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Effect of hypoxic resistance training on the regulation of muscle mass and phenotype

Louise Deldicque, Olouyomi Gnimassou, Geoffrey Warnier, Nicolas Benoit, Damien Naslain, Henri Nielens, Marc Francaux
Institute of Neuroscience, UCLouvain

Objective Hypoxia is a state of lowered oxygen tension in tissue that can be created by environmental or pathological conditions. Whatever the origin of hypoxia, different tissues will adapt acutely and/or chronically to deal with this reduction in oxygen availability. Hypoxia has recently emerged as a particularly efficient stimulus to stimulate muscle cell proliferation and accretion of muscle mass and hypoxic resistance training has become popular amongst athletes as it is thought to favor muscle accretion. However, the molecular mechanisms are largely unknown.

Methods To determine those molecular mechanisms, 19 volunteers participated to 12 sessions of resistance training spread over 4 weeks whether in normoxia (n=9) or in hypoxia (n=10, FiO_2 13.5% corresponding to 3500m altitude). Each session consisted in 6 sets of 10 repetitions of a one-leg extension exercise at 80% of one repetition maximum (1-RM). Blood and muscle samples in each leg were taken before and after the 4-week training period. Fiber types were determined by immunohistochemistry based on myosin heavy chain isotypes. Blood saturation (SpO_2 , pulseoximetry) and tissue saturation index (TSI, near-infrared spectroscopy) were monitored during the exercise sessions.

Results Muscle thickness determined by ultrasound was increased by 7% in normoxia only ($p=0.04$). The 1-RM was increased in both groups but the increase was higher in hypoxia (+34%) than in normoxia (+24%) ($p=0.02$). In average, SpO_2 stayed around 98-99% in normoxia and around 93-94% in hypoxia during each set of contractions. No difference in TSI between normoxia and hypoxia was measured, which averaged 60% before starting muscle contractions and 40% during muscle contractions. A trend towards a shift in fiber type from type I to type IIa was observed in normoxia ($p<0.09$) but not in hypoxia. Fiber area was not modified by any condition.

Conclusions In summary, 4 weeks of hypoxic resistance training induced a larger increase in 1-RM compared to normoxic resistance training, independently of muscle hypertrophy or any change in fiber type. Further investigation should determine whether metabolic or molecular changes may explain this potentiation of maximal muscle force by hypoxia.