小角散乱ユーザーグループ

Structures of Thin-actin Filaments in the Resting State, upon Activation and during Contraction of Skeletal Muscles by Synchrotron X-ray Fiber Diffraction

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Abstract

In order to clarify the structural changes of thin-actin filaments related to the regulation and contraction mechanisms in skeletal muscle, the intensities of the thin filament-based reflections in the X-ray fiber diffraction patterns were investigated in the resting state, upon activation and during isometric contraction. Structural modeling of the thin-actin filament was performed using the crystallographic data of constituent molecules which have been derived until now, and the structural changes of the regulatory proteins (troponin, tropmyosin) and actin filaments were analyzed in the resting state, upon activation and during contraction.

(1) The conformation of the globular core domain of troponin, the angular position of tropomyosin were altered upon activation, and underwent additional changes during an isometric contraction.
(2) The subunit, TNT1 part of troponin moved together with the tropomyosin strand to partially and fully uncover the myosin binding site of the subdomain 1 of actin upon activation and during contraction, respectively.
(3) Domain structure of the actin subunit was altered upon activation and further altered during contraction.

Thus, the structural changes of the regulatory proteins and actin in the thin filament occur in two steps, the first in response to Ca^{2+}-binding to the subunit, troponin C in troponin and the second induced by actomyosin interaction. Alteration of the actin structure relates to both the regulation and contraction mechanisms. The conclusion is that the reciprocal intensity changes of the first and second low-angle layer lines cannot be modeled without a tropomyosin shift in position. The stereo blocking idea remains a possibility and myosin heads can produce a further shift of tropomyosin. Allowing tropomyosin and TNT1 in troponin to move independently do not yield good fits to the observed layer-line intensity data. Along with the tropomyosin shifts there seem to be movement of subdomains 1 and 2 in actin.