YOUTH SPORTS
PARTICIPATION,
TRAINABILITY
AND READINESS

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CHAPTER 10: TRAINABILITY OF VO$_2$max DURING CHILDHOOD AND ADOLESCENCE

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INTRODUCTION

VO$_2$max develops just like other processes related to growth and maturation during childhood and adolescence. Longitudinal studies show an increase of absolute and relative VO$_2$max. Absolute VO$_2$max of untrained children and adolescents increases from about 1.0 l/min at the age of 6 to 2.0 and 2.8 l/min at the age of 15 for girls and boys, respectively. After this age, improvement of untrained boys continues, while VO$_2$max of untrained girls reaches a plateau (Krahenbuhl et al., 1985). VO$_2$max relative to body mass shows a different pattern in untrained children. It improves in boys and girls until about 10 years; subsequently, VO$_2$max remains at a plateau in boys and declines in girls (Krahenbuhl et al., 1985; Bar-Or, 1986; Rowland, 1996).

Although VO$_2$max is partly determined by genotype, it can be improved with systematic training it is also trainable. Much research has been done with adults and improvements up to 30% have been recorded (Powers and Howley, 2003). The responsiveness of VO$_2$max to training is also partly determined by genotype (Bouchard et al., 1997). In contrast to adults, less research has been conducted on the responsiveness of VO$_2$max to training in children and adolescents. The available research also shows variation in results (Baquet et al., 2003; Thompson and Baxter-Jones, 2002), ranging from no significant changes (e.g., Gilliam and Freedson, 1980) to improvements reaching 15% (e.g., Stansky et al., 1979).

The focus of this review is the trainability of VO$_2$max in children and adolescents. The review is set within the context of three stages of sport development that characterize childhood and adolescence (Côté and Hay, 2002) which are set within the deliberate practice model of expertise (Ericsson, 2003; Ericsson et al., 1993). The first stage covers the sampling years (6-12) during which there is high frequency of deliberate play and a low frequency of deliberate practice. The second stage is the specializing years (13-15) which are characterized by similar amounts of deliberate play and deliberate practice. The third stage, the investment years (16+) is dominated
by deliberate practice with low frequency of deliberate play. Relevant questions are the following: Are changes in VO2max due only to growth and maturation or are they also due to training? Do changes in VO2max occur in each of the sport developmental stages? What is the magnitude of change in VO2max in each of the stages?

METHODS

The focus of this review is literature over the past 15 years (since 1993). Articles were collected by means of computer search through relevant databases (Web of Science, PubMed, and Google Beta). The search items were as follows: “maximal oxygen uptake”, “VO2max”, “endurance training”, “aerobic training”, “anaerobic training”, “effects of training”, “physical training”, “trainability” and “cardiovascular system”. The results were then refined for “children”, “adolescents”, “young athletes”, “youth”, “teenagers”, “pubertal” and “prepubertal”. Articles were selected based on abstract reading. Only studies of healthy, non-obese children and adolescents were included.

Selected articles were reviewed with a focus on the following: number of participants and sex, chronological age, characteristics of the training intervention (content, duration, intensity, frequency, length), presence or absence of control group, absolute and/or relative values for VO2max at the beginning and end of the training program, percentage change and significance of the change.

VO2max is the most commonly used term for maximal achieved oxygen uptake. However, VO2max in children and adolescents is characterized by a plateau and a real maximal value is not always attained. The highest level of VO2 is used is expressed as peak VO2. Although peak VO2 is generally treated as equivalent to VO2max in children and adolescents (Rowland 1993), the term VO2max is used in this review.

RESULTS

VO2max without a training intervention

Studies of VO2max without a training intervention in children and adolescents are summarized in Table 1. Studies of VO2max of trained and untrained children and adolescents should be noted. Untrained youth generally show lower levels of VO2max compared to trained youth with relative values ranging from 35.2 to 48.0 ml/kg/min in boys and from 35.8 to 41.7 ml/kg/min.