

**THE EFFECT OF STRENUOUS EXERCISE AND  $\beta$ -ADRENERGIC  
BLOCKADE ON THE VISUAL PERFORMANCE OF JUVENILE  
RAINBOW TROUT, *ONCORHYNCHUS MYKISS***

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**EXTENDED ABSTRACT ONLY- DO NOT CITE**

A wide variety of stressors are known to increase the susceptibility of fish to predation. The underlying causal mechanisms remain poorly understood but a stress-related disruption to the visual sense has been hypothesised (Mesa et al., 1994).

Rainbow trout, in common with many other teleosts, possess Root effect haemoglobins that have reduced oxygen-carrying capacities under conditions of low pH. The physiological significance of this effect is strongly linked with the choroid rete mirabile that generates an extremely high partial pressure of oxygen within the ocular fluids ( $PO_2 = 445$  mmHg)(Pelster and Randall, 1998).

An extreme bout of strenuous exercise can significantly affect the blood-oxygen transport of trout because the partial pressure of oxygen and pH of arterial blood is reduced (Milligan and Wood, 1987). A significant drop in arterial Hb- $O_2$  binding (27 - 32 %) is expected in the absence of  $\beta$ -adrenergic responses. It is hypothesised that these post-exercise responses will be a liability to high ocular  $PO_2$  due to the restricted binding of oxygen at the gills, premature Hb- $O_2$  dissociation within the arterial blood supply of the choroid rete, and the diffusive shunt of unbound oxygen to the venous capillaries involved in counter-current exchange (Pelster and Randall, 1998).

Given that high levels of ocular PO<sub>2</sub> are necessary for trout retinal functions (Fonner et al., 1973), the present study has examined the effect of strenuous exercise on the visual performance of the rainbow trout.  $\beta$ -adrenergic blockade was also used as a tool to assess the potential role of red cell volume regulation in maintaining Hb-O<sub>2</sub> affinity and hence the visual performance of fish post-exercise.

The ability to resolve moving objects, as an ecologically relevant form of visual performance, was determined behaviourally using the optomotor response. Fish that are able to resolve high contrast objects on a moving background exhibit an optomotor response by behaviourally orientating with the background in an attempt to stabilise an image on the retina (Douglas and Hawryshyn, 1990). Fish were contained within a clear, circular holding tank and were exposed separately to 5 visual backgrounds that encircled the tank at 4 revs min<sup>-1</sup>. The high contrast backgrounds consisted of alternating black and white bars that subtended different visual angles (i.e. 60, 120, 180, 240 and 300 min of arc) on the fishes' eye. Fish were also exposed to a control white background (i.e. 0 min of arc). The behavioural response of fish to the moving backgrounds was monitored over a 3 min period and the magnitude of the optomotor response was quantified according to angular swimming velocity (net revolutions min<sup>-1</sup>). The optomotor response threshold was defined as the minimum visual angle required to induce a significant optomotor response (with respect to control (i.e. 0 min of arc) reactions).

Two experiments were conducted to examine the effect of strenuous exercise (Experiment 1) as well as  $\beta$ -adrenergic blockade (Experiment 2) on the optomotor response threshold of juvenile trout (Mean wt  $\pm$  S.D., 14.0  $\pm$  1.8 g). The behavioural optomotor response of individual fish was therefore screened in a relative "resting", "post-exercise" and "post-exercise/propranolol" state. These states were monitored physiologically by collecting blood (via caudal venepuncture) and measuring haematocrit (Hct), haemoglobin concentration (Hb), mean corpuscular haemoglobin concentration (MCHC as an indicator of red cell swelling) and blood lactate.

Strenuous exercise induced a metabolic acidosis (8.0 mmol l<sup>-1</sup> blood lactate) and a significant red cell swelling response but no change in the optomotor response threshold (120 min of arc) was observed between pre- and post-exercise fish (Figure 1).

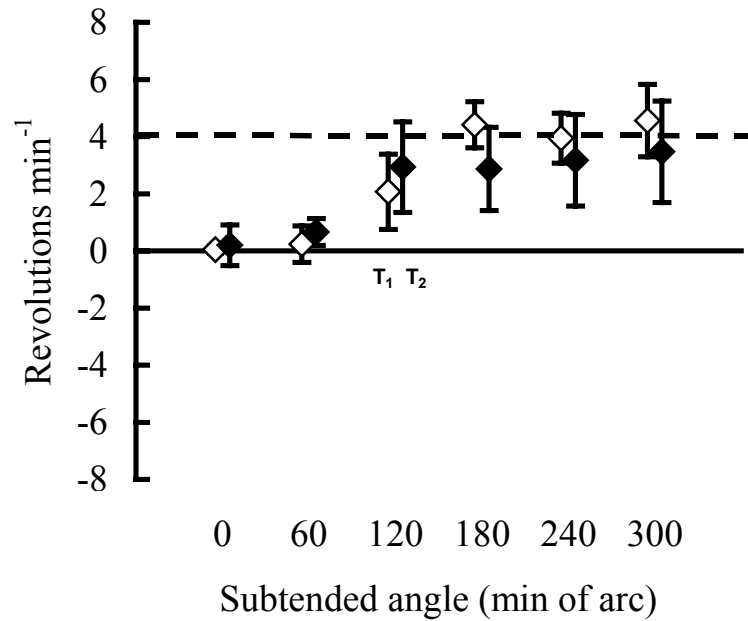


Figure 1. The effect of subtended angles on the optomotor response of trout both pre-exercise (open symbols) and post-exercise (closed symbols). The dashed line indicates the angular velocity of the moving background in a positive (clockwise) direction. Error bars represent 95 % confidence intervals.  $T_1$  and  $T_2$  represent the optomotor response thresholds for the pre-exercise and post-exercise fish respectively.

Beta-adrenergic blockade (propranolol) abolished post-exercise red cell swelling but optomotor response thresholds were still maintained at 120 min of arc despite a significant blood lactate load ( $7.8 \text{ mmol l}^{-1}$ )(Figure 2). Surprisingly, exercise-propranolol fish exhibited an enhanced optomotor response at 240 - 300 min of arc.

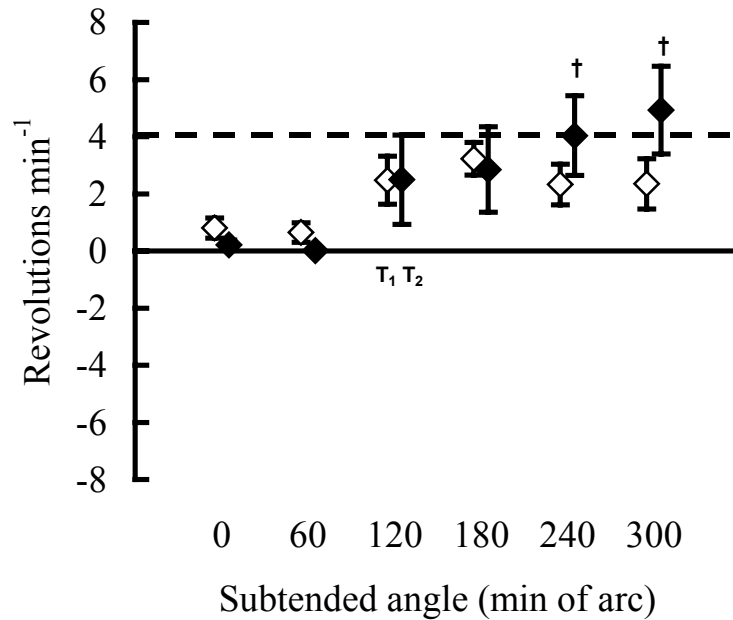


Figure 2. The effect of subtended visual angles on the optomotor response of resting (open symbols) and exercise-propranolol (closed symbols) trout. The dashed line indicates the angular velocity of the moving background in a positive (clockwise) direction. Error bars represent 95 % confidence intervals. T<sub>1</sub> and T<sub>2</sub> represent the optomotor response thresholds for the pre-exercise and exercise-propranolol fish respectively. † represents a significant difference between resting and exercise-propranolol reactions at the respective angle.

We suggest that the treatment of post-exercise fish with propranolol may have induced “tunnel vision” and strengthened optomotor reactions as a result of a restricted field of view being predominantly exposed to moving visual stimuli. It is possible that adrenergic regulation of Hb-O<sub>2</sub> affinity may possibly maintain high gradients of ocular PO<sub>2</sub>, which satisfies the metabolic demand of peripheral retinal cells, after strenuous exercise. We conclude that strenuous exercise does not affect the ability of trout to resolve high contrast moving objects but future work should examine the possibility that stressed trout have impaired peripheral vision.

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