EFFECTS OF SEXUAL MATURATION ON MORPHOLOGICAL AND BIOCHEMICAL CHARACTERISTICS OF THE MALE RAINBOW TROUT HEART

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ABSTRACT

Growth of the vertebrate heart is an adaptive response to accomodate increasing myocardial workload. Recent studies report that relative ventricular mass increases during sexual maturation in male, but not female, rainbow trout. Expansion of myocardial mass may impose metabolic constraints on the ventricle by increasing energetic demands and oxygen diffusion distance. Furthermore, regional differences in oxygen availability may exist in the trout ventricle, which consists of an inner, trabecular layer perfused with venous blood, and an outer, compact layer supplied with oxygenated blood through coronary arteries. In the present study, we asked the following questions: (1) Does enlargement of the heart in maturing male trout result from selective growth of one myocardial layer, or equivalent expansion of both? (2) Does energy metabolism differ between myocardial layers, and does transmural energy metabolism change as the heart enlarges? To address these questions, we characterized ventricular morphometrics, and measured maximal activities of key metabolic enzymes (hexokinase (HK), citrate synthase (CS), β-hydroxyacyl CoA dehydrogenase (HOAD), and lactate dehydrogenase (LDH)) involved in oxidative and anaerobic pathways, in ventricles from male rainbow trout sampled at various stages of sexual maturity. Male rainbow trout were raised in concrete raceways under conditions of constant temperature (15°C) and natural photoperiod. Hearts were isolated from anesthetized fish, weighed, separated into layers, and the layers weighed and frozen at -70°C until assayed. Testes weight was used as a measure of sexual maturity. Measurements of enzyme activity were performed spectrophotometrically at 15°C. Sexual maturation was associated with a remarkable two-fold increase in relative ventricular weight. Growth of the ventricle resulted from an expansion of both myocardial layers, however the relative contribution of the compact myocardium increased with ventricular enlargement. We observed a significant transmural difference in mass-specific tissue metabolism that consistently favors the trabecular layer ($P<0.01$). Although this suggests that the trabecular layer has a higher potential for energy metabolism, sexual maturation altered the transmural pattern of metabolic fuel utilization. Activities of HOAD and CS increased in the compact layer (25% and 20%, respectively) but remained unchanged in the trabecular layer as relative ventricle mass increased. Interestingly, although LDH activity remained unchanged in both layers, activity of HK decreased (25%) in both layers as trout matured. These results suggest that, as male trout become sexually mature, expansion of ventricular mass, and especially the compact layer, is associated with an increase in oxidative capacity, with no change in anaerobic potential. Increased oxidative capacity appears to result from an expansion of fat utilization but a decrease in carbohydrate metabolism.