Phenomenological Modeling of Human Jumping Activities in Response to an Auditory Cue

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Abstract

This research investigates the ability of humans to synchronize their jumping motion with an external audible stimulus, providing insight into the nonlinear dynamics of human rhythmic movement. Experiments were conducted in which individuals were asked to jump in rhythm with the periodic click of a metronome. Ground reaction forces and body kinematics were measured to characterize the dynamic response of the body and identify key features of the coordination mechanism. The observations suggest that the human neuromuscular control system can be idealized as a nonlinear dynamical system exhibiting a limit cycle, representing the stable periodic motion of the jumping activity. When exposed to an external auditory cue, the system demonstrates phase entrainment, i.e., the synchronization of the internal oscillation with the external frequency. This entrainment capability was clearly observed experimentally and successfully reproduced by a reduced-order nonlinear model, confirming the theoretical predictions of synchronization phenomena in human movement. Although the current work focuses on single individuals, it establishes a robust experimental and modeling framework for future extensions to groups of jumpers, where mutual coupling effects and collective synchronization dynamics will be explored. Such developments have potential applications in biomechanics, crowd dynamics, and vibration mitigation of flexible structures.