Force-Velocity-Endurance profile in running: How a good RACLET sheds light on humans and chamois' uphill locomotion?

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Résumé

Introduction

In a mountain environment, locomotion performances result from the interactions between environmental external constraints and muscular capacities, the latter being partly governed by two fundamental relationships. First, maximal velocity is limited by the force required for propulsion (linear decreasing Velocity-Force relationship; V(F); Samozino et al., 2016). When running uphill, the higher the gradient (α), the greater the propulsive force demands (F=m.g.sin(α)), the lower the velocity. Then, maximal velocity also depends on exercise durations (decreasing, convergent Velocity-Time relationship; V(t); Kramer et al., 2020). Although often considered separately, the V(F) and V(t) relationships interferes, the interindividual variability in the effect of gradient on endurance capacities remaining unclear. Interactions between the two relationships has been observed for discrete gradient/force or fatigability conditions but never modelled over a continuum (Carter & Dekerle, 2013). Thus, we propose a V(F,t) relationship that can be described by four parameters: V0i and V0c the theoretical maximal and critical velocity on flat ground; F0i, and F0c the theoretical propulsive force up to which it is possible to move in a fresh and exhausted state respectively. The objectives were i) to characterise individual V(F,t) relationships (Force-Velocity-Endurance profiles) on flat ground using loaded sleds, and ii) to test their prediction capacity of uphill running performances.

Method

Twenty-six participants (22.6±3.00yo, 1.75±0.08m, 64.9±7.17kg) completed 4 sessions interspersed by 48-h rest. The 3 first sessions aimed at assessing individual V(F,t) relationships. Participants performed 2 running sprints and a Ramp Above Critical Level Endurance Tests (RACLET) in 5 resistance conditions imposed by a loaded sled (simulating 0, 6, 12, 18, and 24% slopes). Each RACLET consisted in a 5-min decreasing velocity ramp with 3-s sprints every 30s to assess maximal velocity (18Hz, GPexe). Maximal velocities were adjusted with a V(t) model to obtain Vi and Vc in each force condition (Bowen et al., 2024). V(F,t) relationship was fitted from RACLET parameters to obtain V0i, F0i, V0c, and F0c. Last session consisted in a Time-Trial (TT) at randomly fixed gradient (between 4 and 22%) and distance (between 400 and 2420m). Median(Interquartile-range) r^2 was calculated for Vi(F) and Vc(F) relationships. Individuals' parameters were used as input in Bowen et al. (2024) model to predict TT performances. Prediction accuracy was quantified through mean±SD differences and correlation between predicted and actual performances.

*Intervenant

Results

Vi(F) and Vc(F) relationships were accurately modelled with a linear function (r^2=0.94(0.93;0.96) and 0.96(0.95;0.98) respectively, V0i=7.8±0.5m.s-1; F0i=6.3±1.0N.kg-1; V0c=4.0±0.5m.s-1; F0c=3.3±0.3N.kg-1). TT performances were predicted with small errors (mean difference of 13.0±54.3s, 2.80±11.9%) for TT lasting from 69.2 to 902s. Prediction were highly correlated with actual performances (r=0.976, p< 0.001).

Discussion

Uphill running endurance capacities can be well characterized by Vc(F) linear relationship and present high interindividual variability. Although obtained from level ground resisted running tests, the Vc(F) relationship accurately predicted maximal performances uphill.

Conclusion/Perspectives

RACLET is a non-exhaustive test that provides valid running Force-Velocity-Endurance profiles when repeated in different force/resistance conditions. This improves our understanding of locomotion in different environments. As it is possible to determine uphill running performances from the Force-Velocity-Endurance profile, it is also possible to characterise the Force-Velocity-Endurance profile from data recovered from the field. This makes possible characterisation of the profile of runners from training data, but also more broadly in the understanding of animal locomotion, to characterise the FoVE profile of chamois equipped with GPS, bringing insights about the interaction between their behaviour and their capacities. This is how a good RACLET sheds light on humans and chamois' uphill locomotion.

References

Bowen, M., Samozino, P., Vonderscher, M., Dutykh, D., & Morel, B. (2024). Mathematical modelling of exercise fatigability in the severe domain: A unifying integrative framework in isokinetic condition. *Journal of Theoretical Biology*, *578*.

Carter, H., & Dekerle, J. (2013). Change in critical speed but not its associated metabolic rate when manipulating muscle contraction regimen: Horizontal vs. uphill treadmill running. *Science and Sports*, *28*(6).

Kramer, M., Thomas, E. J., & Pettitt, R. W. (2020). Critical speed and finite distance capacity: norms for athletic and non-athletic groups. *European Journal of Applied Physiology*, *120*(4).

Samozino, P., Rabita, G., Dorel, S., Slawinski, J., Peyrot, N., Saez de Villarreal, E., & Morin, J. B. (2016). A simple method for measuring power, force, velocity properties, and mechanical effectiveness in sprint running. *Scandinavian Journal of Medicine and Science in Sports*, *26*(6).