A 2 DEGREE OF FREEDOM TRANSLATING SUPPORT SURFACE FOR POSTURAL COORDINATION DYNAMICS ASSESSMENT

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1. INTRODUCTION

The introduction of experimental and commercial dynamic posturography systems has moved the investigation of balance disorders from the quiet condition body sway recording, the so called static posturography, to the study of the postural adjustments modes required to prevent falling induced by unexpected perturbations during upright stance, that is named dynamic posturography.

For example Nashner [1] realized unexpected gait perturbations using a movable platform in a walkway, Ko and colleagues investigated how perturbation frequency and motion amplitude affect postural coordination strategies [2], while Brown and colleagues investigated in how the displacement waveform characteristic underlying the translating board perturbation is revealed in postural responses [3].

A perturbation, performed by the support platform movement, empathizes the postural coordination modes; it shows the all known control strategies (i.e. rigid mode, ankle mode, ankle-hip mode, ankle-hip-knee mode), and it tends to enhance the pathological features of the balance.

A number of recent researches studied the effects of the platform translations on the postural movements [4-8]. These studies suggest that, in order to better understand how balance is maintained during everyday life and how it is affected by disease, there is the need of assessing postural responses in multiple directions.

We have therefore designed a new 2-degree of freedom mobile platform (fig. 1), that can perform a wide range of combinations of antero-posterior and medio-lateral either sudden or slow, both impulsive and harmonic movements.

![Fig. 1. The 2-degree of freedom mobile platform (120x116x70cm, 80Kg) architecture. Galil DMC 1822 is the PCI axis control board located inside the PC. IOG1800 is the interface board that manages the Kollmorgen Pico Drive servos, located in the Control & Power unit, on the left of the PC.](image-url)
Both the axis platform movements range from 0 mm to 180 mm. The platform movements permit a large amount of support perturbations that are characterized by large ranges of velocity and frequency (fig. 3).

The system provides external triggers thus permitting synchronization with external systems, such as the body movement analysis systems, the EMG recording devices, etc. An analogical output (ranges +/-10V) of the position of the centre of the movable support is available.

2.2 Procedure

The perturbations can be programmed by describing the velocity, the amplitude, and the shape parameters in the user-friendly, mouse-driven, ad hoc realized software-interface (fig. 2). The software tool was developed using modular structures with the aim to permit further adaptation and customization [9].

Two kind of basic perturbation shape are available:

1. “Pulse”, that is a trapezoidal perturbation which is defined by the centre platform shifting velocity from the starting position to the final one (we fixed a maximum value of 1.2m/s), the plate au time duration and the platform going back velocity to the initial position.

2. “Harmonic” perturbation consists of a periodic motion, performed at the perturbation frequency (we fixed a maximum value of 1.6Hz), between to extremes defined by the perturbation amplitude.

The user can define a “protocol” that consists of a series of different perturbations. Each perturbation is described by selecting the number of the axis (one or two), the shape (“Pulse” or “Harmonic”), the amplitude (expressed in mm), the frequency or the velocity of the movement, and the duration of movement.

3. DISCUSSION

The coordination strategies of whole body posture and balance were studied predominantly by considering few condition, in particular either during the quiet standing or studying the postural adjustments to prevent the fall. It was shown that assessing the postural responses in multiple directions is a key issue to better understand how balance is maintained during everyday life and how it is affected by diseases.

Furthermore, it was shown that standing on a continuously moving platform improves balance control in elderly and in patients with unilateral vestibular deficit [9].

Recently the needing of very short reproducible perturbations to study the postural control system while not forcing adaptive strategies was pointed out [10]. For these reasons we have developed an innovative device, able to perform both harmonic and trapezoidal perturbation within no restriction in the XY plane (fig. 3).

The needing of standardization in evaluation or rehabilitation procedures is satisfied by the “experimental session” saving feature, that stores the list of the used protocols.
the XY plane it is possible to view the actual dynamic of the centre of surface support: while the X was performing the harmonic, a lateral shift occurred along Y. After the 2sec of pulse plate au the home shifting happened.

The management of the mobile platform by a graphical user interface makes easy to define, to try and to achieve different sequences of the perturbations, and it offers a reproducible procedure for the diagnosis or the rehabilitation. Therefore the need of standardization of platform perturbations between laboratories (that utilize translating platform system to disturb quiet standing balance) is satisfied. Furthermore the possibility to deliver programmable multi-direction perturbations, (characterized by wide ranges of amplitudes, velocities, frequencies, etc.) leaves the possibility to better explore and characterize which parameter more affects both balance adjustments and coordination strategy pathologies.

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