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Stabilizing function of antagonistic neuromusculoskeletal systems: an analytical investigation. (English) Zbl 1084.92005

Biol. Cybern. 89, No. 1, 71-79 (2003).

Summary: Under normal conditions human walking or running consists of stable cyclic movements. Minor perturbances such as a stone or a pothole do not disrupt the cycle, and the system returns to its prescribed trajectory. We investigated whether a pair of antagonistic muscles is able to stabilize the movement without neuronal feedback. The human is represented by a model consisting of a massless two-segment linkage system (leg) topped by a point mass. Both the extensor and flexor muscles are described by a Hill-type muscle model [*A. Hill*, Proc. R. Soc., Ser. B 126, 136–195 (1938)]. Conditions for stability are calculated analytically based on the Lyapunov theory and the results are illustrated by numerical examples. The activation functions of both the extensor and flexor muscles can be calculated for a prescribed trajectory to maintain the self-stabilizing ability of such a system. Experimental evidence supports the prediction. Our investigation shows that a moving center of rotation of the kneejoint, a biarticular flexor muscle group, the force-velocity relation, and the ascending limb of the force-length relation improves the self-stabilizing ability of human movement.

MSC:

92C10 Biomechanics
92C20 Neural biology