THE BODY CENTER OF MASS DISPLACEMENT DURING VARIOUS TYPES OF SUPPORT SURFACE PERTURBATION

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INTRODUCTION

Previous studies have revealed differences of muscle responses between translational and rotational platform perturbation [1,2]. The differences in the organization of postural responses were ascribed to the different mechanical demands of the perturbations. Regulation of the body center of mass (COM) seemed to be the main function of postural control. No kinematic data including COM trajectory were collected to test the effects of all four of the platform displacements (forward/backward translation, F/B and toe-up/toe-down rotation, U/D), perform at same velocity, on the same subjects. Allum et al (2001) used combinations of support surface rotation and backward translation (BU and BD) to induce balance corrections [3]. It seemed to increase task difficulty. Two additional types of combination of support surface rotation and forward translation (FU and FD) were not studied in the literature. Therefore, the purpose of this study was to investigate the differences of COM trajectories under various types of support surface perturbations including uni-axial (F, B, U and D) and bi-axial (BU, BD, FU and FD) perturbations.

METHODS

Six healthy subjects (4 males, 2 females; ages 19-22 years) consented to participate in the study. A tri-axial postural perturbation platform was used to provide both uni-axial and bi-axial support surface perturbation. The velocity and amplitude of platform movement was 50 mm/s for 70mm or 50 degree/s for 7 degrees, respectively. All subjects were tested under eight types of perturbations with 3 trials of each perturbation. These perturbations were delivered in a random sequence and commenced 1 second after the start of the data collection. A six-camera video-tracking motion analysis system (Motion Analysis Corp., CA, USA) was used to collect three-dimensional kinematic data with thirty-nine retro-reflective spherical markers fixed over the whole body of the subjects. The data was collected at 200Hz for 3seconds. The 13-segment model was used to calculate the total body COM. We divided the COM trajectories into two phases: a passive imposed postural sway and an active automatic postural reaction phases. The maximal horizontal (anterior/posterior, A/P), vertical and medial-lateral displacement of the body COM with respect to support surface in two phases was measured respectively.

RESULTS AND DISCUSSION

There were no differences of the maximal medial-lateral COM displacement among various types of perturbation, and the means were range from 10 to 20 mm. Table 1 presents the COM displacement and Figure 1 shows the COM trajectories in A/P horizontal and vertical directions. During uni-axial perturbation, all the four types of perturbation induced quite a large horizontal COM displacement, while the forward translation induced larger displacement than the others. Platform rotation (U and D) induced more vertical COM displacement than translation. All the bi-axial perturbation induced more horizontal displacement than uni-axial perturbation. The BD and FU tests demonstrated the adding effects of the imposed sway. However, the vertical displacement conformed to the expected adding and counterbalanced effects. In automatic postural reaction phase, translational tests recovered more displacement than rotational tests. Because rotational tests changed the end COM position by bringing the COM forward in D test and backward in U test. During bi-axial BU and FD test, the subjects recovered larger displacement in horizontal and vertical directions than BD and FU tests. It was assumed that the "enhanced" ankle input of BU and FD generated agonist stretch reflex that stabilizes the posture. Whereas the "nulled" ankle input of BD and FU tests produced weaker balance-reaction responses regardless of the greater imposed postural disturbance. It was presumed that BD and FU tests are the more challenge tests for balance control.

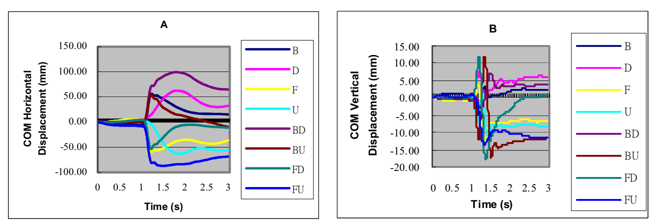

Figure 1: The horizontal trajectory (A) and the vertical trajectory (B) of the body COM of eight types of support surface perturbation.

Table 1: Mean of the maximal horizontal and vertical displacement of the body COM during the passive imposed sway and active postural reaction phases in eight types of support surface perturbation

Displacement (mm)	Horizontal								Vertical							
	B	D	F	U	BD	BU	FD	FU	B	D	F	U	BD	BU	FD	FU
Imposed Sway	63.25	53.06	-66.97	-63.98	91.31	71.89	-69.69	-89.3	-8.25	12.88	4.56	-9.47	4.31	-15.89	18.05	-9.24
Postural Reaction	-65.46	-23.41	55.89	23.66	-55.30	-74.93	68.92	32.38	13.6	8.45	9.57	12.52	14.74	32.34	-21.48	10.26

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