Submission is in reply to the Letter to the Editor by Dr. Broxterman, manuscript number JAPPL-00759-2015.

Title: Reply to Broxterman, Richardson and Amann

Authors: Johnson MA[1], Sharpe GR[1], Williams NC[1], Hannah R[2]

Affiliations: [1]Sport, Health and Performance Enhancement (SHAPE) Research Group, Department of Sports Science, School of Science and Technology, Nottingham Trent University, Nottingham, UK; [2]Sobell Department of Motor Neuroscience and Movement Disorders, Institute of Neurology, University College London, London, UK.

Corresponding Author:

Dr Michael A Johnson, School of Science and Technology, Nottingham Trent University, Nottingham, NG11 8NS, UK

Telephone: +44 (0)115 8483362

Fax: +44 (0)115 8486680

E-mail: Michael.johnson@ntu.ac.uk

TO THE EDITOR: We thank Broxterman and colleagues for their comments regarding our recent work on the effects of prior upper body exercise on subsequent cycling exercise tolerance and associated changes in neuromuscular function and perceptual responses (3).

Previous studies suggested that prior upper body exercise reduces subsequent knee extensor and cycling exercise tolerance by accelerating the development of quadriceps muscle fatigue. The stated aim of our study was to test the hypothesis that prior upper body exercise reduces subsequent cycling exercise tolerance and that this is associated with less peripheral locomotor muscle fatigue incurred but a greater/accelerated perceptual response. Using prior arm-cranking exercise followed by leg cycling exercise performed to the limit of tolerance ensured that our study was appropriately designed to address this research question and our data confirmed our hypothesis. Thus, it is important to clarify that (contrary to the critique of Broxterman and colleagues) our aim was not to evaluate the validity of the critical threshold of peripheral fatigue concept. Furthermore, we do not conclude that our data “disprove” this concept.

A key finding of our study was that individuals experience less peripheral locomotor muscle fatigue after cycling exercise to the limit of tolerance preceded by upper body exercise. Our study therefore extends the observations of single-leg knee extension exercise studies (1) by demonstrating that peripheral fatigue *per se* is not a variable that is *independently* regulated during whole-body exercise. Rather, our findings indicate an important limiting role for the ensemble group III/IV muscle afferent feedback in mediating exercise tolerance, since it can be assumed that prior upper body exercise results in an elevated ensemble group III/IV muscle afferent feedback at the start of subsequent cycling exercise (2). Our data suggest that the limit of exercise tolerance is largely determined by the attainment of a critical sensory tolerance limit that is primarily mediated by the ensemble group III/IV muscle afferent feedback and which coincides with, but is not exclusively mediated by or reflective of, a certain degree of peripheral locomotor muscle fatigue. This notion is supported by three observations from our study: (1) ratings of leg discomfort during cycling were higher despite quadriceps muscle activation being unaffected by prior upper body exercise; (2) ratings of leg discomfort during cycling were higher despite less quadriceps muscle fatigue incurred when cycling was preceded by upper body exercise; and (3) the reduced cycling exercise tolerance after prior upper body exercise was correlated with accelerated increases in ratings of leg discomfort and dyspnea. These findings are important because they indicate that potentially limiting perceptions of leg discomfort during cycling exercise may be potentiated by group III/IV afferent projections originating at remote sites.

To conclude, our data shed light on the determinants of whole-body exercise tolerance and the mechanisms by which prior upper body exercise reduces subsequent cycling exercise tolerance. The notion that individuals cannot surpass a task-specific maximum level of peripheral fatigue was not the focus of our study and, therefore, remains an exciting avenue for future investigation.

Disclosures: The authors report no conflicts of interest.

Author contributions: M.A.J. drafted manuscript; M.A.J., G.R.S., N.C.W., and R.H. edited and revised manuscript; M.A.J., G.R.S., N.C.W., and R.H approved final version of manuscript.

References

1. Amann M, Venturelli M, Ives SJ, McDaniel J, Layec G, Rossman MJ, Richardson RS. Peripheral fatigue limits endurance exercise via a sensory feedback-mediated reduction in spinal motoneuronal output. *Journal of Applied Physiology*: 115, 355-364, 2013.
2. Jammes Y, Balzamo E. Changes in afferent and efferent phrenic activities with electrically induced diaphragmatic fatigue. *Journal of Applied Physiology*: 73, 894-902, 1992.
3. Johnson MA, Sharpe GR, Williams NC, Hannah R. Locomotor muscle fatigue is not critically regulated after prior upper body exercise. *Journal of Applied Physiology*: 119, 840-850, 2015.