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

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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 [1]. 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 [2-4]. The decrease in the intensity by stretch and by releases 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 present experiment it was found that M3 increases during stretch and decreases during release if the applied length change is smaller than 1% of the muscle length. When the applied length change is larger than 1%, both stretch and release induce the decrease in the intensity.

Methods

The sartorius muscles from a bullfrog were used. The muscles were 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 X-ray patterns were recorded by an X-ray CCD detector with a time resolution of 15 msec.

Results

Fig.1 shows the time courses of M3 together with tension and length records when a very slow stretch is applied to the tetanized muscle. At the plateau of isometric contraction, the muscle was stretched by 3%Lo (Lo; initial muscle length) with a constant velocity 0.015Lo/sec. M3 increased at the beginning of stretch in pararel with the gradual increase in tension, but at the middle of stretch M3 started to decrease. It was found that the length at where M3 started to decrease was about 1%Lo. Fig.2 shows the time courses of M3 when a sinusoidal length change (2Hz, 1%Lo amplitude) is applied to the tetanized muscle. Because the length change is less than 1%Lo, M3 increases and decrease in paralell with the applied length change. When the length change is larger than 1%Lo (for example, 3%Lo), M3 decreases both in stretching and releasing phases [4].

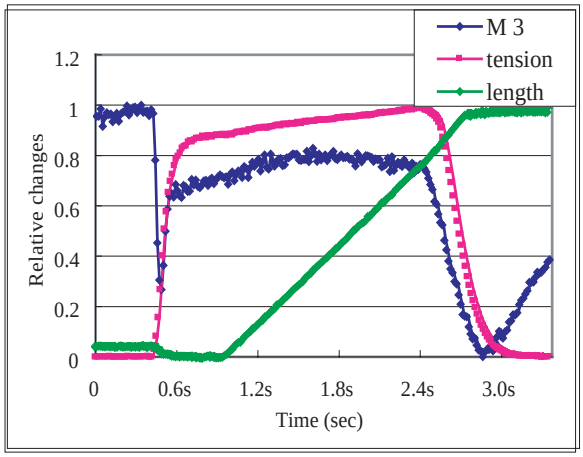

Fig.1 At the plateau of contraction, the muscle was slowly stretched by 3 % Lo with a steady velocity of 0.015Lo/sec. Note that the M3 increased nearly in proportional to the amount of stretch at the beginning of stretch, but it started to decrease in the middle of stretch.

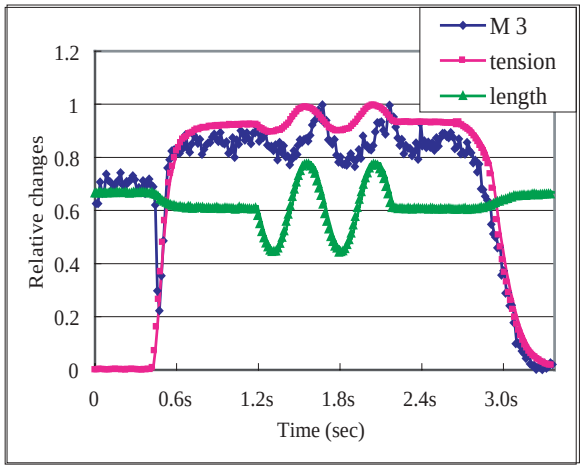

Fig.2. At the plateau of contraction, a sinusoidal oscillation (2Hz, 1% Lo) was applied to the muscle. Note that the change of M3 is similar to the applied sinusoidal length change.

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