The young athlete: Some physiological considerations

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The young athlete: Some physiological considerations

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Child athletes have a low ability to generate high-intensity anaerobic power and their local muscular endurance is low compared with that of adult athletes. This is reflected in children's low performance in short and long sprints, jumps and throwing events. On the other hand, children achieve steady-state at the start of intense exercise and recover more quickly than adults following intense exercise. A practical implication is that, during high-intensity interval training, children may need shorter resting periods than adults. Children take longer than adults to acclimate or acclimatize to heat. Upon transition to a warmer climate, their daily training volume and intensity should therefore be curtailed more so than in adults. Compared with adults, children thermoregulate less effectively during dehydration. Adequate fluid replenishment is therefore paramount for the child athlete. Flavouring the fluid is one means of enhancing young athletes' drinking volume. It is possible that adding sodium and chloride to the drink will further enhance drinking volume.

Keywords: Anaerobic exercise, beverage flavouring, children, dehydration, recovery, rehydration.

Introduction

In recent years, children's participation in high-level sports has become increasingly prevalent. Understanding of the factors that affect children's exercise performance and their well-being during high-level training and competition has thus been gaining importance. To date, knowledge of nutritional and other physiological characteristics of the young athlete has lagged behind that generated for adults. This is because of ethical limitations and methodological constraints. It is extremely rare, for example, for paediatric exercise scientists to biopsy their subjects, insert catheters into their arteries, use radioactive materials, or perform experiments in hostile environments such as extreme heat, cold or altitude. Likewise, it is difficult to equate training regimens or to identify an optimal method of correcting for major differences in body size, when comparing children, adolescents and adults.

Even though the physiological responses to exercise and training are similar in children, adolescents and adults, certain physiological characteristics are unique to a young athlete's responses. This brief review is intended to highlight some of these characteristics. "Young athlete" here refers to a child or adolescent athlete. An emphasis, however, will be given to prepubescents. Space does not allow for a comprehensive review of this topic. The interested reader is referred to two recently published books: Intensive Participation in Children's Sports (Cahill and Pearl, 1993) and Volume 6 of the International Olympic Committee's Encyclopedia of Sports Medicine, The Child and Adolescent Athlete (Bar-Or, 1995).

Anaerobic and aerobic exercise

Anaerobic performance

When expressed per kilogram body mass or fat-free mass, maximal aerobic power is similar in boys and men. In fact, girls below the age of 14 years often have a higher maximal aerobic power than their more mature counterparts. In contrast, children of both genders have a low peak anaerobic power and local muscular endurance, whether expressed per kilogram body mass (Falgarette et al., 1991; Inbar and Bar-Or, 1986) or lean body mass (Blimkie et al., 1988). Indeed, children's performance in primarily 'anaerobic' athletic events, such as the short and long sprints, high jump or discus, is distinctly lower than that of adults. Division by total body mass or lean body mass may not be the best scaling approach to compare the performance of children and adults (Winter, 1992) but the relative deficiency of children's anaerobic power, compared with their aerobic power, prevails irrespective of the scaling approach (Falk and Bar-Or, 1993).
Despite children’s lower anaerobic performance, there are no scientific data to confirm the often stated notion that anaerobic exercise is harmful to their health.

Achievement of steady-state and the rate of recovery

In contrast to the relative deficiency in their anaerobic performance, children have some advantages in their physiological responses to submaximal exercise. One of these is the faster attainment of steady-state at the onset of exercise compared with adults. This is evident at intensities above the ‘anaerobic threshold’ (Armon et al., 1991), but less so at lower intensities (Zanconato et al., 1991). The above pattern gives the young athlete an advantage over adults, because of the lower oxygen deficit that he or she incurs at the start of exercise. Another advantage is the faster recovery of children following ‘supramaximal’ (i.e. at a higher intensity than maximal aerobic power), short-term exercise (Hebestreit et al., 1993; Zanconato et al., 1991). For example, 9- to 12-year-old boys managed to reproduce 100% of their performance in the Wingate Anaerobic Test within 2 min of rest, compared with 10 min in young adults. Time constants for the recovery of functions such as heart rate, oxygen uptake, CO₂ output and ventilation following the Wingate test, were half as long in the boys as in the men (Hebestreit et al., 1993). In addition, blood lactate and hydrogen ion concentrations during recovery were considerably lower in the boys (Hebestreit et al., 1994). This suggests that, despite the supramaximal nature of the exercise task, the children used anaerobic pathways less than did the adults. A practical implication for the coach is that during high-intensity interval training, young athletes may need shorter rest periods than are commonly used by adults.

The question has often been raised whether children’s greater reliance on aerobic pathways is because they cannot convert metabolic energy through anaerobic pathways at the same rate as adolescents or adults, or because they do not need to resort to anaerobic pathways to perform high-intensity physical tasks. While a definitive answer is not yet available, there is circumstantial evidence to suggest that children’s ability for anaerobic glycolysis is indeed limited. This is based on the lower activity of muscle phosphofructokinase – an anaerobic rate-limiting enzyme – as well as the reduced anaerobic flux in children’s muscles (Eriksson et al., 1973; Keul, 1982; Kindermann et al., 1978).

Fluid and electrolyte replenishment in climatic heat

Because of morphological and physiological factors, children are less effective thermoregulators during exercise in hot climates (particularly if the air temperature is 40°C or higher) than adults (for details, see Bar-Or, 1989). The major morphological and physiological differences are the larger surface area-per-mass ratio in children, their lower sweating rate, higher metabolic heat production per unit body mass during walking or running, slower rate of acclimation to the heat and a reduced tolerance time when exposed to a high metabolic-plus-climatic heat stress. One practical implication is that, upon transition to a warmer climate, the reduction in the young athlete’s training volume and intensity during the first 7–10 days should be greater than for adult athletes.

From a nutritional point of view, replenishment of fluids lost in sweat and urine is of utmost importance to athletes of all ages. The hypohydration that results from insufficient fluid intake may be detrimental to their performance, well-being and health. It is also important that athletes should have sufficient dietary replenishment of salts – sodium and chloride in particular. For a recent review regarding rehydration in the exercising child, see Meyer and Bar-Or (1994).

When offered water ad libitum during prolonged exercise in a hot environment, children do not drink enough (Bar-Or et al., 1980, 1992). The degree of such ‘voluntary dehydration’ in children is similar to that found in adults. However, for a given level of hypohydration, defined as percent body weight loss, children’s core temperature increases faster than in adults (Bar-Or et al., 1980). The implication is that dehydration in the young athlete should be prevented, even more so than in the adult athlete. We have found that proper education of children and their parents in that regard can be effective. A simple practical instruction is to advise the young athlete to drink periodically ‘until you are not thirsty any more, and then another few gulps’.

When the child is younger than 10 years, we have recommended half a cup beyond thirst, and a full cup for an older child or adolescent.

An important element in enforcing full fluid replenishment is to provide the young athlete with beverages that are palatable to him or her. In a recent study, Meyer et al. (1994) found that most children prefer the grape flavour to orange or apple flavours, or water. This was apparent during rest, following maximal intensity exercise in a thermoneutral environment and following progressive dehydration in a hot environment. Further preliminary results show that flavouring of the beverage markedly increases the volume that an exercising child consumes voluntarily (Wilk et al., 1994). No information is available regarding the optimal electrolyte and carbohydrate content of beverages consumed by the young athlete. Even though children’s sweat contains less sodium and chloride than that of adults (Meyer et al., 1992), there is no proof that children’s performance...
The young athlete

improves when given beverages more diluted than those commonly recommended for adults (Meyer et al., in press). Nor is there any improvement in their thermoregulatory effectiveness. The above conclusion, however, is limited to a single exposure to climatic heat in non-acclimatized, non-athlete children. It cannot be generalized at present for young athletes who are exposed frequently to prolonged exercise in ambient heat. The mechanism underlying the maturation-related difference in sweat electrolyte content is not clear. It does not seem to result, however, from children’s lower sweating rate (Meyer et al., 1992).

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References


