Chaos in Gait

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It is quite evident that human gait is variable. In fact, no two footfalls are exactly alike. Using a newly developed pseudoperiodic surrogation algorithm, we have rigorously demonstrated that variations in the gait pattern are not noise; rather they have a deterministic pattern. Our scientific explorations of the nature of these variations have demonstrated that the elderly have less certainty for selecting the appropriate neural pathways for stable locomotion. Less certainty appears to be related to a more random chaotic gait pattern in the elderly. However, it is not currently clear what neural control mechanisms alter the structure of the chaotic variability in the elderly. We initially used a passive dynamic walking model that has a chaotic gait pattern to explore this question. Our simulations indicated that hip joint actuations that assist the motion of the swing leg alter the structure of the chaotic gait pattern and that they can be used to transition to stable gaits embedded within the chaotic locomotive attractor. For example, a systematic increase in hip joint assistance promotes a period-4 gait pattern to bifurcate to a period-8, and a period-8 gait to bifurcate to a period-16. We explored if these concepts extend to human chaotic gait patterns with a custom built mechanical hip actuator that assisted the motion of the swing leg during gait. The largest Lyapunov exponent (LyE) was used to quantify the chaotic structure of the gait pattern. An increase in the magnitude of the LyE would indicate a similar behavior as our model. Our results indicated that swing assistance systematically increased the magnitude of the LyE. Hence, neural control of the swing limb plays an important role in the structure of the chaotic gait variability. Potentially, a lack of certainty on how to properly ‘tune’ the motion of the swing leg may be related to the altered chaotic variability seen in the elderly.