

AMERICAN ACADEMY OF PEDIATRICS

Committee on Sports Medicine and Fitness

Intensive Training and Sports Specialization in Young Athletes

ABSTRACT. Children involved in sports should be encouraged to participate in a variety of different activities and develop a wide range of skills. Young athletes who specialize in just one sport may be denied the benefits of varied activity while facing additional physical, physiologic, and psychologic demands from intense training and competition.

This statement reviews the potential risks of high-intensity training and sports specialization in young athletes. Pediatricians who recognize these risks can have a key role in monitoring the health of these young athletes and helping reduce risks associated with high-level sports participation.

There appear to be increasing numbers of children who specialize in a sport at an early age, train year-round for a sport, and/or compete on an "elite" level. Media coverage of national and international competition in sports such as gymnastics, figure skating, swimming, diving, and tennis has focused attention on a number of very talented but very young competitors. The successes of young athletes can serve as a powerful inducement for others to follow. Most Olympic sports have selection processes that attempt to identify future champions and initiate specialized training—often before the prospect finishes elementary school. The lure of a college scholarship or a professional career can also motivate athletes (and their parents) to commit to specialized training regimens at an early age. The low probability of reaching these lofty goals does not appear to discourage many aspirants.

To be competitive at a high level requires training regimens for children that could be considered extreme even for adults. The ever-increasing requirements for success creates a constant pressure for athletes to train longer, harder, more intelligently, and, in some cases, at an earlier age. The unending efforts to outdo predecessors and outperform contemporaries are the nature of competitive sports. The necessary commitment and intensity of training raises concerns about the sensibility and safety of high-level athletics for any young person.

Adverse consequences from intense training and competition have been reported in the lay and medical literature.^{1,2} Many pediatricians can cite examples of undesirable outcomes from sports participation involving patients in their own practices. Unfortunately, anecdotal reports and case studies are insuf-

ficient grounds for drawing conclusions about the safety of intense training or high-level competition.

The short-term and long-term health consequences of such training in young athletes need to be further investigated. Physical, physiologic, and psychologic tolerances to stress in children have been studied in laboratory settings and can be defined by observing the threshold for injury in clinical settings. Unfortunately, this information is difficult to directly apply to the specific clinical scenarios of concern to the pediatrician. Studying the risks of "specialized," "intensely trained," or "elite" athletes is hampered by the lack of clear definitions of these at-risk populations. Even if a study group could be defined, the level of variation between sports, individuals, and training regimens creates further methodologic challenges for investigators.

Despite recognized inadequacies of current information, pediatricians can still help safeguard their young athletic patients by being aware of potential problems associated with intense training. Because pediatricians serve as the primary medical contact for most young athletes, they may have the best opportunity to recognize, treat, and monitor injuries or illnesses resulting from strenuous training. To respond to parental concerns and to more effectively monitor the child athlete engaged in intensive training, increased awareness of the following issues is suggested.

CARDIAC

Child athletes have superior cardiac functional capacity compared with nonathletes. Nonetheless, there is some cause for caution. Data obtained from studies using animals and humans indicate that myocardial function can be depressed, at least transiently, after intense exercise. Echocardiographic studies have indicated a transient decrease in left ventricular contractility after extremes of athletic competition (ie, 24-hour ultramarathon runs).³

A limited number of studies have failed to identify an adverse effect of intense endurance training on the heart of the child athlete. In these investigations, no differences in resting echocardiograms or electrocardiograms have been observed between trained prepubertal runners and nonathletes.^{4,5} Rost studied a group of young swimmers longitudinally with echocardiograms over a 10-year period. Cardiac volume and chamber size exceeded those of nonathletic children.⁶ The effects of sustained submaximal exercise on cardiac function are similar in children and adults.⁷ Evaluation of cardiac function before and immediately after a 4-km road race by echocardi-

The recommendations in this statement do not indicate an exclusive course of treatment or serve as a standard of medical care. Variations, taking into account individual circumstances, may be appropriate.

PEDIATRICS (ISSN 0031 4005). Copyright © 2000 by the American Academy of Pediatrics.

grams in run-trained boys ages 9 to 14 years showed no evidence of change in left ventricular contractility.⁸

Based on these limited data, currently there is no indication that intense athletic training of the child athlete results in injury to the heart. However, closer study of the cardiac characteristics of children training at elite levels is necessary before this conclusion can be verified. Careful assessment of cardiovascular status (heart murmurs, abnormal rhythms) remains important in ongoing medical care of the child athlete.

MUSCULOSKELETAL INJURY AND GROWTH

With low or absent physical activity, muscle tissue becomes atrophic, and bone mineral content decreases. An increase in physical activity stimulates musculoskeletal growth and repetitive stress can stimulate positive adaptive responses in musculoskeletal structures. However, excessive stress or overload can lead to tissue breakdown and injury. To realize maximum gains, athletes must correctly identify and train just below the threshold for injury.

Overuse injuries (tendinitis, apophysitis, stress fractures) can be consequences of excessive sports training in child and adult athletes. Certain aspects of the growing athlete may predispose the child and adolescent to repetitive stress injuries such as traction apophysitis (Osgood-Schlatter disease, Sever disease, medial epicondylitis [Little League elbow]), injuries to developing joint surfaces (osteochondritis dissecans), and/or injuries to the immature spine (spondylolysis, spondylolisthesis, vertebral apophysitis).⁹

Because of the potential for long-term growth disturbances, injuries to epiphyseal growth centers are a particular concern for young athletes. Because the physeal plate may be weaker than surrounding ligamentous structures, external stress may disrupt a growth plate rather than damaging a ligament or related soft-tissue structure. Physeal fractures can result in growth arrest or deformity of long bones. Fortunately, there is no evidence that epiphyseal fractures or growth complications caused by epiphyseal injuries are seen disproportionately in children who participate in organized sports or higher levels of competition.

The long-term effects of repetitive microtrauma to the epiphysis is still under investigation. Damage to the distal radial epiphysis with subsequent alterations in radial-ulnar growth has been described in highly competitive gymnasts.¹⁰ Epiphyseal injuries to the long bones of prepubertal children involved in distance running and other weight-bearing sports (that might potentially affect development of stature) have not been described. Similarly, cross-sectional and longitudinal studies describing growth in child athletes indicate that size and rate of growth of athletes are not negatively influenced by intensive training and competition.¹¹ Short stature in gymnasts has been considered most likely a consequence of genetic and physique preselection rather than a result of training, although some have concluded that training

starting before and maintained throughout puberty can alter growth rates.¹²

NUTRITION

Proper nutrition is critical for both good health and optimal sports performance. For child athletes, an adequate diet is critical because nutritional needs are increased by both training and the growth process. Young athletes and their parents are frequently unaware of the appropriate components of a training diet. The following 4 areas are of particular concern.

Total Caloric Intake

Athletic training creates a need for increased caloric intake, and requirements relative to body size are higher in growing children and adolescents than at any other time in life. In child athletes, the energy intake must be increased beyond the needs of training to maintain adequate growth. Children who engage in sports in which slenderness is considered important for optimizing performance (ie, gymnastics, ballet dancing) may be at risk for compromising their growth. A risk for pathologic eating behaviors also may be increased in children participating in sports where leanness is rewarded.

Balanced Diet

Balance, moderation, and a variety of food choices should be promoted. The Food Guide Pyramid can be used to plan a diet that is balanced and provides sufficient nutrients and calories for both growth and training needs. Athletes who focus on particular dietary constituents (such as carbohydrates) at the expense of a well-rounded diet may potentially compromise their performance as well as their health.

Iron

The body's requirement for iron is greater during the growing years than at any other time in life. Adequate iron stores are important to the athlete to provide adequate oxygen transport (hemoglobin), muscle aerobic metabolism (Krebs' cycle enzymes), and cognitive function. However, athletes often avoid eating red meat and other iron-containing foods. Moreover, sports training itself may increase body iron losses.

Calcium

Inadequate calcium intake is common in athletes, presumably because of their concern about the fat content in dairy foods. Normal bone growth, and possibly, prevention and healing of stress fractures, are contingent on sufficient dietary calcium.

SEXUAL MATURATION

Athletic girls tends to experience menarche at a later age than nonathletic girls, leading to concern that intensive sports training might delay sexual maturation. The average age of menarche in healthy North American girls is 12.3 to 12.8 years, while that of athletes in a wide variety of sports is typically 1 to 2 years later. Undernutrition, training stress, and low levels of body fat have been hypothesized to account for this delay. Alternatively, it is possible that the

later age of menarche in athletes simply reflects a preselection phenomenon.¹³ Girls who have narrow hips, slender physiques, long legs, and low levels of body fat—advantageous characteristics in many girls' sports—are more likely to experience later menarche regardless of sports participation.

Secondary amenorrhea, or cessation of menstrual cycles after menarche, can occur as a result of intense athletic training. Prolonged amenorrhea may cause diminished bone mass from the associated decrease in estrogen secretion, augmenting the risk for stress fractures and the potential for osteoporosis in adulthood. Efforts to improve nutrition or diminish training volume in these girls may permit resumption of menses and diminish these risks.

Studies of males have indicated no evidence of an adverse effect on sexual maturation related to sports training. Progression of Tanner stages of pubertal development has not been observed to be retarded in athletic compared with nonathletic adolescents.¹¹

PSYCHOSOCIAL DEVELOPMENT

Considerable research has addressed anxiety and stress that affect children who engage in competitive sports but little data exist about the effects of more intense or sustained training on young athletes. Anecdotal reports suggest risks of "burnout" from physical and emotional stress, missed social and educational opportunities, and disruptions of family life. Unrealistic parental expectations and/or exploitation of young athletes for extrinsic gain can contribute to negative psychological consequences for elite young athletes. Survey studies suggest, however, that while such adverse effects occur, they are experienced by only a small minority of intensely training athletes.¹³ Most athletes find elite-level competition to be a positive experience.

Research supports the recommendation that child athletes avoid early sports specialization. Those who participate in a variety of sports and specialize only after reaching the age of puberty tend to be more consistent performers, have fewer injuries, and adhere to sports play longer than those who specialize early.¹⁵

HEAT STRESS

Child athletes differ from adults in their thermoregulatory responses to exercise in the heat.¹⁶ They sweat less, create more heat per body mass, and acclimatize slower to warm environments. As a result, child athletes may be more at risk for heat-related injuries in hot, humid conditions. It is particularly critical that coaches, parents, and young athletes are aware of signs of heat injury. They also should be aware that limiting sports play and training in hot, humid conditions and ensuring adequate fluid intake can prevent heat injury.

RECOMMENDATIONS

Although many concerns surround intense sports competition in children, little scientific information is available to support or refute these risks. Nonetheless, it is important to make efforts to assist young athletes in avoiding potential risks from early exces-

sive training and competition. The following guidelines are suggested keeping in mind 1) the importance of assuring safe and healthy sports play for children, 2) the need to provide practical and realistic guidelines, and 3) the limited research basis for making such recommendations.

1. Children are encouraged to participate in sports at a level consistent with their abilities and interests. Pushing children beyond these limits is discouraged as is specialization in a single sport before adolescence.
2. Pediatricians should work with parents to ensure that the child athlete is being coached by persons who are knowledgeable about proper training techniques, equipment, and the unique physical, physiologic, and emotional characteristics of young competitors.
3. In the absence of prospective markers of excessive physical stress, physicians and coaches should strive for early recognition and prevention and treatment of overuse injuries (tendinitis, apophysitis, stress fractures, "shin splints"). Child athletes should never be encouraged to "work through" such injuries. Treatment recommendations for overuse injuries that include only "rest" or cessation of the sport are unlikely to be followed by the committed child athlete and are unlikely to adequately address the risk of further injury.
4. The conditions of child athletes involved in intense training should be monitored regularly by a pediatrician. Attention should be focused on serial measurements of body composition, weight, and stature; cardiovascular findings; sexual maturation; and evidence of emotional stress. The pediatrician should be alert for signs and symptoms of overtraining, including decline in performance, weight loss, anorexia, and sleep disturbances.
5. The intensely trained, specialized child athlete needs ongoing assessment of nutritional intake, with particular attention to total calories, a balanced diet, and intake of iron and calcium. Serial measurements of body weight are particularly important in ensuring the adequacy of caloric intake and early identification of pathologic eating behaviors.
6. The child athlete, family, and coach should be educated by the pediatrician about the risks of heat injury and strategies for prevention.

COMMITTEE ON SPORTS MEDICINE AND FITNESS, 1999–2000

Steven J. Anderson, MD, Chairperson
Bernard A. Griesemer, MD
Miriam D. Johnson, MD
Thomas J. Martin, MD
Larry G. McLain, MD
Thomas W. Rowland, MD
Eric Small, MD

LIAISON REPRESENTATIVES

Claire LeBlanc, MD
Canadian Paediatric Society
Robert Malina, PhD
Institute for the Study of Youth Sports

Carl Krein, ATc, PT
National Athletic Trainers Association
Judith C. Young, PhD
National Association for Sport and Physical
Education

SECTION LIAISONS

Frederick E. Reed, MD
Section on Orthopaedics
Reginald L. Washington, MD
Section on Cardiology

CONSULTANT

Oded Bar-Or, MD

STAFF

Heather Newland

REFERENCES

1. Ryan J. *Little Girls in Pretty Boxes: The Making and Breaking of Elite Gymnasts and Figure Skaters*. New York, NY: Warner Books; 1996
2. Tofler IR, Stryer BK, Micheli LJ, Herman LR. Physical and emotional problems of elite female gymnasts. *N Engl J Med*. 1996;25:335:281-283
3. Niemela KO, Palatski JJ, Ikaheimo MJ, Takkunen JT, Vuori JJ. Evidence of impaired left ventricular performance after an uninterrupted competitive 24-hour run. *Circulation*. 1984;70:350-356
4. Rowland TW, Delaney BC, Siconolfi SF. "Athlete's heart" in prepubertal children. *Pediatrics*. 1987;79:800-804
5. Rowland TW, Unnithan VB, McFarlane NG, Gibson NG, Paton JY. Clinical manifestations of the "athlete's heart" in prepubertal male runners. *Int J Sports Med*. 1994;15:515-519
6. Rost R. *Athletics and the Heart*. Chicago, IL: Yearbook Medical Publishers; 1987
7. Rowland TW, Rimany TA. Physiological responses to prolonged exercise in premenarcheal and adult females. *Pediatr Exerc Science*. 1995;7:183-191
8. Rowland TW, Goff D, Popowski B, DeLuca P. Cardiac effects of a competitive road race in trained child runners. *Pediatrics*. 1997;100(3). URL: <http://www.pediatrics.org/cgi/content/full/100/3/e2>
9. Micheli LJ. Overuse injuries in children's sports: the growth factor. *Orthop Clin North Am*. 1983;14:337-349
10. Caine DJ. Growth plate injury and bone growth: an update. *Pediatr Exerc Science*. 1990;2:209-229
11. Malina RM. Physical growth and biological maturation of young athletes. *Exerc Sports Sci Rev*. 1994;22:389-434
12. Thientz GE, Howald H, Weiss V, Sizonenko PC. Evidence for a reduction of growth potential in adolescent female gymnasts. *J Pediatr*. 1993;122:306-313
13. Malina RM. Menarche in athletes: a synthesis and hypothesis. *Ann Hum Biol*. 1983;10:1-24
14. Donnelly P. Problems associated with youth involvement in high-performance sport. In: Cahill BR, Pearl AJ. *Intensive Participation in Children's Sports*. Champaign, IL: Human Kinetics Publishers; 1993:95-126
15. Bompa T. *From Childhood to Champion Athlete*. Toronto, Canada: Veritas Publishing, Inc; 1995
16. Bar-Or O. *Pediatric Sports Medicine for the Practitioner*. New York, NY: Springer-Verlag; 1983