Interplay between aerobic and anaerobic exercise metabolism in children

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Children's exercise performance progressively improves with age but data on the interplay of the aerobic and anaerobic metabolism supporting exercise during growth and maturation are sparse. Direct measures of anaerobic power are not available and research has focused on the assessment of short-term power output. Much of the data have been obtained from variants of the Wingate anaerobic test which allows the determination of cycling peak power output (PP), usually over a 1s or 5s period, and mean power output (MP) over the 30s test period. PP and MP increase with age. Sex differences are minimal until about 12 years with boys generally outscoring girls thereafter. Both sexes benefit from an enhanced non-linear increase in PP and MP during the early and mid teen years with the effect being more marked in boys. Body mass and composition are strongly related to PP and MP but age exerts an additional positive effect on performance (Van Praagh, 2000). Aerobic power data show that peak oxygen uptake increases with age in both sexes. Peak oxygen uptake is strongly correlated with body size but with body size appropriately controlled for boys’ peak oxygen uptake increases through childhood and adolescence into adulthood whereas girls’ values tend to level-off as they approach young adulthood. Maturation induces increases in aerobic power in both sexes independent of those explained by body size, body composition and age (Armstrong and Welsman, 2000). The age-related rise in aerobic and anaerobic performance is not, however, synchronous and children experience a more marked improvement in anaerobic than aerobic performance during adolescence.

For ethical reasons, invasive techniques used almost routinely with adults are not appropriate for use with children. Understanding of the cellular metabolic activity of children and adolescents is therefore incomplete but information from several methodologies provides a consistent picture. Muscle biopsy studies (fibre types): indicate that the percentage of type 1 fibres in the vastus lateralis decrease in sedentary to moderately active individuals between the ages of 10 to 35 years (Jansson, 1996). Muscle biopsy studies (energy stores): demonstrate that resting ATP stores are invariant with age but PCr and glycogen stores progressively increase from childhood into adolescence and adulthood (Eriksson and Saltin, 1974). Muscle biopsy studies (enzyme activity): the few available data suggest that prepubertal children have higher oxidative enzyme activity and lower glycolytic enzyme activity than adolescents but the evidence indicating that the glycolytic activity of adolescents is less than adults is equivocal. Haralambie (1982) showed that the ratio of PFK/ICDH activity is 1.633 in adults and 0.844 in 13 to 15-year-olds suggesting that the tricarboxylic acid cycle as compared to glycolysis functions at a higher rate in adolescents than in adults. Lactate production: young people consistently accumulate less blood lactate than adults during both submaximal and maximal exercise. Pianosi et al (1995) reported the blood lactate/pyruvate ratio to rise with exercise in an age-related manner suggesting greater glycolytic activity in adults. Substrate utilization: data indicate that there exists an age-dependent preference for lipid utilization with children demonstrating greater FFA oxidation than adults during exercise (Berg and Keul, 1995). Hormonal responses: exhaustive exercise induces a lower sympathetic response in young people than adults suggesting a reduced anaerobic capacity in children (Berg and Keul, 1995). 31P magnetic resonance spectroscopy: monitoring the Pi/PCr ratio and pH during progressive exercise to volitional exhaustion indicates a similar rate of mitochondrial oxidative metabolism during low intensity exercise but a superior glycolytic capacity in adults during heavy exercise (Zanconato et al., 1993). A significantly faster resynthesis of PCr following maximal exercise suggests a higher oxidative capacity during childhood than in young adulthood (Taylor et al., 1997). Oxygen uptake kinetics: children’s faster primary time constant, greater oxygen cost of exercise and smaller slow component of oxygen uptake are likely to be due to the presence of an enhanced oxidative function and/or a greater percentage of type 1 fibres during childhood (Fawkner and Armstrong, 2004). Recovery studies: demonstrate the greater ability of boys than adults to resist fatigue during intermittent high intensity exercise and this can be partly explained by boys’ ability to resynthesize PCr during recovery periods faster than adults (Ratel et al., 2003). As the initial phase of PCr resynthesis is oxygen dependent a higher oxidative capacity in boys is indicated.

The data are not unequivocal but the weight of evidence clearly indicates an interplay of anaerobic and aerobic exercise metabolism in which children have a relatively higher oxidative capacity than adolescents or adults but there is a progressive increase in glycolytic activity at least into adolescence and possibly into young adulthood.

References
Berg A, Keul J (1995) Young Athletes