Power spectral density in balance assessment

M. Syczewska¹, T. Zielińska²

¹ Dept. Padiatric Rehabilitation, The Children’s Memorial Health Institute, Warsaw, Poland
² Dept. Mechanics, Energetics and Aviation, Technical University of Warsaw, Poland

1. Introduction

Maintaining the upright body posture in a stable and safe way is one of the pre-requisites of every day life activities. In many diseases this ability is affected. In patients with balance problems the aim of the treatment is the restoration of the balance function, or at least the prevention of the further deterioration. Therefore the assessment of balance function is one of the most common functional test performed in clinical settings. One of the methods used for this assessment is posturography. The sway of the centre of pressure (COP) is measured with the help of force plates, and various parameters are then calculated from the COP trajectory. Postural sway results from corrective signals, which tries to keep the COP within the safety limits. More difficult tasks require more corrections from central nervous system (CNS). Although the COP trajectory is strongly dependent on the body centre of mass (COM) [1,2] the amount of the correction signal should influence this dependence. Therefore the aim of the present study is the assessment of the amount of the correction with power spectral density function of the COP vs COM signal.

2. Material and Methods

One adult healthy subject participated in the study. The subject, although healthy, has some individual postural features: posterior pelvic tilt and knee hyperextension. She performed several standing tasks:
- standing with eyes open, feet parallel, distance approximately equal to pelvic width;
- standing with eyes closed, feet parallel, distance approximately equal to pelvic width;
- standing on one leg in yoga asana “Tree”, version one;
- standing on one leg in yoga asana “Tree”, version two;
- standing on one leg in yoga asana “Dancing Shiva.”

The last three task require high level of correction from CNS, therefore they were chosen to mimic the behaviour of the patients with balance problems. Each task lasted approximately one minute.

The COP trajectory was recorded using the Kistler force plate. Simultaneously the kinematic data were recorded (35 markers were placed on all subject’s body segments) using VICON 460 system. This data were later used to calculate body COM using Plug-In-Gait model. The kinematic data were sampled at 60 Hz frequency, and force platform data with 1980 Hz.

The COM data were subtracted from COP trajectory in antero-posterior (AP) and lateral direction. Later the power spectral density (PSD) was calculated for the new signals. Fig.1 shows this difference in lateral and antero-posterior (AP) directions during eyes open and “dancing Shiva” conditions.

3. Results

The obtained results are presented on Fig.1. and Fig. 2.

Fig.1. shows the difference between COP and COM trajectories in lateral and AP directions in two conditions: eyes open (the smallest difference), and in “Dancing Shiva” asana (the highest difference).

Fig. 2. shows the power spectral density of the new signals (COP-COM) for four conditions: eyes open, eyes closed, Dancing Shiva, and Tree v.2.

4. Discussion

Although COM and COP trajectories are dependent on each other the results show that in all four condition there is a difference between them both in AP and in lateral directions. This difference is small in case of eyes open condition, but increases with the difficulty level of the balance task.

Power spectral density is very low for the eyes open condition, but increases with the difficulty of task. This is connected with the amount of the corrective movements and the need of constant control of the CNS needed for the maintaining of body posture while standing on one leg.
All correction signals, regardless of the balance task, have low frequency up to 5 Hz, which is connected with mechanical properties of the human body. The eyes closed task requires lowest amount of the corrections, while “Dancing Shiva” the highest. During the eyes open and “Tree” v.2 conditions the maximum values of PSD are approximately the same for AP and lateral directions, while in eyes closed and “Tree” v.1 conditions the energy is higher in AP direction, and in “Dancing Shiva” in lateral direction. This reflects the fact in which direction the maintaining of the body posture and balance is more difficult, thus requiring more control and control exhibited by CNS.

Acknowledgements  This study was supported by the research grant N NN14 297935 of Polish Ministry for Science and Higher Education.

References