筋細胞レベルでの
筋線維組成が stretch-shortening cycle による
パフォーマンス増強に与える影響の解明

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Influence of Fiber Type on the Enhanced Performance by Stretch-Shortening Cycle in Single Muscle Fibers

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ABSTRACT

Physical performance is enhanced by counter movement. This phenomenon is called stretch-shortening cycle effect（SSC effect）. Recently, elasticity of attached cross bridges and residual force enhancement（RFE）have been suggested as possible mechanisms. This study examined the contribution of these factors by comparing the SSC effect attained in fast and slow twitch fibers. Rabbit psoas（fast）and soleus（slow）were harvested, and single muscle fibers were isolated. In the SSC trial, fibers were isometrically activated at an average sarcomere length of 2.4 μm, and stretched to 3.0 μm within 2 seconds. Immediately after the end of stretch, the fibers were shortened to 2.4 μm within 2 seconds. In the control trial, fibers were isometrically activated at an average sarcomere length of 3.0 μm, and shortened to 2.4 μm in 2 seconds. Mechanical work attained during the shortening phase was calculated, and relative increase in mechanical work between SSC and control trials was adopted as the index for the SSC effect. In addition, RFE and control trials were conducted. In

the RFE trial, the fibers were isometrically activated at an average sarcomere length of 2.4 μm, and then stretched to 3.0 μm within 2 seconds. After the end of stretch, fiber length was kept constant for 15 seconds. In the control trial, fibers were isometrically activated at an average sarcomere length of 3.0 μm. This state was maintained for 15 seconds. The isometric force of the RFE and control trials 15 seconds after the end of stretch was compared to confirm whether RFE was induced. SSC effect was significantly larger in the soleus than in the psoas, but the magnitude of RFE was not different between the muscles. These results suggest that the observed difference in the SSC effect between the muscles was not caused by RFE, but by the elasticity of the attached cross bridges.

要　旨

主動作の前に反動として伸張性収縮を行うと（stretch-shortening cycle：SSC），主動作のパフォーマンスが増強する（SSC 効果）．SSC 効果を生じさせる要因としてクロスブリッジおよびタイチンの弾性が提唱されている．本研究では，クロスブリッジ動態およびタイチンの形状が異なる速筋線維および遅筋線維を対象に SSC を行い，SSC のメカニズムを検証した．大腰筋（速筋線維）とヒラメ筋（遅筋線維）の単一筋細胞を対象に，伸張性収縮の後に短縮性収縮を行う SSC 試行，等尺性収縮の後に短縮性収縮を行う Control 試行を行った．また，タイチンの弾性が SSC 効果に与える影響を検証するため，伸張性収縮の後に等尺性収縮を行う residual force enhancement 試行，等尺性収縮のみを行う Control 試行を実施した．その結果，SSC 効果はヒラメ筋にて大きかった．一方，タイチンの弾性に関連している RFE は筋間に差はなかった．したがって，筋線維タイプ間でみられた SSC 効果の違いは，タイチンではなくクロスブリッジの弾性によるものだと考えられる．