Control and stability of the complex inverted pendulum models in application to postural sway analysis of the vertical human stance

Natalya Kizilova

Mechanisms of balance control is investigated on computerized posturography data on vertical two-legged and one-legged stances measured on healthy subjects and the patients with osteohondrosis and coxarthrosis. Oscillations of the centre of mass in the course of 30 s standing and the corresponding trajectories for a step forward off the force platform have been computed. Spectral analysis of the time series revealed three main harmonics for the studied postures. When a volunteer was balancing standing on one leg, all the harmonics were shifted towards the high frequencies and the sway amplitude was twice increased in comparison with comfortable two-legged vertical stance. Decomposition of the sway trajectories into the rambling and trembling components has been carried out. It was shown that in the course of the one-legged stance the balance control strategy includes 'scanning' of the larger area with bigger sway amplitudes in the vicinity of the stable state as compared to two-legged stance. A mathematical model of the body as a multi-link system is considered. Mass and inertia of each body segment and torques in joints are taken into consideration. The calculated own and forced frequencies of the model correspond to the spectral analysis of the posturography data. One-legged stance is proposed as an excellent tool for revealing the balance problems. It is shown that investigation of the oscillations and trajectories of the centre of mass for the step forward off the force platform is perspective for medical diagnostics to distinguish between the spine and joint pathologies.