Towards a general cost function for bouncing gaits

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Motivation: The metabolic cost of locomotion is commonly partitioned into the metabolic cost of doing work and the metabolic cost of producing force. However, it is not entirely clear which aspect of force production is most important in determining the metabolic cost of bouncing gaits. Direct metabolic assessment of running suggests that the cost/time of muscle force production is determined by either average muscle force (cost/gait cycle is proportional to muscle impulse)[1] or muscle force rate (cost/gait cycle is proportional to muscle force)[2], while direct metabolic assessment of ankle bouncing suggests that the metabolic cost/time of producing force is determined by force rate/time (cost/gait cycle is proportional to force rate)[3]. We wanted to determine the extent to which these three aspects of force production influence the metabolic cost of human hopping across a broad range of testing conditions.

State of Art: Generally metabolic cost is measured under one set of partially-constrained testing constraints – most commonly speed-constrained (treadmill) for running and frequency-constrained (metronome) for hopping. However, one downfall of this approach is that only one small cross section of the metabolic landscape is examined in a given study. Therefore, if one formulates a cost function based on one such study, one runs the risk of formulating a cost function that fits a small cross section of data quite well but fits the whole cost landscape rather poorly.

Own Approach to the Question: To minimize this problem, we directly measured the metabolic cost of hopping over a wide range of hop height hop frequency combinations to create a metabolic cost surface and compared this to the predictions of hypothetical cost functions that included terms to account for the metabolic cost of work and all three aspects of force production. We chose to study human hopping because hopping employs the same basic bouncing movement used in running without the mechanical complications of forward translation and leg swinging. We found that the metabolic cost/time of hopping is best described by average muscle force alone and that including terms for muscle force rate and force rate/time does not improve the fit of the cost function substantially.

Discussion Outline:
- Can we predict the activity and testing conditions under which a given aspect of force production will dominate metabolic cost?
- What is the best way to formulate a generalized cost function that describes the metabolic cost of all bouncing gaits and testing conditions equally well?
- Is finding a general cost function important?

Keywords: hopping, running, metabolic cost

References

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