



# Hysteresis Area of Psychobiological Variables. A New Non-Invasive Biomarker of Effort Accumulation?

Lluc Montull<sup>1</sup>, Óscar Abenza<sup>2</sup>, Robert Hristovski<sup>3</sup> & Natàlia Balagué<sup>4</sup>

<sup>1</sup>Complex Systems in Sport Research Group. National Institute of Physical Education of Catalonia (INEFC), University of Lleida (UdL), La Seu d'Urgell (Spain).

<sup>2</sup>Complex Systems in Sport Research Group. Faculty of Medicine, University of Barcelona (UB) (Spain).

<sup>3</sup>Complex Systems in Sport Research Group, Faculty of Physical Education, Sport and Health, Ss. Cyril and Methodius University in Skopje, Skopje (Macedonia).

<sup>4</sup>Complex Systems in Sport Research Group. National Institute of Physical Education of Catalonia (INEFC), University of Barcelona (UB) (Spain).



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## \*Corresponding author:

Natàlia Balagué  
[nbalague@gencat.cat](mailto:nbalague@gencat.cat)

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A young sprinter prepares herself with a track series to work on her explosiveness. @Jérôme Aufort/Adobestock

## Abstract

The hysteresis area, which reflects the history-dependency of psychobiological parameters, has been recently suggested as a new non-invasive marker of exercise stress and tolerance. However, its promising applications are still underexplored. This study aims to test if the hysteresis area of the perceived exertion (RPE), heart rate (HR), and muscle oxyhaemoglobin concentration (muscle O<sub>2</sub>Hb) are sensitive to effort accumulation over multiple bouts of running exercise. Ten physical education students performed five consecutive running bouts at maximal aerobic velocity. The consecutive bouts started when participants reported at least an RPE ≤ 11 (Borg's 6-20 scale). The hysteresis areas of RPE, HR, and muscle O<sub>2</sub>Hb were calculated for each bout, and their magnitude was compared using Friedman ANOVA and Wilcoxon test. Effect sizes were calculated through Cohen's *d*. The hysteresis areas of all studied variables changed between the initial and final bouts: RPE and HR increased (between bouts 1-4:  $Z = -1.99, p = .04$ ;  $Z = -2.19, p = .03$ , respectively), and muscle O<sub>2</sub>Hb decreased (between bouts 1-4:  $Z = -2.80, p < .01$ ). Large effect sizes ( $d = 1.22 - 1.81$ ) were found in HR between bouts 1-4, 1-5, 2-4, 2-5, and muscle O<sub>2</sub>Hb between bouts 1-4 and 1-5. The results showed that the hysteresis areas of RPE, HR, and muscle O<sub>2</sub>Hb were sensitive to effort accumulation during repeated running exercises performed at maximal aerobic velocity. Despite further research is warranted, the hysteresis area of psychobiological variables points towards being a sensitive biomarker for monitoring acute fatigue.

**Keywords:** complex adaptive systems, fatigue, history-dependency, recovery efficiency, sports monitoring, training.