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The effects of sustained exercise and hypoxia upon oxygen tensions in the red muscle of rainbow trout

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Abstract:

Teleost fish possess discrete blocks of oxidative red muscle (RM) and glycolytic white muscle, whereas tetrapod skeletal muscles are mixed oxidative/glycolytic. It has been suggested that the anatomy of RM in teleost fish could lead to higher intramuscular O_2 partial pressures (Po_2) than in mammalian skeletal muscles. This study provides the first direct experimental support for this suggestion by using novel optical fibre sensors to discover a mean (± S.E.M., N=6) normoxic steady-state red muscle Po_2 ($PRMo_2$) of 61±10 mmHg (1 mmHg=133.3 Pa) in freeswimming rainbow trout *Oncorhynchus mykiss*. This is significantly higher than literature reports for mammalian muscles, where the Po_2 never exceeds 40 mmHg. Aerobic RM powers sustained swimming in rainbow trout. During graded incremental exercise, PRM_{02} declined from 62±5 mmHg at the lowest swim speed down to 45±3 mmHg at maximum rates of aerobic work, but then rose again to 51±5 mmHg at exhaustion. These measurements of $PRMo_2$ during exercise indicated, therefore, that O_2 supply to the RM was not a major limiting factor at exhaustion in trout. The current study found no evidence that teleost haemoglobins with a Root effect cause extremely elevated O_2 tensions in aerobic tissues. Under normoxic conditions, $PRMo_2$ was significantly lower than arterial P_{02} (119±5 mmHg), and remained lower when the arterial to tissue Po_2 gradient was reduced by exposure to mild hypoxia. When two sequential levels of mild hypoxia (30 min at a water Po_2 of 100 mmHg then 30 min at 75 mmHg) caused Pao_2 to fall to 84±2 mmHg then 61±3 mmHg, respectively, this elicited simultaneous reductions in $PRMo_2$, to 51±6 mmHg then 41±5 mmHg, respectively. Although these hypoxic reductions in $PRMo_2$ · were significantly smaller than those in PaO_2, the effect could be attributed to the sigmoid shape of the trout haemoglobin–O_2 dissociation curve.

Key-words: O_2-sensitive optode, Root effect, O_2 partial pressure, arterial blood O_2 content, O_2 consumption, swimming