Abstract User Meeting 2019|Adaptation Mechanisms Of Zebrafish Respiratory Organ To Endurance Training

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Aims

In order to study the adaptation of the respiratory organ and the O_2 metabolism due to training, we subjected adult zebrafish (*Danio rerio*) to endurance exercise for 5 weeks. After the training period, the swimmer group showed a significant increase in swimming performance, body weight and length.

The gills increased their volume significantly ($p<0.05$) by 11.8 % from 0.490 mm^3 to 0.549 mm^3. The space-filling complexity of the gills dropped significantly ($p<0.01$) by 8.2 % from 38.8 % to 35.9 %. We conclude that the respiratory organ of the adult zebrafish shows a high plasticity.

Method

The presented data here are part of a much larger study, in which we assessed the respiratory organ of the zebrafish with different methods; here we only report on the microtomographic imaging. After critical point drying, heads of 20 fishes were imaged on a Bruker SkyScan1172 high resolution microtomography machine (Bruker microCT, Kontich, Belgium). Ten fish fishes were subjected to endurance training, ten fish were from the control group. A tomographic data set of each fish head was obtained in between 6 and 19 hours and with an isometric voxel size of 1.65 µm. We manually delineated the gills in CT-Analyser (Bruker, Version 1.17.7.2+) and exported the resulting volumes of interest as a set of PNG images for each fish. We used a simple threshold to binarize each VOI image into gills and background. The gill volume was then simply calculated as the volume of all the binarized pixels. The organ area was extrapolated by binary closing of the thresholded gill image and summation of said image.

Results

The gill volume in trained fish was significantly higher than in control fish: 0.55±0.09 mm3 vs. 0.49±0.07 mm3 (+11.8 %, n=10 each, p=0.048, Fig. 2, left). left). We extrapolated the hull of the gills by filling the small voids between the secondary filaments with a closing filter. This is analogous to covering the gills with cling-film and it gives us an approximation of the total volume which the gills occupy in the animal. Dividing this hull volume by the gill volume calculated above gave us an estimate of the filling factor of the gills, e.g. the space filling complexity. The gills of the swimmer group are filling significantly less space in

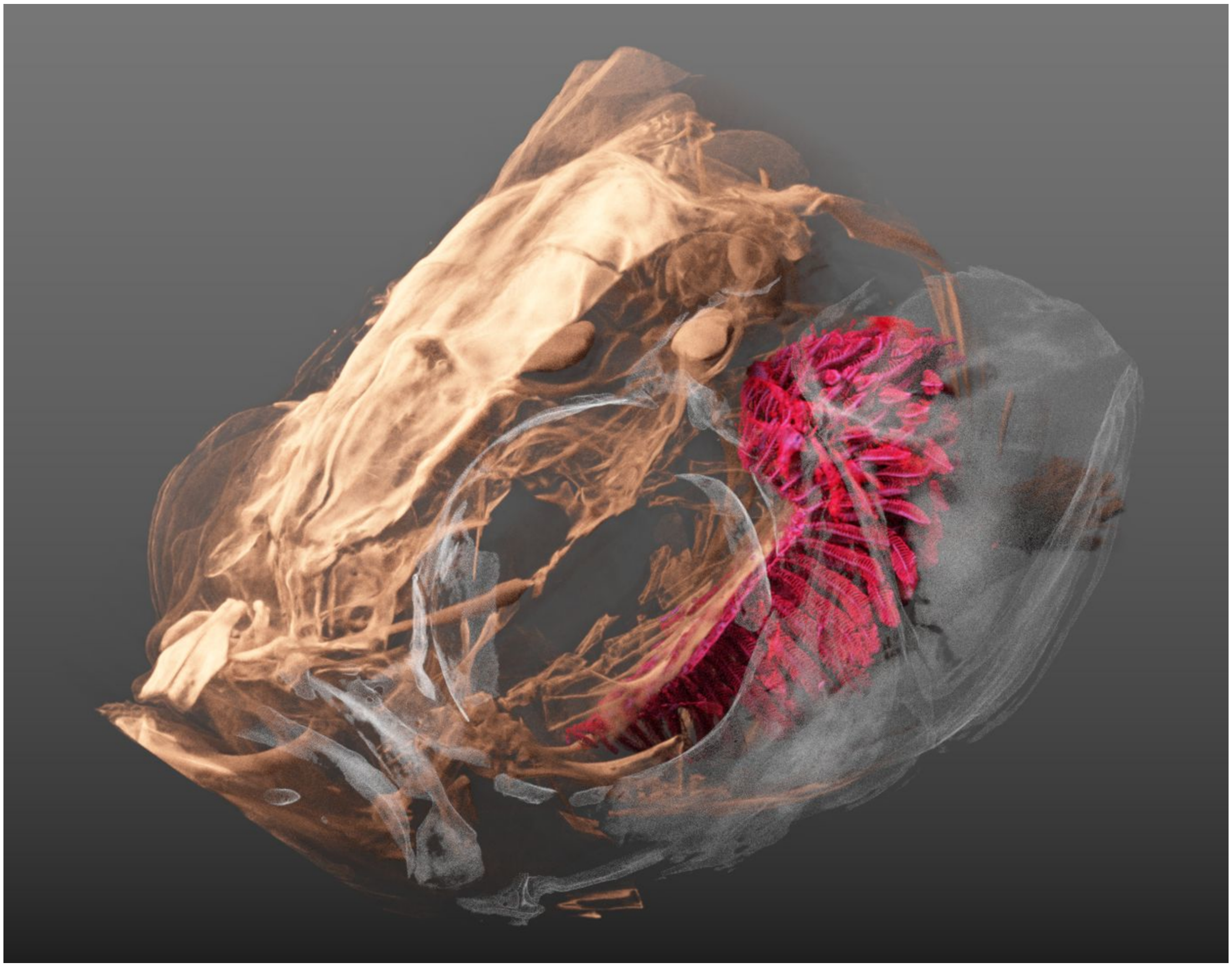

Figure 1: The image shows a 3D visualization of a tomographic scan of a fish from the control group. The left side of the head is rendered semitransparently, the delineated gills are shown in red. The tip-to-tip distance of the gills is approximately 1.9 mm.

the total organ hull (35.9±2.0 % for the swimmer vs. 38.8±2.9 % for the control group, a decrease of 8.2 %, $p<0.01$).

Conclusion

Training the fishes increases their body length and weight and changes the gill morphology considerably. The gill volume of the trained fish is significantly increased and the space filling ration is highly significantly decreased. We conclude that the gills of the swimmer group are less compact than the gills of the control group. It is thus expected that the flow of oxygen-rich water is facilitated in the gills of the swimmers.

Endurance-training-related adaptations in the pathway of oxygen in mammals and fish are very similar. O_2 uptake, heart, erythrocytes and muscles are all adapting in a comparable way. We confirm that the zebrafish is a good model to study human physiology. The gas exchange organ in our study showed high plasticity. We think that within the respiratory cascade in fish, the gills represent a bottle neck. Human lungs either

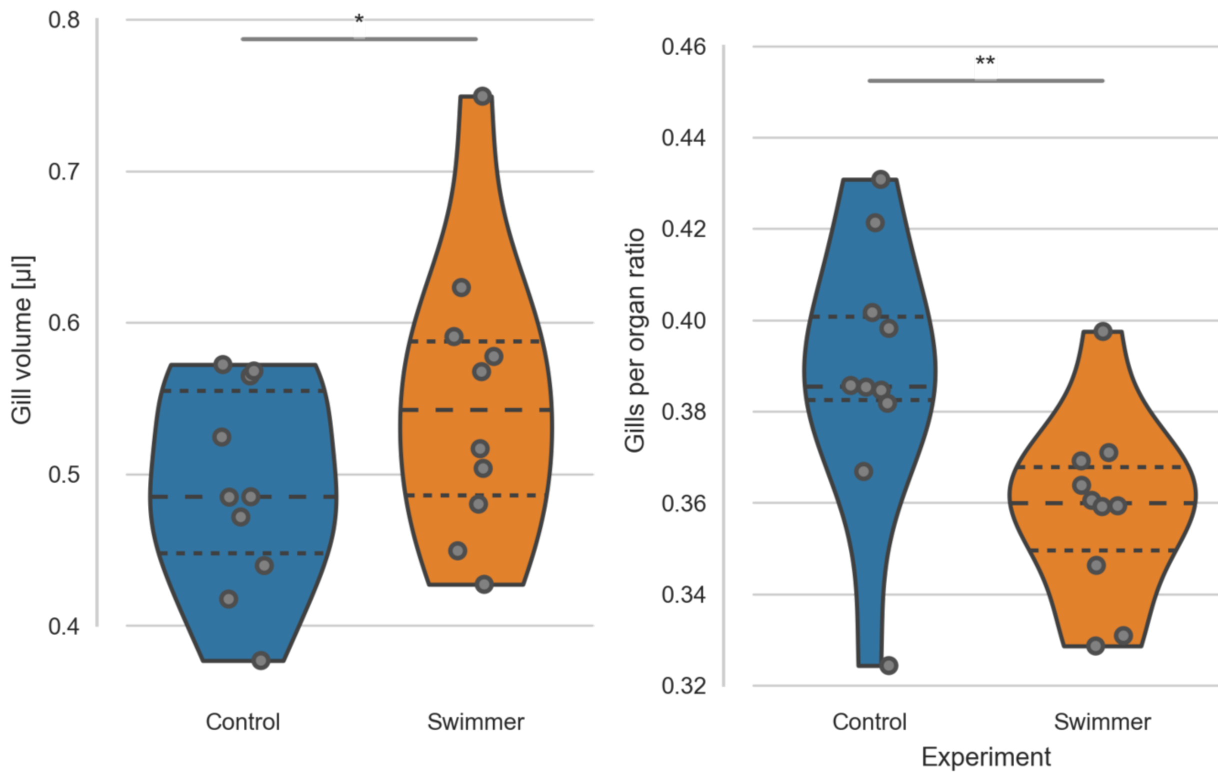

Figure 2: Left: Volume of the gills from microtomographic assessment (p=0.048). Right: Ratio of gills per organ area (explanation in the text). The swimmers have significantly less gills per organ, e.g. more room between the filaments (p=0.0088).

have already sufficient volume to satisfy times of higher demand, or they would like to extend their volume but cannot because they are, in contrast to fish, locked in their thoracic cavity.