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Energy Metabolism and Mitochondrial Biogenesis in Muscles of Rats Subjected to Cold Water Immersion

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Abstract : Exposure to cold temperatures can be considered a stressor that can lead to adaptive responses. The present study hypothesized the possibility of a positive effect of cold water exercise on mitochondrial biogenesis and muscle energy metabolism in aging rats. The purpose of this study was to evaluate the effects of cold water exercise on energy status, purine compounds, and mitochondrial biogenesis in the muscles of aging rats as indicators of the effects of cold water exercise and their usefulness in monitoring adaptive changes. The study was conducted on 64 aging rats of both sexes, 15 months old at the time of the experiment. The rats (male and female separately) were randomly assigned to the following study groups: control, sedentary animals; 5°C groups animals - training swimming in cold water at 5°C; 36°C groups - animals training swimming in water at thermal comfort temperature. The study was conducted with the approval of the Local Ethical Committee for Animal Experiments. The animals in the experiment were subjected to swimming training for 9 weeks. During the first week of the study, the duration of the first swimming training was 2 minutes (on the first day), increasing daily by 0.5 minutes up to 4 minutes on the fifth day of the first week. From the second to the eighth week, the swimming training was 4 minutes per day, five days a week. At the end of the study, forty-eight hours after the last swim training, the animals were dissected. In the skeletal muscle tissue of the thighs of the rats, we determined the concentrations of ATP, ADP, AMP, Ado (HPLC), PGC-1a protein expression (Western blot), PGC1A, Mfn1, Mfn2, Opa1, and Drp1 gene expression (qRT PCR). The study showed that swimming in water at a thermally comfortable temperature improved the energy metabolism of the aging rat muscles by increasing the metabolic rate (increase in ATP, ADP, TAN, AEC) and enhancing mitochondrial fusion (increase in mRNA expression of regulatory proteins Mfn1 and Mfn2). Cold water swimming improved muscle energy metabolism in aging rats by increasing the rate of muscle energy metabolism (increase in ATP, ADP, TAN, AEC concentrations) and enhancing mitochondrial biogenesis and dynamics (increase in the mRNA expression of proteins of fusion-regulating factors – Mfn1, Mfn2, and Opa1, and the factor regulating mitochondrial fission – Drp1). The concentration of high-energy compounds and the expression of proteins regulating mitochondrial dynamics in the muscle may be a useful indicator in monitoring adaptive changes occurring in aging muscles under the influence of exercise in cold water. It represents a short-term adaptation to changing environmental conditions and has a beneficial effect on maintaining the bioenergetic capacity of muscles in the long term. Conclusion: exercise in cold water can exert positive effects on energy metabolism, biogenesis and dynamics of mitochondria in aging rat muscles. Enhancement of mitochondrial dynamics under cold water exercise conditions can improve mitochondrial function and optimize the bioenergetic capacity of mitochondria in aging rat muscles.

Keywords : cold water immersion, adaptive responses, muscle energy metabolism, aging
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