Intensive training in young athletes

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An increasing number of children take part in organized sporting activities, undergoing intensive training and high level competition from an early age. Although intensive training in children may foster health benefits, many are injured as a result of training, often quite seriously. This paper reviews some of the areas of research dealing with intensively trained young athletes, and focuses on physical, cardiovascular and muscular effects, sports injuries and psychological effects of intensive training. It is concluded that measures should be taken to modify present training and competition schemes to avoid the deleterious effects of intensive physical activity on these children.

Keywords: Intensive training, children, sports injuries

In the past few years, competitive sport participation has become an established feature of Western society¹. Youngsters in their early teens may have already undergone intensive training and high level competition for several years in sports like gymnastics, swimming or tennis². Rowley has reported that early participation of children in competitive training activities is due to the 'catch them young' philosophy³, and to the belief that, to be able to achieve international acclaim, it is necessary to start intensive training before puberty.

The number of children taking part in competitive sports is so high that some medical bodies have issued guidelines regarding participation^{4,5}. Although all the risks of injury in these youngsters are, at present, unknown⁶, an epidemic of sports injuries, as children change from free play to the stereotyped demands of the specialized patterns of movement imposed by a single sport, has been predicted^{7,8}.

The emphasis on intensive training and high level competition in a single sport begs the following questions:

Should young children participate in intensive training and high level competition?

Are children involved in intensive training at risk of injuries to their developing musculo-skeletal system?

Can psychological problems arise from intensive sports participation at a young age?

Physical, cardiovascular and muscular effects

Increase in strength and endurance are an established feature of growth and development⁹ and of training¹⁰. The effects of physical training are difficult to separate from those of normal puberty⁹. Studies involving children have detected a wide range of results, from certain ill effects, such as growth retardation¹¹, and no effects at all^{1,12-14}. It is known that a certain amount of physical activity is required for normal growth^{1,11}, but the minimum needed has not been identified, and the ill effects of intensive training have not been fully clarified^{1,9,11-14}.

In girls, one of the most sensitive areas of research has been menarche and menstrual disorders. The age of achieving menarche, and the incidence and duration of menstrual disturbances in young athletes engaged in intensive training have been reviewed^{1,9}. With few exceptions, menarche is delayed in athletes¹. Moreover, female athletes engaged in intensive training show an increased frequency of menstrual irregularities¹². The data dealing with this issue have not been convincingly researched. Factors that could influence the time of menarche, such as genetic influences or nutritional status, must be systematically controlled for meaningful conclusions to be drawn.

Also, the skeletal maturation of young male athletes engaged in cycling, rowing and ice hockey was followed from 12 to 15 years by Kotulan *et al.*¹³ who concluded that regular physical activity has no effects on the growth of young male athletes.

The question of athletic potential has been addressed. The response of a given athlete to a particular training regimen is due to an inherited genotype¹⁵. Only approximately 30% of the maximal oxygen uptake (VO₂ max) and maximal force and power of top class competitors can be accounted for by training.

Young athletes undergoing vigorous training were found to be taller and to have less body fat and higher VO₂ max than sedentary controls¹⁶. In another study, 34 boys aged between 12 and 16 years old engaged in competitive middle and long distance running were compared with 56 controls not undergoing intensive training¹⁷. The runners had been training for 2 to 5 years, and had less body fat and lower resting heart rates. Statistically significant differences were only achieved between the 16 year olds. The young runners in this study also had larger heart volumes,

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and a higher VO_2 max relative to body weight and respiratory capacity.

In another study, the effects of endurance and sprint training were studied on the vastus lateralis muscles of boys aged 16 and 17 years¹⁸. Endurance training resulted in a significant increase to type I and IIA fibre areas, together with increased activity of some of the enzymes of the Krebs cycle. On the other hand, sprint-trained boys showed a significant increase in the activity of glycolytic enzymes.

Fewer controlled studies have dealt with the trainability of muscular strength in children. Pre- and post-pubescent children of both sexes can significantly increase their muscular strength by resistance training^{19,20}. The traditional view¹⁹ in this respect is that the potential to develop strength is not at its maximum before puberty. Nevertheless, according to Pfeiffer and Francis, pre-pubescent children are likely to have a greater muscular strength trainability than older age groups²¹. When interpreting the effects of a strength training programme, one should consider that the natural increase in strength in boys reaches its maximum only approximately 1 year after the growth spurt, while in girls this occurs during the period of growth spurt itself²².

Intensive training may result in staleness. There have been a number of reports of a fatigue syndrome in top class athletes. However, no controlled studies have been performed. Some possible important contributing factors to fatigue include an increased predisposition to viral infections, fatigue from over-training or combination of physical and psychological fatigue analogous to the 'burn out syndrome' reported in other contexts^{10,23,24}. Keast *et al.* have stated that sports mediated immune response alterations may play a major role in determining increased susceptibility to infections²⁵.

Sports injuries

Some epidemiological studies have shown that between 3% and 11% of school-aged children are injured each year due to sports activity^{26,27}. Physical characteristics can play a major role both in the choice of sport and on the pattern of injuries²⁸. For example, joint laxity may result in a child's choice of gymnastics, but is associated with recurrent sprains and dislocations²⁹.

During the growth spurt, adolescents are particularly vulnerable to injuries, partially due to imbalance in strength and flexibility⁷. The huge increases in participation, training and competition have resulted in children incurring injuries previously seen almost exclusively in adults^{30,31}.

The skeletal system is extremely plastic in children and shows pronounced adaptive changes to intensive sports training³². The long-term effects on bone of participating in intensive training during the period of growth and development are still obscure. Low-intensity training can stimulate bone length, but high intensity training may inhibit it^{33,34}.

Sports injuries could result in damage to the growth mechanisms with subsequent life-lasting damage³⁵. Physiological repetitive loading is indeed beneficial³⁶, but excessive efforts may result in

serious injury of the weight-bearing joint surfaces³⁷. Due to the presence of growing cartilage, and the process of growth itself, the skeletal system of a young athlete is more prone to specific types of injuries³⁸. In addition, ligaments in children are two to five times stronger than the cartilage and bone of the epiphysal plate to which they are attached^{39,40}. This results in a greater likelihood of fracture of the epiphysal-metaphysal junction rather than the ligamentous tears seen in adults.

Over-use injuries are characterized by chronic inflammation due to repeated microtrauma. Young athletes may develop one or more of a group of over-use injuries referred to as osteochondroses⁴¹. In some instances, an osteochondrosis involves degeneration of the centre of ossification where a major tendon attaches to the bone (an apophysis). Common sites are the posterior aspect of the calcaneus (Sever's disease), the tibial tubercle (Osgood-Schlatter disease), and the lower pole of the patella (Sinding-Larson-Johansson syndrome). The small carpal and tarsal bones may also be affected. Young athletes are therefore at risk of developing stress lesions to these susceptible growth areas. In childhood, compression stress fractures occur more commonly than the oblique type seen in adults^{42,43}. Endurance training regimens are probably responsible for at least 60% of all over-use injuries sustained³⁸ and could be avoided by appropriate changes in training.

In case of injury, the first therapeutic measure is rest⁴¹. At high performance level, it is important to know whether an alteration of training regimen after an injury can maintain fitness and ensure rapid healing. Very little research has been performed in this area, although in one study that replaced endurance running with endurance cycling for 4 weeks it was observed that maximal aerobic power and submaximal running performance for moderately trained women runners was maintained⁴⁴.

Psychological effects

Young competitors undergo increased stress and anxiety due to competition⁴⁵, the outcome of which can be influenced by parents⁴⁶, potentially leading to a greater incidence of aggression in the young athletes⁴⁷. These concerns have led to the extreme position of calling for a complete ban on high level competition in pre-adolescence because of the possible long term deleterious effects⁴⁸. Detailed reviews of the psychological effects of intensive training on young athletes have recently been published^{3,14}.

Conclusions

The physiological responses to training in children appear to be similar to those found in adults and, in the short term at least, seem beneficial. Definitive statements about the effects of intensive training on young athletes cannot yet be made. However, concerns about the physical and psychological injury remain, and it is likely that the age of the child and the particular sport should influence the type and intensity of training.

Health professionals dealing with young athletes should be aware of these controversial issues. Children are not just adults in miniature, and they should not be assumed to be able of the same amount and quality of exertion as adults. Probably, it is safe to follow the '10% rule'⁴⁹, which advocates progressing the intensity of any training programme no more than ten per cent a week.

Preparation and performance standards should take into account the chronological and biological age of the participants, as well as their physical and psychological immaturity. Adults dealing with high standard athletic children must not exploit the youngsters, but maintain the state of health of the children under their care, while helping them to improve their athletic performance. Better insight into different aspects of training is needed to avoid serious damage to children in high level competition. When planning a training programme, the physiological maturation process which the children undergo should be taken seriously into consideration. Time is needed for a growing child to incorporate his own body changes, and probably little room is left at this critical stage for developing speed, strength and resistance⁵⁰.

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