Optimization of running strategies based on anaerobic energy and variations of velocity

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Abstract

We present new models, numerical simulations and rigorous analysis for the optimization of the velocity in a race. In a seminal paper, Keller (1973,1974) explained how a runner should determine his speed in order to run a given distance in the shortest time. We extend his analysis, based on the equation of motion and aerobic energy, to include a balance of anaerobic energy (or accumulated oxygen deficit) and an energy recreation term when the speed decreases. We obtain a proof of Keller's optimal race, and relate the problem to a relaxed formulation. Our analysis leads us to introduce a bound on the variations of the propulsive force to obtain a more realistic model which displays oscillations of the velocity. Our numerical simulations qualitatively reproduce physiological measurements.Optimizing over a period, we recover these oscillations of speed.

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References

[1] J.F. Bonnans and A. Aftalion, *Optimization of running strategies based on anaerobic energy and variations of velocity*, Rapport de Recherche INRIA 8344, Aug. 2013.