The use of ^{31}P MRS and Near-Infrared Spectroscopy (NIRS) to Assess the Kinetics of Children and Adults at the Onset of Moderate Intensity Exercise

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Introduction

^{31}P spectroscopy has the potential to provide a wide range of insights into differences in phosphorous metabolite kinetics. In the present study, the aim was to assess whether any changes can be detected between individuals due to age and/or sex at the onset of moderate intensity quadriceps exercise.

Methods

Twelve 9-10 year old children (7 boys, 5 girls) and 15 young adults (8 men, 7 women) participated in the study after written consent was obtained. The exercise protocol was performed within a 1.5T Philips Gyroscan Clinical Intera system using a 6cm ^{31}P transmit /receive surface coil placed within the subject bed centred over the quadriceps muscle. Matching and tuning of the coil was carried out followed by an automatic shimming protocol. Subsequently, an unsaturated ^{31}P spectrum was acquired to allow T1 correction for those spectra obtained during the exercise protocol. Subjects were then required to perform knee extension and flexion exercise with their right leg against a pulley system, to which a mass was attached equal to 80% of the Pi/PCr intracellular threshold which had been determined at a prior visit. Exercise was carried out with a frequency of 0.66 Hz, with all force and power measurements recorded via a non-magnetic strain gauge and shaft encoder present within the pulley system. To ensure a consistent work rate and muscle position relative to the coil during exercise, the subject was visually queued, with associated feedback. During the entire protocol, phosphorous spectra were acquired every 1.5 seconds and phase cycling with 4 phase cycles was employed, leading to a spectra acquired every 6 s, with all scanning conforming to NRPB guidelines (1). The exercise protocol consisted of 2 minutes of baseline measurements, 6 minutes of exercise and 6 minutes of recovery during which time spectra were continuously obtained. Near-infrared spectroscopy (NIRS) was also undertaken on the vastus lateralis muscle every second to monitor deoxyhemoglobin (Hb) dynamics.

^{31}P spectra were quantified via peak fitting, assuming prior knowledge, using the jMRUI (version 2) software package employing the AMARES fitting algorithm (2, 3). Spectra were fitted assuming the presence of the following peaks: inorganic phosphate (Pi), phosphodiester, phosphocreatine (PCr), α-ATP (2 peaks, amplitude ratio 1:1), γ-ATP (2 peaks, amplitude ratio 1:1) and β-ATP (3 peaks, amplitude ratio 1:2:1) allowing the calculation of d[PCr]/dt during exercise and recovery. pH was calculated from the chemical shift of Pi relative to PCr. The decrease in PCr at the beginning of exercise was fitted to a single-exponential curve with associated time constant, whereas a single-exponential model including both a time constant and delay term was used for the Hb response.

Results

No significant sex related differences at the onset of exercise were found for the PCr time constant or for the Hb delay term or time constant. However, when comparing characteristics between children and adults, a shorter Hb delay time, a faster Hb time constant and a more rapid Hb mean response time were shown in children.

Conclusion

The kinetics of muscle PCr are independent of age and sex at the beginning of moderate intensity quadriceps exercise. However, there is the suggestion of age-related variation of Hb dynamics, which may reflect an underlying imbalance between muscle O_2 delivery and utilisation in children.

References

1) National Radiological Protection Board. 1991. Documents of the National Radiological Protection Board, Vol. 2. 2) Naressi, C., *et al.*, MAGMA, 2001. 3) Vanhamme, L., *et al* Journal of Magnetic Resonance 129: 35-43, 1997.