Skeletal muscle oxidative capacity in children: a 31P-MRS study

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Introduction

Although it has been previously suggested that children display a greater resistance to fatigue as compared to adults during repeated bouts of high-intensity exercise (Ratel et al. 2002), the exact causative factors have not been clearly discriminated. A larger muscle oxidative capacity allowing a faster restoration of short-term muscle power after exercise would account for this phenomenon (Bogdanis et al. 1996). However, comparative analyses of skeletal muscle oxidative capacity in children and adults are controversial (Kuno et al. 1995, Taylor et al. 1997) and these conflicting results could reveal drawbacks in subjects' selection and/or data interpretation. For instance, the inference on aerobic metabolism from the measurements of PCr resynthesis rates should be done with caution and different end-of-exercise pH and PCr values could be confounding factors that have to be and that have not been systematically taken into account (Roussel et al. 2000). The aim of the present study was to investigate *in vivo* comparatively and non-invasively skeletal muscle oxidative capacity from the measurements of PCr resynthesis rates during the post-exercise recovery period in children and adults, using 31-phosphorus magnetic resonance spectroscopy (^{31}P-MRS).

Methods

Seven young boys (mean ± SD, 11.7 ± 0.6 yr) and ten men (35.6 ± 7.8 yr) volunteered to be included in the study after informed written consent was obtained. They performed finger flexions at a frequency of 0.7 Hz against a weight adjusted to 15% of the maximal voluntary contraction for 3-min and MR data were recorded at 4.7T (Bruker 47/30 Biospec) before (3-min), during (3-min) and after (15-min) the exercise period. The skeletal muscle oxidative capacity was measured from the rate constant of post-exercise PCr recovery (k_{PCr}) using a monoexponential time course. In addition, the half-time of PCr recovery ($t_{1/2\ PCr}$) was calculated as follows: $t_{1/2\ PCr}$ (s) = ln (2)/(k_{PCr} x 60). Also, the theoretical maximum rate of oxidative phosphorylation (V_{max}) was calculated according to the model of Michaëlis-Menten. Intracellular pH was obtained from the chemical shift of the inorganic phosphate (Pi) signal relative to the PCr signal. An unpaired Student t test was used to analyze the effects of age on the different metabolic variables (« StatView SE+ Graphics® », Abacus Concepts, Inc.).

Results

Given that the workload during exercise was adjusted to the maximal voluntary contraction, the absolute mechanical power output was significantly lower in boys (0.5 ± 0.2 W) than in men (1.5 ± 0.3 W, P<0.001). At the end of exercise, pH values were not significantly different in boys and men (6.6 ± 0.2 and 6.5 ± 0.2, respectively). However, PCr consumption during exercise was significantly higher in men as compared to boys (64.8 vs. 45.1 %, P<0.05).

	Boys	P	Men
k_{PCr} (min^{-1})	1.7 ± 1.2	<0.05	0.7 ± 0.2
$t_{1/2\ PCr}$ (s)	33.0 ± 14.4	<0.01	62.4 ± 19.7
V_{max} ($mM.min^{-1}$)	49.7 ± 24.6	<0.05	29.4 ± 7.9

Table 1: Metabolic variables measured throughout the post-exercise recovery period

PCr time-dependent-changes during the post-exercise recovery period and the corresponding line-fitting are shown in Fig. 1. The rate constant of PCr recovery (k_{PCr}) and V_{max} were significantly higher in boys as compared with men (Table 1). In addition, the half-time of PCr recovery ($t_{1/2\ PCr}$) was about two fold lower in young boys than in men.

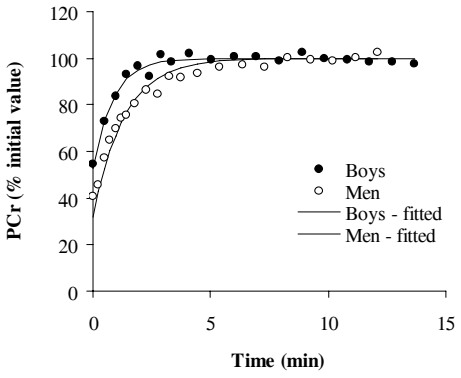

Fig. 1: Time course of phosphocreatine concentration ([PCr]) during the post-exercise recovery period in boys and men.

Discussion-Conclusion

It has been shown that in contrast to k_{PCr}, V_{max} would be insensitive to end-of-exercise pH and PCr consumption (Roussel et al 2000). In the present study, although end-of-exercise pH values were similar in the two age groups, PCr consumption was higher in men than in boys. Hence, V_{max} should be considered as an additional index to k_{PCr} in order to compare the skeletal muscle oxidative capacity between children and adults. The higher k_{PCr} and V_{max} values in young children indicate that they are characterised by a greater mitochondrial oxidative activity as compared to adults. This is in line with the results of Taylor et al. (1997) showing that $t_{1/2\ PCr}$ after a graded exercise protocol was approximately two-fold lower in children aged 6-12 compared to adults aged 20-29 yr (12 ± 4 vs. 27 ± 8 s, respectively). Accordingly, V_{max} in children was faster than in adults (91 ± 46 vs. 54 ± 17 $mM.min^{-1}$, respectively). In contrast, these data are not in agreement with those of Kuno et al. (1995) showing similar rate constants of PCr recovery between 12 yr-old children and 25 yr-old adults following a graded exercise protocol. However, considering that end-of-exercise metabolic conditions were different between the two groups (i.e., lower post exercise pH and PCr/Pi values in adults), these results should be interpreted with caution. The faster ATP regeneration through aerobic metabolic pathways in children reported in the present study could explain their greater resistance to fatigue during high-intensity intermittent exercise. However, further studies are required in order to clarify this issue.

References

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