Biological Science

15A/2003G318

The effect of muscle length changes on the X-ray diffraction pattern from tetanized frog skeletal muscle II

Hidehiro TANAKA[1], Takakazu, KOBAYASHI[2], Yasunori TAKEZAWA[3], Yasunobu SUGIMOTO[3], Kanji OSHIMA[3], Katsuzo WAKABAYASHI[3]

[1]School of Nursing, Teikyo Heisei Junior College, Ichihara, Chiba 290-0192
[2]Dept of Electronic Engineering, Shibaura Institute of Technology, Minato-ku, Tokyo l08-8548
[3]Dept of Biophysical Engineering, Graduate School of Engineering Science, Osaka University, Toyonaka, Osaka 560-8531

Introduction

When the skeletal muscle is stretched slowly at the plateau of the isometric tetanus, the tension increases during the stretch. The tension starts to return to a new tension level, which is higher than the initial isometric level when the length change terminates. In a release, the tension behaves in a similar but opposite way. The intensity of the 3rd meridional reflection (M3), which arises from the 14.3 nm repeat of the myosin heads, decreases during both stretch and release [1-3]. The change of M3 by the length change is explained as follows: if myosin heads attach to the thin filament in a configuration perpendicular to the filament axis, both stretch and release tilt the myosin heads. This tilting of the myosin heads results in the broadening of axial projection of the mass of the myosin heads [2,3]. In the previous report it was showed that M3 increases during stretch and decreases during release if the applied length change is smaller than 1% of the muscle length. [4,5]

Methods

The sartorius muscle from a bullfrog was tetanized for 2.2 sec by applying supra-maximal current pulses (20Hz at 12^0C). The contraction was repeated 10 times at an interval of 3 min. The length change of the muscle was applied at the plateau of the isometric tetanus. The X-ray patterns were recorded by an X-ray CCD detector with a time resolution of 15 msec.

Results

Fig.1 shows the intensity distribution across the meridian in the region of the M3 reflection. Peak broadening of M3 was observed when the muscle contracted. But the width of M3 after the contraction remained unchanged during and after stretch. The absence of peak broadening rules out some types of disorder as possible origins of the intensity change, and suggests it is due to either (i) a change in conformation of the myosin heads so that their mass projection is more sharpened (increased) or spread out (decreased) along the filament axis, or (ii) a change in the dispersion of the axial positions of the heads from the ideal 14.3 nm periodicity. Fig.2 shows an increase in M3 when the muscle is stretched by 1 % Lo with a steady velocity, which is 10 times faster velocity than the previous case [4], suggesting an intensity increase by stretch is caused by the amount of stretch rather than the speed of the stretch.

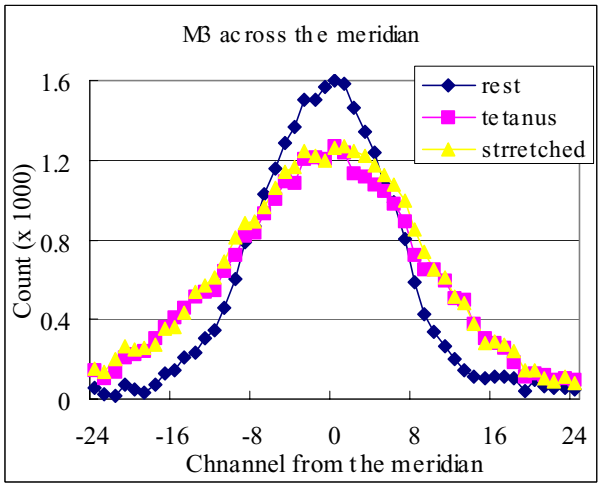

Fig.1. Intensity profiles of M3 reflection across the meridian. The ordinate, total x-ray counts. The abscissa, channel numbers from the meridian. Half width of M3 increased when the muscle contracted, but appreciable effect of the stretch on the half width was not seen.

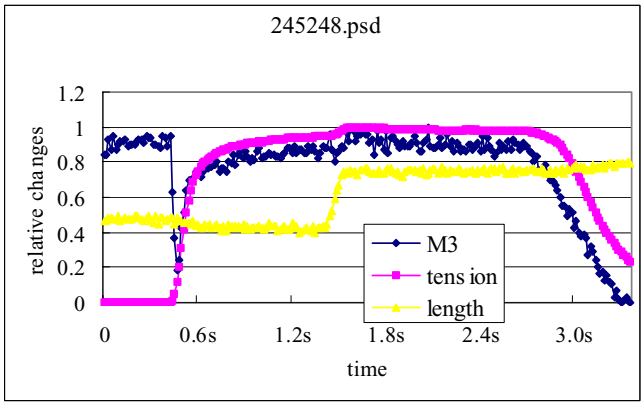

Fig.2 At the plateau of contraction, the muscle was stretched by 1 % Lo with a steady velocity of 0.15Lo/sec, which is 10 times faster velocity than the previous case[4].

References

[1] N.Yagi & I.Matsubara, Biophys.J. 45 611 (1984)
[2] N.Yagi & K.Wakabayashi, J.J.Physio1. 45 583 (1995)
[3 K.Wakabayashi et al, Biophys.J. 49 581 (1986)
[4] H.Tanaka et al PF activity report 2004
[5] H.Tanaka et al J.J.Physiol. 55, Supplement (2005)
kobataka@sic. shibaura-it.ac.jp