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Modeling residual force enhancement with generic cross-bridge models. (English)

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Summary: The interaction of actin and myosin through cross-bridges explains much of muscle behavior. However, some properties of muscle, such as residual force enhancement, cannot be explained by current cross-bridge models. There is ongoing debate whether conceptual cross-bridge models, as pioneered by *A. F. Huxley* [Muscle structure and theories of contraction. Prog. Biophys. Biophys. Chem. 7, 255 ff (1957)] could, if suitably modified, fit experimental data showing residual force enhancement.

We prove that there are only two ways to explain residual force enhancement with these 'traditional' cross-bridge models: the first requires cross-bridges to become stuck on actin (the stuck cross-bridge model) while the second requires that cross-bridges that are pulled off beyond a critical strain enter a 'new' unbound state that leads to a new force-producing cycle (the multi-cycle model). Stuck cross-bridge models cannot fit the velocity and stretch amplitude dependence of residual force enhancement, while the multi-cycle models can. The results of this theoretical analysis demonstrate that current kinetic models of cross-bridge action cannot explain the experimentally observed residual force enhancement. Either cross-bridges in the force-enhanced state follow a different kinetic cycle than cross-bridges in a 'normal' force state, or the assumptions underlying traditional cross-bridge models must be violated during experiments that show residual force enhancement.

MSC:

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