J Appl Physiol 139: 1716–1717, 2025.
doi:10.1152/japplphysiol.00694.2025

american physiological society | JOURNAL OF APPLIED PHYSIOLOGY

LETTER TO THE EDITOR

Viewpoint: Durability, Fatigability, Repeatability, and Resilience in Endurance Sports: Definitions, Distinctions, and Implications

Integrating biomechanics into endurance performance frameworks: an urgent need

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TO THE EDITOR: We read with interest the recent Viewpoint by Meixner et al. (1), which proposes a conceptual expansion of endurance performance through four constructs: durability, fatigability, repeatability, and resilience. The authors rightly point out that the classical physiological markers are insufficient to fully account for individual differences in performance, particularly in competitive settings involving prolonged or repeated efforts. In response, they advocate for a multidimensional framework to better capture the complexity of endurance across disciplines and situations.

Yet, like many performance models, we believe that it remains incomplete without incorporating biomechanical parameter factors. The proposed variables focus almost exclusively on energetic input, the "fuel" delivered to the system, but overlook the mechanical output: how that fuel is transformed into movement (2). This oversight reflects a broader trend in exercise physiology: the near-absence of biomechanics in defining and evaluating endurance performance.

Running economy is sometimes treated as a proxy for output, but it merely reflects the metabolic cost of maintaining a certain speed. Does an average pace of 14 km/h truly reflect the mechanical work performed? Two runners may reach this speed using vastly different strategies, resulting in distinct muscular demands and fatigue profiles [as humorously illustrated in *Friends* (Season 6, Episode 7), where Rachel Green and Phoebe Buffay run side by side with radically different running patterns]. Despite such variability, none of the constructs currently describe how muscles and joints generate or adapt movement under stress.

This becomes even more relevant when applied beyond elite runners. Among trained athletes, movement patterns most likely tend to converge toward efficiency. But across sports, or among less experienced individuals, gait strategies can diverge widely (3). More importantly, fatigue amplifies biomechanical differences. Indeed, prolonged or repeated efforts inevitably alter neuromuscular control, coordination, and the mechanical properties of biological tissues (4). In response, athletes may unconsciously adjust their movement strategies, shifting from performance-oriented patterns to more protective ones that prioritize joint integrity or stability. Such biomechanical adaptations are likely to vary between individuals depending on experience, injury risk, and internal factors such as perceived effort. Yet, these responses are rarely captured by traditional physiological indicators.

Recent findings reinforce this idea: manipulating perceived time through visual feedback can alter the trajectory of physical fatigue, independently of actual exertion (5). To better characterize these dynamics, future work should leverage models that account for individual changes in mechanical output and also subjective state. Such models could help identify which variables are prioritized under different types of stress, offering a more comprehensive view of how endurance is constructed and maintained.

The framework proposed by Meixner et al. (1) represents a valuable step forward in clarifying key constructs underlying endurance performance, laying the groundwork for more nuanced assessment and individualized training strategies. We believe the next step is to extend this framework by incorporating biomechanical descriptors alongside perceptual and cognitive factors that influence how fatigue is experienced and managed. We hope that future work will bridge these complementary domains to offer a more complete and mechanistic understanding of endurance. Mechanical factors such as spatiotemporal parameters, lower-limb stiffness, and work and power done to move the body in space not only shape the energetic cost of locomotion but also influence how fatigue is perceived and managed. We hope that future work will bridge these complementary domains—energetic, mechanical, and perceptual—to offer a more complete and mechanistic understanding of endurance.

DISCLAIMERS

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Submitted 24 July 2025 / Revised 17 September 2025 / Accepted 25 September 2025

DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the authors.

AUTHOR CONTRIBUTIONS

A.H.D. drafted manuscript; A.H.D., V.K., and R.M.M. edited and revised manuscript; A.H.D., V.K., and R.M.M. approved final version of manuscript.

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