# THE EFFECT OF HIGH-HEEL SHOES ON LOCAL DYNAMIC STABILITY

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**INTRODUCTION:** High-heeled shoes with a wide variety of heights are worn by Korea women. Even though walking with high-heeled shoes makes woman appear more slender and taller, a narrow toe box, an excessive plantar curvature and a rigid heel cap have been associated with the development of various foot deformities (Stefanyshyn et al., 2000). The effect of walking with high-heeled shoes on foot pressure distribution, muscle EMG, kinematics, and kinetics was investigated in previous studies (Stefanshyn et al., 2000; Liu & Wang, 2004). Few nonlinear dynamic studies have been conducted to detect differences in local dynamic stability as heel height increases. Thus, the purpose of this study was to determine, via a nonlinear analysis, the local dynamic stability present in time series data generated from high-heeled gait.

**METHOD:** Twelve women (mean height: 162.3±4.1 cm; mean body mass: 55.4±5.5 kg, mean age: 24.5±4.4 yrs), without a history or complaint of lower limb pain, participated in this study. Participants were asked to walk on a treadmill at their preferred walking speed (mean speed: 3.14±0.5 km/hr). A three-dimensional motion analysis was performed with a 6-camera motion capture system (SF: 100Hz; Qualisys, Inc., Sweden). Each participant was asked to perform 100 continuous strides of treadmill walking in footwear with three different high heel heights (3, 7, 9 cm). From the 100 strides, the average of 11,667, 11,338, and 11,213 data points for 3, 7 and 9m heights, respectively, were used in the analysis. Local dynamic stability is defined as the sensitivity of the system to small perturbations during locomotion (Dingwell & Cusumano, 2000). To quantify local dynamic stability, the Lyapunov exponents (LyE) were computed for nonlinear time series of center of the forehead displacement and the knee joint angle in sagittal plane. The largest LyE was calculated as the maximum convergent values of the average logarithmic divergence of the neighboring trajectories in the state space. Before calculating LyE, the state space was reconstructed by computing the number of embedding dimensions and the appropriate time delay. The estimation of embedded dimensions was determined using a false nearest neighbor analysis. The time delays were calculated from the first minimum of the average mutual information function (Buzzi et al, 2003). No statistic tests were used to detect the effect of heel height on the local dynamic stability.

**RESULTS AND DISCUSSION:** LyE of the knee angle and forehead displacement in anterior-posterior direction were generally less at the 3 cm heel height than at heel heights of 7 and 9 cm. LyE of the forehead displacement in superior-inferior direction increased systematically with increasing heel height. In this study, heel height had an effect on local stability. We speculated that increased local dynamic stability may make the body be more vulnerable to fatigue and fatigue during walking may cause a lack of balance. This lack of balance may increase the likelihood of injury. These results suggest that women should wear high-heeled shoes with moderate heel height and avoid wearing them for long periods.

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