Some paradoxes of muscle mechanics

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Muscle myofibrils are usually modeled as one-dimensional mass-spring chains with active springs representing half-sarcomeres (HS). The active force–length relation for individual HSs (isometric tetanus) is known to have a segment with a negative stiffness. Despite the potential mechanical instability on such a 'descending limb', the observations suggest that the deformation of a myofibril remains affine. In view of this paradox, the question whether the mechanical behavior of a myofibril can be interpreted as a response of a single contractile unit has been a subject of considerable controversy. Passive response of skeletal muscles is equally puzzling. In such regimes, operative at small time scales, one can neglect the detachment of myosin cross-bridges and model a HS as a parallel array of passive cross-linkers. Due to the almost rigid connection of such cross-linkers to a myosin backbone, the interactions in this system are of long-range type, which is responsible for negative overall stiffness in physiologically relevant conditions. This creates again a stability problem for a passive myofibril, given that it can be viewed as a series connection of HSs. In this talk we discuss the physical origin of these apparent paradoxes and propose some ways to rationalize the physiological observations.