

肉離れは、なぜ筋全体ではなく局所的に生じるのか？ —筋線維内におけるサルコメアの不均一な伸長に着目して—

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Why Does Muscle Strain Occur Regionally? An Examination from The View of Heterogeneous Elongation of Sarcomere

by

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ABSTRACT

It is generally considered that sarcomere length becomes nonuniform after eccentric contraction. This phenomenon might be related to muscle strain which occurs regionally along muscle fibers. However, the existence of this sarcomere length dispersion has not been clarified experimentally. Therefore, we directly measured sarcomere length after an eccentric contraction. Single skinned fiber (psoas, N=4) was obtained from a New Zealand white rabbit. This isolated single fiber was set under an inverted microscope to directly measure the sarcomere length. In the eccentric condition, fibers were activated isometrically, and then, actively stretched by 25% of the initial fiber length in 2 s, followed by a 15 s isometric contraction. In the isometric condition, fibers were passively stretched by 25% of the initial fiber length in 2 s, and then, activated isometrically. The isometric force obtained after the active stretch was compared to that obtained in the purely isometric contraction. At the same time, sarcomere length was measured. As a result, the isometric force was significantly larger in the eccentric condition (0.44 ± 0.23 mN) than in the isometric condition (0.38

± 0.20 mN) ($p = 0.039$) . The average sarcomere length and the standard deviation were $2.8 \pm 0.3 \mu\text{m}$ for the eccentric condition and $2.8 \pm 0.4 \mu\text{m}$ for the isometric condition, respectively. An F-test revealed that the variation of sarcomere length was not statistically different between these conditions. Unlike our hypothesis, the variation of the sarcomere length in the eccentric condition was not different compared to that in the isometric condition. This result indicates that the theory of sarcomere length nonuniformity should be reconsidered, and other factors, which might be titin, should contribute to the stable sarcomere length even after the eccentric contraction. Based on this finding, muscle strain would not be explained by sarcomere length nonuniformity.

要 旨

筋線維の一部が断裂するという肉離れは、伸張性収縮によってあまり引き伸ばされていないサルコメアと過度に引き伸ばされたサルコメアが混在するようになるという sarcomere length nonuniformity と関連している可能性がある。しかしながらこの sarcomere length nonuniformity は実験的に観察されているわけではない。そこで本研究では、実際にサルコメア長を可視化することで、sarcomere length nonuniformity が実際に生じるかどうかを確認した。単一の筋線維を対象に、サルコメア長が不均一になると言われている伸張性収縮を行い、その後の等尺性収縮中の局面のサルコメア長の分布を、純粋な等尺性収縮中のサルコメア長の分布と比較した。その結果、従来のセオリーに反し、サルコメア長の分布は条件間で違いはみられなかった。この結果は、従来は考えられていなかった何かの機構が、サルコメア長を安定させていることを示唆している。結果的に、sarcomere length nonuniformity は、局所的に生じる肉離れを説明できないと考えられる。