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Mapping the classical cross-bridge theory and backward steps in a three bead laser trap setup. (English) Zbl 1208.92023

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Summary: According to the cross-bridge theory [*A. F. Huxley*, Prog. Biophys. Biophys. Chem. 7, 255 ff (1957)], the interaction between myosin and actin is governed by a deterministic process where the myosin molecule pulls the actin filament in one specific direction only. However, studies on single myosin-actin interactions produced displacements of actin not only in the preferred but also in the opposite direction. This phenomenon is typically referred to as backward steps by the myosin head. *J. E. Molloy* et al. [Biophys. J. 68, 298 ff (1995)] speculated that these backward steps are not caused by the molecular interactions of actin with myosin but are an artifact of the Brownian motion associated with these molecular level experiments. The aim of this study was to investigate, whether a theoretical model can support Molloy's speculation. We therefore developed a theoretical model of actin-myosin based muscle contraction that was strictly based on Huxley's assumption of one stepping direction only, but incorporated Brownian motion, as observed in single cross-bridge-actin interactions. The mathematical model is based on Langevin equations describing the classical three-bead laser trap setup and uses a novel semi-analytical approach to study the percentage of backward steps. We analyzed the effects of different initial actin attachment site distribution and laser trap stiffness on the ratio of forward to backward steps. Our results demonstrate that backward steps and the classical cross-bridge theory are perfectly compatible in a three-bead laser trap setup.

MSC:

92C40 Biochemistry, molecular biology
92C10 Biomechanics
60J70 Applications of Brownian motions and diffusion theory (population genetics, absorption problems, etc.)

Keywords:

actin-myosin interaction; optical tweezers; single molecule experiments; stochastic differential equations; analysis of trap displacement

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