fig.4 shows range of motion (ROM) of ankle and hip. ROM of ankle and hip show a larger value in 0.8

frequency than in the 0.2 frequency case.

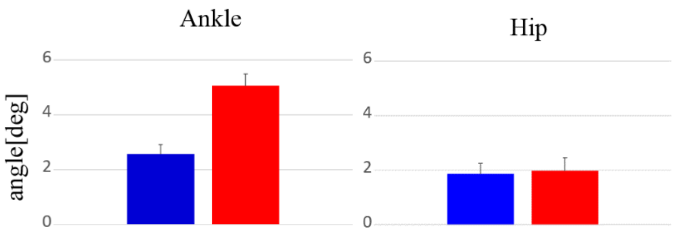

Fig.4 ROM of joint angle

Fig.5 shows the CCF analysis results of ankle and hip. The ankle joint and the hip joint operation have a reciprocal relationship at high frequency of disturbance. In other words, the cooperation pattern between body segments was seen significantly. These results suggests that using the ankle strategy for achieving stability of COM around the ankle joint was done at a low frequency. Moreover, it is considered to have shifted to hip strategy for limiting the COM displacement by the hip and depending on the frequency. This coordination pattern changing is similar to the Buchanan.[1] Results the cooperative operation between the body segments was confirmed to vary and adapt depending on the disturbance frequency.

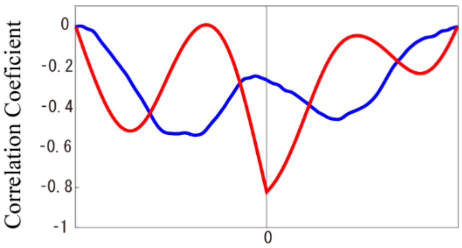

Fig.5 CCF analysis (ankle vs hip)

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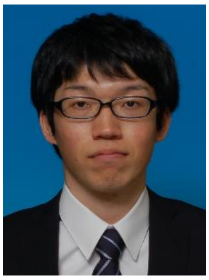
[2] S.Sasagawa et al, “Balance control under different passive contributions of the ankle extensors: quiet standing on inclined surfaces.” Exp Brain Res 196:537–544



Jun Kawano received bachelor’s degree in engineering from department of Bioscience and Engineering, Shibaura Institute of Technology in 2014. Since Apr. 2014, he is a master course’s student at SIT.

Shin-ichiroh Yamamoto is Professor at Department of Biomedical and Engineering, Shibaura Institute of Technology. His research interest including neuro-rehabilitation engineering and neural mechanism for human motor control.