Oxygen consumption in the whole body and the local muscles

K. Skovereng, G. Ettema and MCP. van Beekvelt.

Center for elite sports research, Department Neuroscience, Norwegian University of Science and Technology, Trondheim, Norway.

Introduction
Oxygen consumption (VO₂) for whole body as well as regionally in the legs, has been shown to increase linearly with external work (2). Measuring VO₂ directly in specific muscles is more complicated and has been studied to a far less extent. Studies have reported heterogeneity in muscle recruitment during exercise with increasing intensity (1) which may indicate difference in the VO₂ of specific muscles in relation to external work. The purpose of this study was to investigate the relationship between pulmonary O₂ uptake (pVO₂) and localized muscle VO₂ (mVO₂) measured simultaneously by pulmonary gas exchange and near-infrared spectroscopy (NIRS) during cycling exercise at various constant-load work rates.

Methods
18 trained male subjects (VO₂peak 55.9 ± 4.5 ml/kg/min) performed an incremental exercise protocol on a cycle ergometer with 5 or 6 5-min workloads. NIRS was used to measure changes in oxy- and deoxyhemoglobin in the right mm. vastus medialis (VM) and lateralis (VL) during cycling while a short-duration vascular occlusion was used to determine mVO₂. The experimental setup can be seen in figure 1. Both mVO₂ and pVO₂ were normalized to their maximum values in order to compare the results.

Results
- A linear increase was found between pVO₂ and work rate.
- A different response was seen for mVO₂ with a significantly faster initial increase at lower work rates (from 100 W to 150 W) when compared to the increase in pVO₂ (p < 0.001) (figure 3).
- At higher work rates (200-300 W), the increase in mVO₂ leveled off and was significantly lower than that of pVO₂ (from 200 to 250 W: p < 0.01 and from 250 to 300 W: p < 0.001) (figure 3).

Discussion
The main finding of the present study was a significantly different effect of work rate on mVO₂ as compared to pVO₂. The steep initial increase in mVO₂ of both VM and VL muscles indicate that they are probably two of the primary contributors to the total work rate at low intensity. During the increase to high intensity, no additional increase in mVO₂ is seen, which might indicate that although the VM and VL remain active, they probably reached their peak VO₂ and the increased work rate may have been met by increased contribution from other muscles (e.g. hamstrings and gluteals) and anaerobic metabolism. However, measurements of additional muscles are necessary for a more definitive conclusion. The results of the present study indicate that caution should be taken when interpreting pVO₂ as an indication of what happens in the local muscles. In addition, improved knowledge regarding metabolic heterogeneity of power producing muscles may beneficial for optimizing performance for athletes.

References