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Musculoskeletal Biomechanics in Cross-country Skiing

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Abstract

Why copy the best athletes? When you finally learn their technique, they may have already moved on. Using muscluloskeletal biomechanics you might be able to add the "know-why" so that you can lead, instead of being left in the swells.

This dissertation presents the theoretical framework of musculoskeletal modeling using inverse dynamics with static optimization. It explores some of the possibilities and limitations of musculoskeletal biomechanics in cross-country skiing, especially double-poling. The basic path of the implementation is shown and discussed, e.g. the issue of muscle model choice. From that discussion it is concluded that muscle contraction dynamics is needed to estimate individual muscle function in double-poling. Several computer simulation models, using The Anybody Modeling System™, have been created to study different cross-country skiing applications. One of the applied studies showed that the musculoskeletal system is not a collection of discrete uncoupled parts because kinematic differences in the lower leg region caused kinetic differences in the other end of the body. An implication of the results is that the kinematics and kinetics of the whole body probably are important when studying skill and performance in sports. Another one of the applied studies showed how leg utilisation may affect skiing efficiency and performance in double-poling ergometry. Skiing efficiency was defined as skiing work divided by metabolic muscle work, performance was defined as forward impulse. A higher utilization of the lower-body increased the performance, but decreased the skiing efficiency. The results display the potential of musculoskeletal biomechanics for skiing efficiency estimations. The subject of muscle decomposition is also studied. It is shown both analytically and with numerical simulations that muscle force estimates may be affected by muscle decomposition depending on the muscle recruitment criteria. Moreover, it is shown that proper choices of force normalization factors may overcome this issue. Such factors are presented for two types of muscle recruitment criteria.

To sum up, there are still much to do regarding both the theoretical aspects as well as the practical implementations before predictions on one individual skier can be made with any certainty. But hopefully, this disseration somewhat furthers the fundamental mechanistic understanding of cross-country skiing, and shows that musculoskeletal biomechanics will be a useful complement to existing experimental methods in sports biomechanics.