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Conference abstract

EFRT: A realistic model of human exercise, fatigue and recovery

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Abstract: We discuss mathematical models for endurance exercise. Such models are needed to accurately assess athletes' fitness (e.g. for guiding training or identifying talent); and to predict performances (e.g. for optimising race strategies and pacing in track-cycling events).

So-called *W′-balance* models, based around the "critical power" paradigm, are the current state-of-the-art. Unfortunately, W′-balance models cannot account for many essential qualitative features ("stylised facts") of endurance exercise. For instance, they fail to adequately capture that: (a) low ("heavy" or "moderate") exercise intensities cannot be sustained indefinitely; (b) pacing impacts exercise tolerance; (c) exercise modality affects subsequent recovery; (d) fatigue from prolonged exercise changes the power–duration relationship (a.k.a. the *"durability"* concept).

We introduce the *exercise, fatigue and recovery tracking (EFRT)* model – a novel and rigorous framework for endurance exercise which is more realistic than W′-balance models in the sense that it can capture all the above-mentioned stylised facts of endurance exercise (and many more).

The fact that the EFRT model captures these stylised facts (while W′-balance models do not) is a mathematical property and thus not investigable through experimentation. Nonetheless, since the power–duration relationship under the EFRT model follows a power law, empirical evidence from thousands of athletes, including runners, cyclists, swimmers and rowers in [1–5] immediately shows that the EFRT model more accurately predicts the time to exhaustion than W′-balance models – and at a much wider range of exercise intensities.

Despite its realistic behaviour, the EFRT model is still highly parsimonious: it requires only a small number of parameters and all of these have meaningful interpretations: they represent speed, endurance, durability, and recovery.

Keywords: fatigue; recovery; durability; performance prediction; critical power; *W′*-balance modelling.

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