シI-5 Monitoring of muscle oxidative energy metabolism and muscle oxygenation

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Magnetic resonance spectroscopy (MRS) has developed as the "gold standard" for noninvasive evaluation of skeletal muscle energetics since the late 1970's. ^{31}Phosphorus MRS (^{31}P-MRS) is able to measure the concentrations of inorganic phosphate (Pi), phosphocreatine (PCr), and the three phosphates of ATP. Free ADP concentrations are too low to be directly measured but can be calculated via the creatine kinase equilibrium reaction. In addition, ^{31}P-MRS allows the measurement of intracellular pH. In contrast, the optical methods using easy and inexpensive forms of the apparatus, near infrared spectroscopy (NIRS). NIRS can be used to evaluate the kinetics of O_2 demand and O_2 supply in relation to muscle bioenergetics in human tissue in a more simple and portable way than MRS measurements. Although MRS and NIRS cannot replace the conventional biochemical analysis obtained from muscle biopsy, they provide distinct advantages that are not available by biopsies. This paper primarily focuses on noninvasive MRS and NIRS approaches for evaluating skeletal muscle oxygen sufficiency and oxidative energy metabolism, with special reference to the applications of NIRS to fields such as sports medicine and exercise physiology.

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シII-1 Fiber type morphology and capillary supply in human respiratory muscles

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In human respiratory muscles, the diaphragm comprises approximately 50% slow-twitch (ST) fibers, whereas a higher proportion (60%) is found in both inspiratory and expiratory intercostal muscles. The inspiratory intercostal muscles and the diaphragm show an equal distribution of fast-twitch (FTa and b) fibres, while the expiratory intercostal muscles have few FTb fibers. The inspiratory intercostal muscles and the diaphragm have an uniformly small fiber size, in contrast to the expiratory intercostal muscle fibers which are large. The fiber size of the inspiratory intercostal muscles and the diaphragm is maintained with aging, whereas that of the expiratory intercostal muscles appears to be reduced by approximately 30% after the age of 50 yrs. Capillary supply is most abundant in the expiratory intercostal muscles followed by the diaphragm and the inspiratory intercostal muscles. In patients with chronic obstructive pulmonary disease, a reduction in fiber size of the thoracic respiratory muscles associated with an increase in mitochondrial enzyme activities is caused by extreme use due to increased ventilatory work. Histochemical characteristics suggest that, in normal humans, the load on the inspiratory muscles is relatively small during contractions, whereas the expiratory intercostal muscles are exposed to severe continuous activity with a heavy load. These evidences indicate that human respiratory muscles have a potential adaptability to an increase in usage such as ventilatory training, and adaptation may occur similar to those well described in limb skeletal muscles.

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