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Predictions of antagonistic muscular activity using nonlinear optimization. (English)

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Summary: Optimization theory is used more often than any other method to predict individual muscle forces in human movement. One of the limitations frequently associated with optimization algorithms based on efficiency criteria is that they are thought to not provide solutions containing antagonistic muscular forces; however, it is well known that such forces exist. Since analytical solutions of nonlinear optimization algorithms involving multi-degree-of-freedom models containing multijoint muscles are not available, antagonistic behavior in such models is not well understood.

The purpose of this investigation was to study antagonistic behavior of muscles analytically, using a three-degree-of-freedom model containing six one-joint and four two-joint muscles. We found that there is a set of general solutions for a nonlinear optimal design based on a minimal cost stress function that requires antagonistic muscular force to reach the optimal solution. This result depends on a system description involving multijoint muscles and contradicts earlier claims made in the biomechanics, physiology, and motor learning literature that consider antagonistic muscular activities inefficient.

MSC:

92C10 Biomechanics

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Keywords:

human movement; optimization algorithms; antagonistic muscular forces; three-degree-of-freedom model; general solutions; nonlinear optimal design; minimal cost stress function; multijoint muscles

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