MUSCLE HARDNESS DEPENDED ON TENSION DEVELOPED DURING MUSCLE LENGTHENING AND CONTRACTION

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Introduction
The hardness of the muscular tissue has potential for use as a general index of physiological condition. Recently, we have reported that muscle hardness evaluated by the application of perpendicular distortion was influenced by muscle tension (Murayama et al.). The muscle hardness of an isolated frog muscle was proportional to passive tension. Furthermore, muscle hardness is proportional to active tension at muscle length that is close to the maximal passive tension. Based on this result, it is hypothesised that a linear relationship exists between muscle hardness and active muscle tension at various muscle lengths. The purpose of this study was to investigate the correspondence between muscle hardness and muscle length-tension relationship.

Methods
The gastrocnemius muscle was dissected from the frog and immersed in Ringer’s solution. The isolated muscle was mounted horizontally on the base plate in the chamber. The femur was fixed, and the Achilles tendon was attached to a longitudinal force transducer that was coupled to an extension device.

In each experiment series, the muscle was stretched repeatedly from pre-length at which the passive tension begins to rise. The muscle stretching was carried out in steps of 5% pre-length, and the maximal stretching was 150% pre-length. After lengthening the muscle, electrical field stimulation was applied for inducing tetanus by using platinum-plate electrodes positioned on either side of the muscle in Ringer’s solution. The measurement of muscle hardness was performed while maintaining the plateau of passive and tetanic tension.

Muscle hardness evaluation was carried out according to the previous report (Murayama et al.). In brief, perpendicular distortion was applied to the muscle belly, and the relationship between displacement of distortion and response force from the muscle was then evaluated. We defined muscle hardness as the peak response force obtained at 3.5 mm displacement of the muscle.

Results and Discussion
The relationship between normalised tension and normalised muscle hardness was evaluated. Muscle hardness was proportional to the passive and total tension. Regression analysis yielded a significant correlation between muscle hardness and passive and total hardness, with a significant positive slope (passive tension: \( r = 0.986, p < 0.001 \); total tension: \( r = 0.856, p < 0.001 \)). The high correlation between muscle hardness and passive tension was consistent with the finding of the previous study (Murayama et al.). The linear increment in muscle hardness accompanying total tension was probably reflected in the cross-bridge interaction and passive components of the muscle.

In conclusion, our results suggest that muscle hardness depends on contractile tension in the most range in the length-tension diagram.

Reference

Keywords: Exercise Physiology, Muscle Force, Muscle Tightness

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