



UNIVERSITY OF LEEDS

This is a repository copy of *Last Word on Viewpoint: Principles, insights, and potential pitfalls of the noninvasive determination of muscle oxidative capacity by near-infrared spectroscopy*.

White Rose Research Online URL for this paper:  
<http://eprints.whiterose.ac.uk/121482/>

Version: Accepted Version

---

**Article:**

Adami, A and Rossiter, HB [orcid.org/0000-0002-7884-0726](https://orcid.org/0000-0002-7884-0726) (2018) Last Word on Viewpoint: Principles, insights, and potential pitfalls of the noninvasive determination of muscle oxidative capacity by near-infrared spectroscopy. *Journal of Applied Physiology*, 124 (1). p. 256. ISSN 8750-7587

<https://doi.org/10.1152/jappphysiol.00856.2017>

---

© 2018 the American Physiological Society. This is an author produced version of a paper published in *Journal of Applied Physiology*. Uploaded in accordance with the publisher's self-archiving policy.

**Reuse**

Items deposited in White Rose Research Online are protected by copyright, with all rights reserved unless indicated otherwise. They may be downloaded and/or printed for private study, or other acts as permitted by national copyright laws. The publisher or other rights holders may allow further reproduction and re-use of the full text version. This is indicated by the licence information on the White Rose Research Online record for the item.

**Takedown**

If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing [eprints@whiterose.ac.uk](mailto:eprints@whiterose.ac.uk) including the URL of the record and the reason for the withdrawal request.



[eprints@whiterose.ac.uk](mailto:eprints@whiterose.ac.uk)  
<https://eprints.whiterose.ac.uk/>

1 **Last Word on Viewpoint: Principles, Insights and Potential Pitfalls of the Non-**  
2 **Invasive Determination of Muscle Oxidative Capacity by Near-Infrared**  
3 **Spectroscopy**

4

5 Alessandra Adami and Harry B. Rossiter

6

7 Rehabilitation Clinical Trials Center, Division of Respiratory and Critical Care  
8 Physiology and Medicine, Los Angeles Biomedical Research Institute at Harbor-  
9 UCLA Medical Center, Torrance, CA, USA

10

11

12

13

14 **CORRESPONDING AUTHOR:**

15 Alessandra Adami

16 Division of Respiratory & Critical Care Physiology & Medicine

17 Los Angeles Biomedical Research Institute at Harbor-UCLA Medical Center

18 1124 W Carson St., CDCRC Building

19 Torrance, CA 90502

20 USA

21

22 E-mail: [aadami@labiomed.org](mailto:aadami@labiomed.org)

23

24 TO THE EDITOR: We thank the authors for their insightful contributions to  
25 the discussion on use of the NIRS muscle oxidative capacity test. Several good points  
26 were raised: here we develop three general themes that emerged.

27 There is ongoing concern about the potential influence of skin blood flow  
28 (BF) on the measurement and the ability of NIRS to assess skeletal muscle in obese  
29 individuals. Naturally, the NIRS muscle oxidative capacity test relies on sufficient  
30 diffusion of light to reach muscle tissue. Skin BF, melanin content and adipose  
31 thickness may each affect the validity of this assumption (1). However, the method  
32 is effective in isolating the muscle compartment, because it relies upon oxygen  
33 consumption ( $m\dot{V}O_2$ ) recovery kinetics that is induced by brief, low intensity, muscle  
34 contractions. Thus, if these conditions are met, they obviate the potential influence  
35 of skin BF on the  $m\dot{V}O_2$  recovery rate constant ( $k$ ) estimation. High-power time-  
36 resolved (TRS) NIRS (4) is a developing method that increases the depth sensitivity  
37 of NIRS. This technique may overcome difficulty in assessing  $m\dot{V}O_2$  in muscles  
38 where light absorption or the covering adiposity is large. In addition, as deeper  
39 muscles have greater type I fiber expression (3), high-power TRS NIRS provides the  
40 opportunity to assess  $k$  in wider range of muscles and fiber compositions compared  
41 to other NIRS systems.

42 The influence of muscle BF on  $k$  remains another concern. The NIRS muscle  
43 oxidative capacity test requires that BF is occluded, such that measurement validity  
44 depends on: a) ceasing convective  $O_2$  delivery and; b) a  $PO_2$  that does not limit  $m\dot{V}O_2$   
45 (1). We, as others, believe that the method benefits from its simplicity, especially in  
46 the clinical setting. The addition of, for example, Doppler ultrasound to verify BF  
47 occlusion is unlikely to bring significant improvement. The question remains open,  
48 however, of what is the necessary  $PO_2$  (or tissue saturation) to ensure that the  
49 method effectively 'isolates' the intramuscular compartment, and that it is not  
50 influenced by capillary-myocyte  $O_2$  diffusion. It is typically recommended to  
51 maintain tissue saturation >50% of the physiologic normalization range (1,5). On  
52 the other hand, the method could be effectively adapted to investigate the  
53 integrated muscle  $O_2$  transport and utilization response, providing additional

54 information in disease states or interventional studies beyond muscle oxidative  
55 capacity alone.

56         Muscle oxidative capacity is one property of muscle that has heretofore been  
57 complex to assess. The ability to quantify  $k$  using a simple, potentially automated,  
58 system provides an advance in our ability to investigate the strong associations  
59 among muscle mitochondrial function, health and longevity. Oxidative capacity is,  
60 however, a single piece in the puzzle that drives this association, together with  
61 phosphorylative capacity, coupling (P/O ratio) and reactive oxygen species  
62 production, among other mitochondrial functions. These latter currently require  
63 more complex methods, including biopsy or combined optical and magnetic  
64 resonance spectroscopy approaches (e.g. 2). Nevertheless, the relatively simple,  
65 validated and reproducible, NIRS-based assessment outlined in the Viewpoint offers  
66 a first step towards a widely-applicable analysis of muscle mitochondrial function in  
67 health, aging and disease.

68

69 **DISCLOSURES**

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

71

72 **AUTHORS CONTRIBUTIONS**

73 A.A. drafted manuscript; A.A. and H.B.R. edited and revised manuscript; A.A. and

74 H.B.R. approved final version of the manuscript.

75

76 **REFERENCES**

- 77 1. **Adami A, Cao R, Porszasz J, Casaburi R, Rossiter HB.** Reproducibility of NIRS  
78 assessment of muscle oxidative capacity in smokers with and without COPD.  
79 *Respir Physiol Neurobiol* 235: 18-26, 2017.
- 80 2. **Amara CE, Marcinek DJ, Shankland EG, Schenkman KA, Arakaki LSL,**  
81 **Conley KE.** Mitochondrial function *in vivo*: Spectroscopy provides window on  
82 cellular energetics. *Methods* 46: 312-318, 2008.
- 83 3. **Johnson MA, Polgar J, Weightman D, Appleton D.** Data on the distribution of  
84 fibre types in thirty-six human muscles. An autopsy study. *J Neurol Sci* 18: 111-  
85 129, 1973.
- 86 4. **Koga S, Barstow TJ, Okushima D, Rossiter HB, Kondo N, Ohmae E, Poole**  
87 **DC.** Validation of a high-power, time-resolved, near-infrared spectroscopy  
88 system for measurement of superficial and deep muscle deoxygenation during  
89 exercise. *J Appl Physiol* 118(11): 1435-1442, 2015.
- 90 5. **Southern WM, Willingham TB, McCully KK.** Impact of Post-Exercise Muscle  
91 Oxygen Saturation Levels on Measurements of Metabolic Rate Measured with  
92 Near Infrared Spectroscopy. *Med Sci Sports Exerc* 47(5S): 291, 2015.