Effect of temperature increase in fish muscle mechanics

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Introduction

In most fish, a change in aquatic temperature results in a change in body temperature. When faced with climate changes, fish can either adapt physiological or migrate to other areas where temperatures are more suitable (1). The second option is not always possible due to barriers to migration, such as dams (2). High levels of loss of warm water fish habitat are already happening in the Midwest due to increases in temperature in streams of this region (2).

This study investigates if fish are capable of changing muscle mechanics to cope with changes in water temperature and the effects in energetics. We expect to see higher recruitment of white muscle as temperature increases.

Materials and Methods

Bluegill Sunfish and Largemouth Bass were collected during Fall 2016 from local streams. Fish were held at two different temperatures 15°C and 20°C and tested in a recirculating flow tank at 1.5 BL/s swimming speeds at the opposite temperature.

To measure muscle activity, we used intramuscular electromyography where bipolar electrodes were inserted through the skin into the muscle tissue. EMG recordings were collected simultaneously from three positions in along the body as shown in figure 2: (W1) cranial white muscle at 0.35 body length (BL), (W2) medial white muscle at 0.5BL and (R2) red muscle at 0.5BL. Fish were anesthetized in MS222 for 10 minutes and then electrodes were placed. A small suture between the spiny and soft portions of the dorsal fin held the electrodes in place. Fish were allowed to recover in the flow tank at no flow for 30 minutes, after which the flow was turned on to 1.5BL/s and the fish allowed to swim. Data was recorded with Iworx. EMG recordings are analyzed for magnitude, frequency, onset, offset, duration and duty cycle (3).

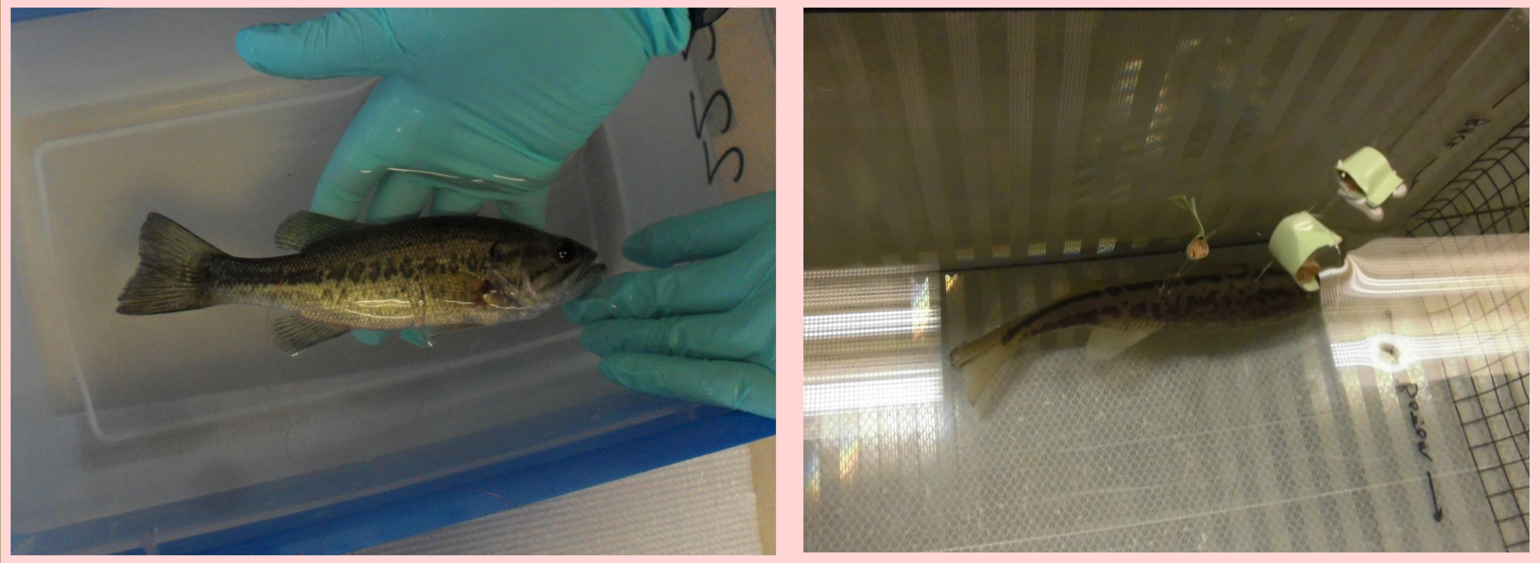

Figure 1: Anesthetizing fish in MS222 and fish in flow tank after insertion of electrodes in fish muscle during recovery.

Results

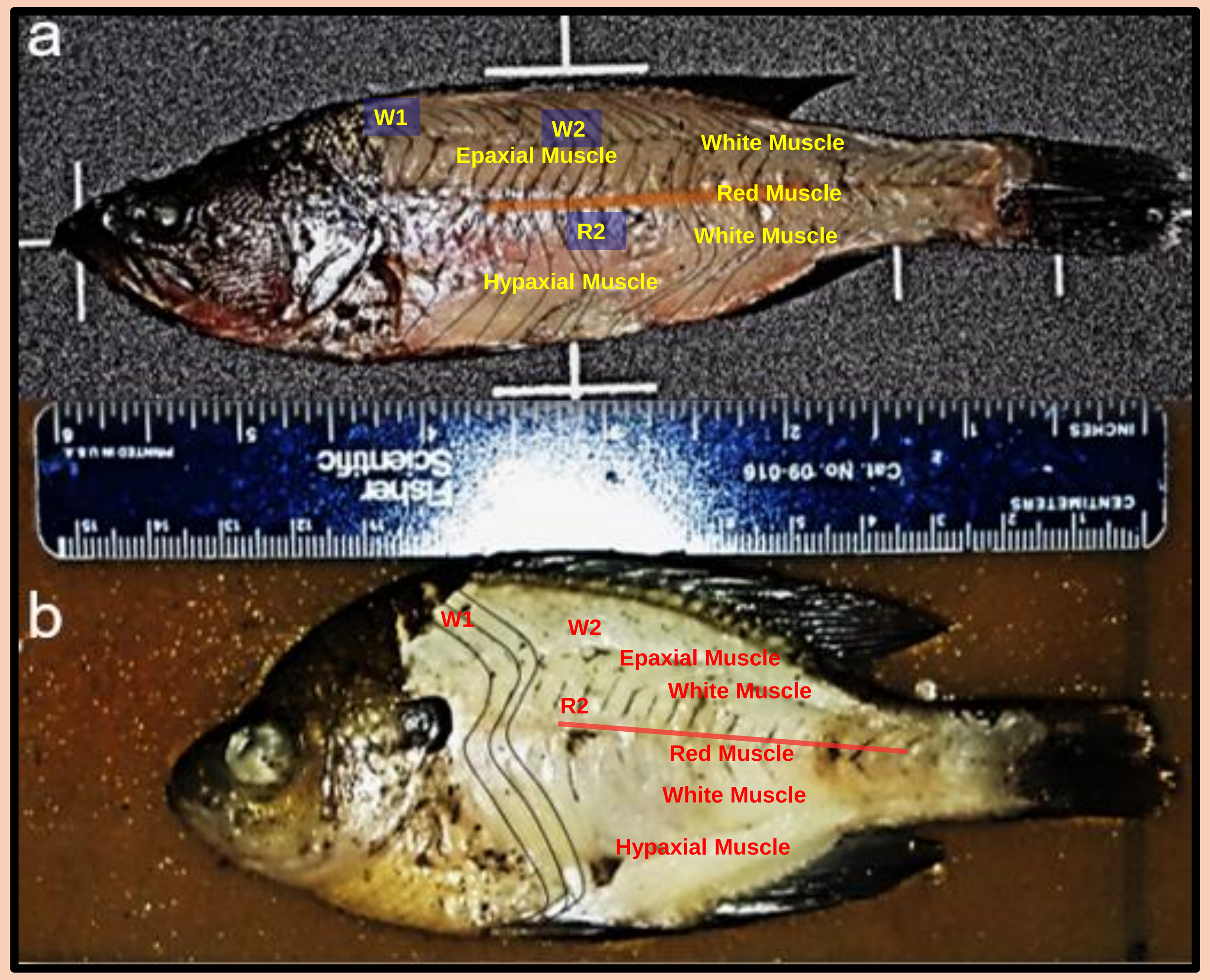

Figure 2: Fish muscle arrangement (a) Largemouth Bass (*Micropterus salmoides*), (b) Bluegill sunfish (*Lepomis macrochirus*).

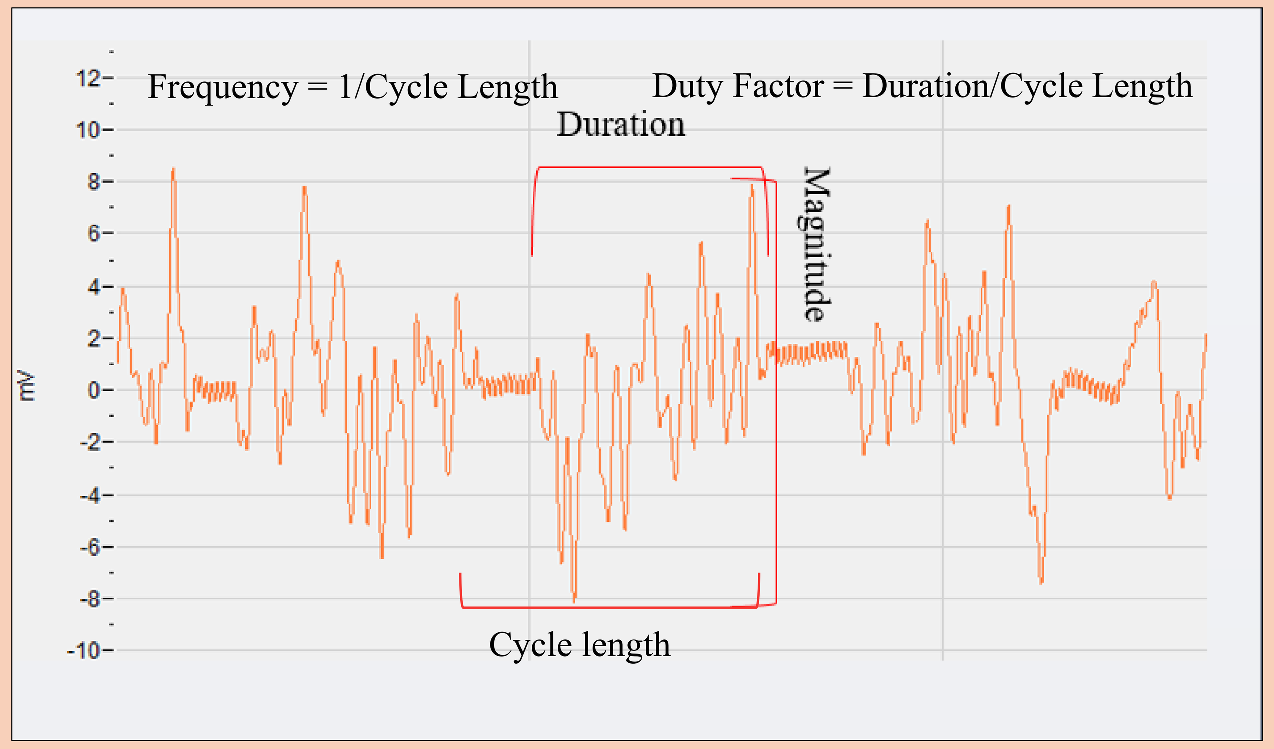

Figure 3: EMG recordings from the cranial white muscle (0.35BL) at 20°C in Largemouth Bass.

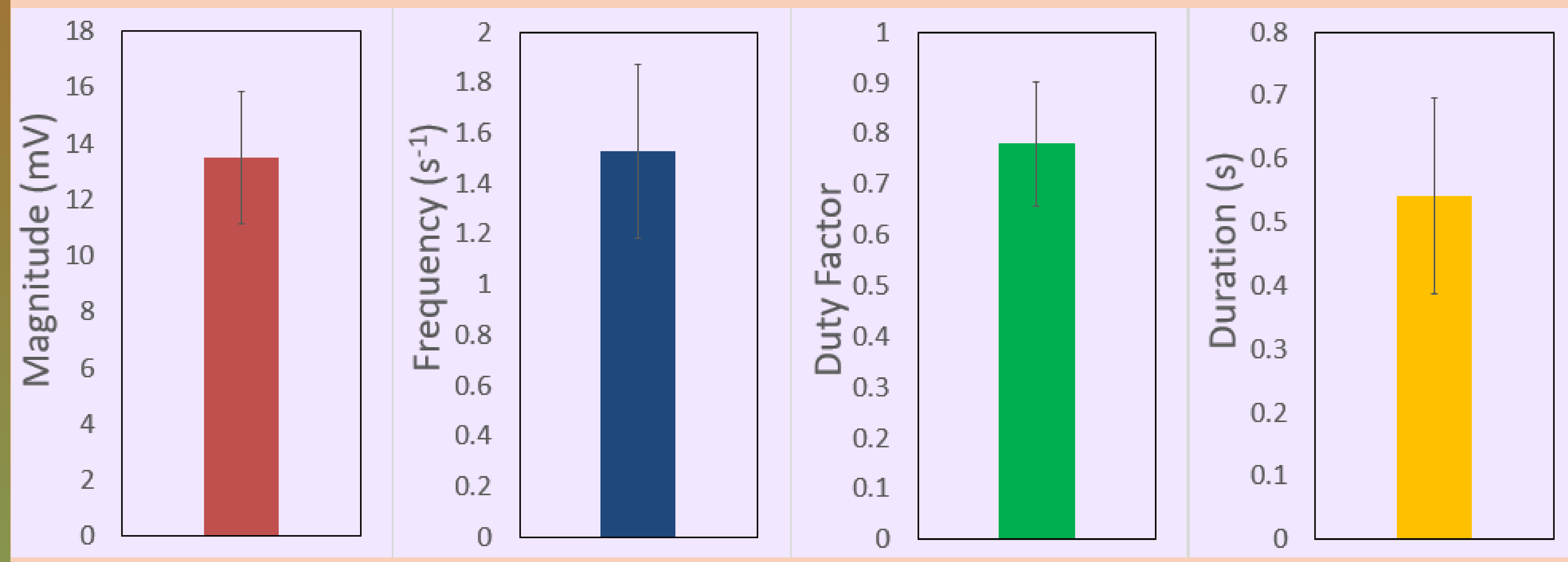

Figure 4: Magnitude, frequency, duty factor and duration of cranial white muscle in Largemouth Bass at 20°C.

Discussion

Dissections of axial musculature showed that red muscle is more superficial and runs along the horizontal septum with 5mm width and 2mm depth in most of the areas in Largemouth Bass. The width of red muscle increases towards the tail. In contrast, white muscle occupies most the axial musculature. Fin musculature appears to be red muscle by gross anatomical observations. Largemouth Bass has more prominent and deeper red muscle than Bluegill Sunfish. Moreover, red muscles in Bluegill Sunfish are wider near the caudal region. Fiber orientation changes from a helical geometry in the bulk of the body to being more parallel to the spine at the caudal peduncle.

Our preliminary characterization of muscle mechanics shows that cranial white fibers in Largemouth Bass have contraction magnitudes of 13.5mV, contraction frequencies averaging 1.5s^{-1}, burst durations on average of 0.54s and duty factor averaging 78% of the cycle. Almost similar muscle contraction were recorded from rostral white muscles when fish accelerated rapidly with magnitude of 8mV with burst duration 0.38 s in Large mouth bass (4,5).

Future Directions

We will continue to collect EMG data on more individuals of Largemouth Bass and in Bluegill Sunfish. We will also test the fish at 15°C. We are also interested in seeing how the muscle activity changes towards the caudal region, and will add electrodes at 0.75BL to understand the better understand the effects of muscle type, temperature and location along the body in muscle mechanics.

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