Multiple regulation of force generation mode for single actomyosin motor

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Motor proteins are force-generating nanomachines that are highly adaptable to their ever-changing biological environments and have a high energy conversion efficiency. Here we constructed an imaging system that uses optical tweezers and a DNA handle to visualize elementary mechanical processes of a nanomachine under load. We apply our system to myosin-V, a well-known motor protein that takes 72 nm 'hand-over-hand' steps composed of a 'lever-arm swing' and a 'Brownian search-and-catch'. We find that the lever-arm swing generates a large proportion of the force at low load (< 0.5 pN), resulting in 3 kBT of work. At high load (1.9 pN), however, the contribution of the Brownian search-and-catch increases to dominate, reaching 13 kBT of work [1]. The result suggests myosin switches force generation mode depending on external load.
In addition, in the presence of osmolyte such as sucrose, myosin-V frequently slides along actin filament during the Brownian search. Sliding direction was stochastic but totally directed in the forward. The osmotic pressure is comparable with that in a cell (0.1-0.5 pN/nm2), therefore, the sliding behavior would have a physiological meaning. To precisely detect the stepping trajectories (5.5 nm = actin monomer size/ step), we're applying a novel experimental system using DNA nanotechnology [2].
In summary, we believe the ability to switch between these three force-generation modes facilitates myosin-V function at high efficiency while operating in a dynamic intracellular environment.

1. K. Fujita, M. Iwaki, A. Iwane, L. Marcucci, T. Yanagida, *Nature Communications*, **3**, 956 (2012).
2. Dietz H, Douglas SM, Shih WM. *Science* 325, 725–730, (2009).