Regional difference in muscle deoxygenation in a single muscle at rest and during bicycle exercise

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Introduction
Recently, heterogeneity of muscle deoxygenation during exercise in humans has been evaluated using positron emission tomography (PET) (Laaksonen et al, 2003). However, the device only produces information after exercise or during static exercise because of moving artifacts. Therefore, it is essentially impossible to monitor heterogeneity of muscle deoxygenation during dynamic whole body exercise such as bicycle exercise using PET. Near-infrared continuous wave spectroscopy (NIRcws) has been widely applied to the evaluation of muscle deoxygenation during bicycle exercise (Kime et al, 2003). More recently, we have evaluated heterogeneity of muscle O2 dynamics during bicycle exercise using multi-channel NIRcws system and found that muscle deoxygenation in a single muscle was more homogeneous at higher workloads (Kime et al 2005). However, we could not evaluate the regional differences in muscle deoxygenation at rest because NIRcws only can measure changing values from the baseline. Therefore, we evaluated regional differences of muscle O2 dynamics between distal and proximal sites in the vastus lateralis (VL) muscle at rest and during bicycle exercise using near-infrared spatial resolved spectroscopy (NIRsrs) that can give us tissue saturation.

Methods
Fifty-one male subjects performed a 30W ramp incremental bicycle exercise test until exhaustion. All subjects were college students, and almost all of the subjects were trained athletes (forty-one competitive college football players, four competitive college triathletes, one pro-boxer, one competitive marathon runner, and four subjects involved in various recreational activities). The tissue oxygenation index (TOI) in the VL was monitored using NIRsrs system. The NIRsrs probes were attached on each distal and proximal site in the VL. The pulmonary O2 uptake and heart rate were monitored continuously during the experiment. Blood samples were taken for blood lactate concentration measurement at 150, 210, 270, 330W, and exhaustion.

Results
The TOI at rest was significantly higher in proximal than distal sites (69.2±4.5 vs. 64.3±5.3%, p<0.001). The TOI at exhaustion was also significantly higher in proximal than distal sites (47.7±7.4 vs. 39.7±6.9%, p<0.001). Moreover, a significant correlation was found between VO2max and the TOI at exhaustion in each proximal and distal site in the VL. Half time reoxygenation, the time to reach a value of half-maximal recovery, was significantly faster in proximal sites than distal sites (24.1±6.6 vs. 26.4±6.7sec, p<0.01).

Discussion/Conclusion
Lower muscle deoxygenation at exhaustion in higher VO2max may be due to enhanced O2 extraction in high oxidative capacity muscle. In addition, slower reoxygenation and lower muscle deoxygenation at the distal site in the VL may be explained by differences in O2 supply and/or muscle fiber composition between distal and proximal sites.

References