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Exercise induced redistribution of oxygen in internal organs

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Objective Exercise induces tissue blood flow redistribution, which decreases splanchnic circulation and leads to physiologic hypoxia in the gastrointestinal (GI) system and liver. We hypothesized that the oxygen redistribution in the internal organs is affected by exercise.
Methods Twenty–four female 8-10wk ROSA26 ODD-Luc/+ mice (n= 6 per group) were used in this study. Three exercise models were conducted: (1) Moderate Exercise (ME): mice voluntarily swam for 30 min. (2) Heavy-intensity Exercise (HE): mice swam for 1.5 hours with 5% body weight loads attached to their tails. (3) Long-time Exercise (LE): mice voluntarily swam for 3 hours or till fatigue. Sedentary mice (SED) were used as controls. A hypoxic marker pimonidazole HCl was applied to detect tissue hypoxia. Pimonidazole HCl forms protein adducts when PO2 is under 10 mmHg. An hour after intraperitoneal injection of pimonidazole HCl (60 mg/kg body weight), the mice were anesthetized with isoflurane then sacrificed. The small intestine, colon, skeletal muscle, heart, liver, spleen and kidney specimens were fixed in 4% paraformaldehyde and stained with a specific monoclonal antibody against the pimonidazole HCl protein adducts to observe the hypoxic level of internal organs.
Results (1) The distributions of immunostaining intensity of pimonidazole HCl were different among the internal organs. In the kidney, the renal tubules demonstrated staining for hypoxia. In the liver, the positive staining was radiating outwards from central veins. In the small intestine and colon, there was the retention of pimonidazole HCl from the crypt to villus. (2) In the ME group, the extent of hypoxia in the kidney, liver and colon was increased compared with the SED. We found the small intestine is susceptible to exercise-induced tissue hypoxia distribution. Exercise resulted in a markedly increased staining in the crypts, whereas decreased staining in the villus. Intensified positive stains were observed in the nuclei of hypoxic cells, mostly in ME and HE groups. (3) The heart, skeletal muscle and spleen were not shown positive staining pre- and post-exercise.
Conclusions This study presented evidences that exercise induces the oxygen redistribution in the small intestine, colon, liver and kidney. The small intestine is susceptible to exercise induced physiological hypoxia.