THE PREVENTION OF SPORTS INJURIES IN CHILDREN

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Injuries from sports participation are a significant cause of hospitalization and health care costs in children and adolescents. Injuries are the second leading cause of emergency room visits for youth and the second leading cause of injury in schools. Although there are no hard statistics, owing to surveillance and external cause of injury code (E-code) limitations (only 33% of injuries are identifiable as a sports injury using the International Classification of Diseases, Ninth Revision [ICD-9] coding system), estimates are that 3 million youth are seen in hospital emergency rooms each year for sports-related injuries, and another 5 million are seen by their physicians and sports medicine clinics for sports-related injuries. Twenty-five percent to 30% of youth sports injuries occur in organized sports, and another 40% occur in unorganized sports. Deaths from some sports, even those specified by E-codes, may be underestimated. For example, in 1986 the 58 recreational scuba diving deaths identifiable in the National Health Statistics Data using E-codes were far fewer than the 94 reported to the National Underwater Accident Data Center. In 1997, the medical cost of sports injuries for youth age 0 to 14 in the United States for product-related injuries was $365,470,091,189 for 28 sports: archery, baseball, basketball, bicycling, boxing, diving, field hockey, football, golf, gymnastics, horseback riding, ice hockey, ice skating, inline skating, martial arts, mountain bikes, roller skating, skiing, soccer, softball, swimming, tennis, track and field, trampolines, volleyball, weightlifting and wrestling. (These statistics do not reflect the large number of overuse injuries currently presented to pediatricians, family physicians, and clinics.)

It is estimated that 25 million scholastic and 20 million organized,
community-based youth participate in sports annually in the United States. Young athletes often begin their competitive careers as early as age 7 and organized sports participation as early as age 4.

MECHANISMS OF SPORTS INJURIES

There are two mechanisms of sports injury: macrotrauma, that is, acute trauma, and repetitive microtrauma, that is, injury resulting from overuse.

Macrotrauma is defined as a sudden acute injury from a major force, for example a collision or a fall. Acute macrotrauma injuries of the musculoskeletal system include fractures of the long bones and axial skeleton; sprains of joint ligaments; strains of muscle tendon units; and contusions involving muscle tendon units and their overlying soft tissue.

Microtrauma results from chronic repetitive injury to tissue over an extended period, such as a stress fracture. Other overuse injuries include bursitis, tendonitis, apophysitis of tendon insertions, and in certain cases, osteochondral injuries of the joint surface.

Injuries related to sports participation range from catastrophic acute accidents, such as spinal damage and concussions, to overuse injuries, such as tennis elbow and shin splints. Overuse injuries may be the commonest class of sports injuries encountered by primary care physicians.

FACTORS CONTRIBUTING TO SPORTS INJURIES

Sports injuries are not accidents. They are predictable incidents that are amenable to prevention. There are many reasons why sports injuries occur. Research has identified the following frequent factors:

- Lack of coaching education
- Inadequate preparticipation physical exams
- Hazardous playing fields
- Conditioning and training errors
- Lack of, improper, poorly fitted, or inadequate safety equipment
- Playing while injured or overtired
- Declining fitness levels of children
- Grouping teams by age instead of size
- Poor nutrition
- Rules and officials
- Improper technique (e.g., in tennis, improper swing may cause the tennis player to develop tennis elbow)
- Inadequate supervision
- Psychologic stress
- Weather conditions
- Growth (e.g., bones grow faster than ligaments and tendons, caus-
ing ligaments to be "tight," which may lead to injury if attention is not paid to flexibility training)

Each young athlete has individual risk factors, and each sport poses its own risk for injury. The number and severity of injuries differs with the level of competition. Unfortunately, little systematic research has been done to obtain baseline rates of injury in youth sports or to study the effects of alterations of their risk factors on the incidence or relative severity of injury. One of the most obvious risk factors is the equipment used in sports, which is relatively accessible for evaluation. In 1988, Janda et al published a landmark prospective study that compared the rates of injury in recreational softball between leagues using traditional fixed bases and leagues using breakaway bases. They demonstrated an injury rate seven times lower in leagues using breakaway bases: Regarding volume and intensity of training, Goldstein et al reported, in 1991, on back injuries in young female gymnasts. They found a significantly increased incidence of back injuries in those gymnasts who trained more than 16 hours per week. A second study provided additional insight into the volume of training outcomes from Japan. This study of youth baseball pitchers found that pitchers who performed more than 300 skilled throws per week in games and training sessions sustained a significantly higher incidence of elbow injuries.

A third area of research, playing technique, has focused recently on the relatively high rate of noncontact anterior cruciate ligament injuries in young female athletes engaged in contact or "cutting" sports, such as soccer, basketball, and team handball. Henning et al first studied the role that playing techniques such as cutting might have on the recurrence or amelioration of this injury in female athletes. More recently, Hewett et al published an important prospective study that demonstrated a significant decrease in ACL injuries in female athletes engaged in soccer and basketball who are taught a structured, proprioceptive technique of cutting and turning before engaging in their sports. Their rate of injury was significantly less compared with controls.

Before preventative measures can be implemented effectively, it is important to determine what types of injuries are most prevalent, who sustains the injuries, and why and where they occur. This is accomplished through surveillance, which is mandatory if progress is to be made in the prevention of sports injuries.

Despite considerable literature devoted to the sports injuries of children and youth, there is no surveillance system to document the epidemiology of the injuries for young athletes. Isolated studies have recorded the incidence and frequency of injuries in some sports, but the methodology of data collection and reporting is so fragmented that a systematic analysis and recommendations for change are speculative.

Recognizing the need for data, the National Institutes of Health convened a conference in 1991, Sports Injuries in Youth: Surveillance Strategies, to develop guidelines for programs to monitor the rates and costs of youth sports injuries. The objectives of the conference were to increase
awareness of the need for data, to demonstrate how the information could be used, to stimulate data collection efforts, and to encourage epidemiologic research in this area. More recently, the Fédération Internationale de Médecine du Sport and the World Health Organization (FIMS/WHO) issued a joint position statement calling for all youth sports organizations to initiate injury surveillance systems.

Several surveillance systems to capture limited data are in existence. The Consumer Product Safety Commission (CPSC) operates the National Electronic Injury Surveillance System (NEISS), which captures data from more than a hundred hospital emergency rooms on only product-related injuries. In 1982, the National Center for Catastrophic Sports Injury Research was established at the University of North Carolina at Chapel Hill. Several national governing bodies of sports have established surveillance systems, in addition to the National Collegiate Athletic Association.

As many as 18 national medical and sports organizations have been involved with injury prevention efforts in the last 20 years, advocating safer sports for youth. The American Academy of Pediatrics, the American Medical Association, the American College of Sports Medicine, the International Federation of Sports Medicine, the American Dental Association, the National Athletic Trainers Association, and the American Association of Orthopedic Sports Medicine have come forth with position papers addressing topics such as nutritional supplements, safety equipment, conditioning, training, and sport-specific injuries. National governing bodies of sports and the National Federation of State High School Associations and the National College Athletic Association have sports medicine committees that address rules, safety equipment, playing time, preparticipation physicals, and supplements. There was however, no system or organization to disseminate the information other than journals, and it took many years for the information to reach the public.

Recognizing the need for the timely dissemination of information and the lack of one organization in the country devoted solely to the prevention of athletic injuries in youth, the National Youth Sports Safety Foundation, Inc. (NYSSF) was created in 1989 to serve as an educational resource. The mission of the NYSSF (a nonprofit educational organization) is to reduce the number and severity of injuries that youth sustain in sports and fitness activities through the education of health professionals, program administrators, coaches, parents, and athletes. The NYSSF’s mission is a commitment to promote the healthy development of youth and to keep them physically active and involved in sports for life.

The NYSSF publishes fact sheets, resource sheets, guidelines, reports, and a quarterly newsletter, Sidelines. In addition, the NYSSF publishes the Yearbook of Youth Sports Safety, a compilation of information from national medical and sports organizations. The NYSSF is the lead organization for National Youth Sports Safety Month, a national health
campaign observed during the month of April to promote safety in youth sports activities, which is supported by more than 60 national medical and sports organizations. The NYSSF has initiated a new movement and is leading the country in promoting safety in sports activities for youth.

Many conferences addressing different aspects of sports injuries have been held throughout the United States. The American Society for Testing and Materials Sports Equipment Committee convened several different conferences on sports safety. In 1992, the Second International Symposium on Safety in Ice Hockey was held in Pennsylvania. It addressed epidemiological factors, injury treatment modalities, playing facilities, and protective equipment such as eye protection, helmets, and mouthguards. A Symposium on Head and Neck Injuries in Sports was held in Atlanta, Georgia in May 1993. It had two objectives, along with its main focus of epidemiology: (1) To review and evaluate the effectiveness of factors related to safety; and (2) to determine whether these safety factors could be modified and improved to reduce injury rates, while not adversely modifying or affecting the basic nature of the physical activity or sports in which the injuries occurred. The Symposium on Safety in American Football was held in Phoenix, Arizona, in 1994 and focused on risks and whether risks could be modified or limited. The International Symposium on Safety in Baseball/Softball was held in Atlanta, Georgia, in 1995. This symposium’s mission was to review the state-of-the-art and science of new products, materials, technology, and epidemiology.

The problem of youth sports injuries also has recently stimulated the Consumer Product Safety Commission (CPSC) and the Centers for Disease Control and Prevention to conduct national forums on this topic. Several roundtable discussions were held that focused on soccer goal posts and baseball safety equipment. In 1996, the CPSC issued a final report on the Youth Baseball Protective Equipment Project. The goal of the project was to develop information for the general public about what types of available protective equipment could prevent or reduce the severity of baseball-, softball-, and tee-ball-related injuries and deaths to children ages 5 to 14. The reported concluded:

> There were an estimated 162,100 baseball related injuries to children ages 5-14 treated in hospital emergency rooms in 1995.
> About one-third of these injuries (more than 58,000 injuries) occurred in circumstances where available protective equipment could be expected to help reduce the severity of the injury, or eliminate it altogether. The 47,900 injuries that involved ball impact to the head/neck area might have been lessened in severity or prevented by the use of softer balls. The 3,900 facial injuries that occurred to batters in organized play could have been prevented by the use of face guards. And the 6,600 base-contact sliding injuries that occurred in organized play might have been lessened in severity or prevented by the use of safety release bases.

On May 4, 1999, the CPSC and the soccer equipment industry
announced the development of a new safety standard that will reduce the risk for soccer goal tip-over. Since 1979, the CPSC has learned of 23 deaths and 38 serious injuries from soccer goals tipping over and crushing children who climb on them or hang from the crossbar.41

Coaching Education

The United States is the only country in the major sporting world that does not have a national coaching education program. With more than 3.5 million coaches in the United States there is no nationally accepted system of certification for coaches.22 There are no federal laws requiring coaching education at any level of competition, including youth sports, interscholastic, collegiate, or Olympic. Untrained coaches unknowingly may contribute to the occurrence of sports injuries instead of helping to prevent them because they may have no formal education in conditioning and training, growth and development, injury prevention, sport pedagogy, or psychology.

Coaching education programs have been developed by individuals, organizations, and universities. Until 1996, there were no standards for these programs until The National Standards for Athletic Coaches, a consensus project, was published. The project was facilitated by the National Association for Sport and Physical Education (NASPE), consisting of more than 200 organizations and individual experts.10 NASPE is currently in the process of developing the National Council for Accreditation of Coaching.29

The National Federation of State High School Associations adopted the American Sport Education Program for coaching education in 1990.35 It is up to each state to mandate it, however. In 1998, it was noted that 36 states had passed legislation requiring coaches to have educational courses to be able to coach.36 More than 50% of the interscholastic coaches in the country do not hold a teaching certificate and have no affiliation with the school systems. Only one state (New Jersey) has any requirements for volunteer coaches.13

In 1997, the United States Olympic Committee (USOC), the lead organization for sports in the United States, joined with the American Red Cross to develop a Sports Safety Training Course (SST) for coaches. The USOC has announced the course will be mandatory for all USOC coaches.7 The SST includes injury prevention, first aid, and CPR, and is delivered nationwide through local chapters of the American Red Cross.

PREVENTION STRATEGIES

It is estimated that up to one half of all injuries sustained while playing organized sports by children and adolescents may be preventable.8 The American College of Sports Medicine8 noted that, as the number of children and adolescents in organized sports increases, new injury patterns are developing that were not apparent when youth spent
most of their sport and fitness time in free play. The following prevention measures were highlighted:

- Coaches and teachers should emphasize that general fitness is the basis for all sports participation. Fitness exercises should be included in the training routine rather than devoting all of each training session to the development of specific skills required for a certain sport.
- Children may be encouraged to participate in several different sports, rather than specializing in a single sport at an early age.
- Instructors of sport should adhere to appropriate training principles and encourage athletes to begin training one or two months before the actual season begins.
- In the prevention of overuse injuries, it is important for adults to allow the children to play. When young children control the intensity of an activity themselves, they seem likely to stay within safe ranges of activity level. Parents or coaches, however, often control the intensity of the game or training, and this may lead to overuse injuries.
- Rules for adult games should be modified as appropriate for young people. For example, softball bases may need to be closer, playing periods shorter, and playing fields proportionately smaller.
- Coaches or parents of young athletes who place too much emphasis on winning may well contribute to the risk for an athlete sustaining an injury.
- Opponents in a sports event should ideally be matched by age, height, weight, maturity and skill in order to decrease the incidence of injury.
- Competitive sports among children and adolescents should be carefully supervised and rules strictly enforced.
- There should be no more than a 10% increase each week in the amount of training time, amount of distance covered, or number of repetitions performed in an activity.
- Training sessions should include warm-up and cool-down periods and flexibility exercises.
- Comprehensive pre-participation physical examinations are recommended for all young athletes.
- Resistance training for children and adolescents should exclude lifting of the maximal weight that an individual can accomplish. The amount of weight lifted or resistance used should be no larger than the amount with which the participant can complete at least ten repetitions in good form.

Consensus Statements

One consensus statement of significance was published by the FIMS/WHO Ad Hoc Committee on Sports and Children. Its recommendations are as follows:
Addressed to Sports Governing Bodies

- Sports governing bodies must be directly responsible for the safety and training of young athletes engaged in their particular sports.
- They should institute systems to monitor the level of intensity and categories of competition in their sports.
- Sports governing bodies should be responsible for preparing and maintaining ongoing statistics of illness and injury for children and adolescents participating in their sports.
- They should be responsible for certifying the credentials of coaches at this age level. This will include direct participation in coaching education, certification, and a reasonable assessment of the ethical and moral character of their coaches.
- Sports governing bodies have the responsibility to determine standards for protective equipment, playing fields, and duration of competition appropriate for children.
- They should formulate the appropriate legislation related to organized sports for children.

Addressed to Youth Sports Coaches

- Coaches should participate in special programs of education.
- They should have credentials that encompass: (1) the techniques and skills of youth sports, (2) the specific safety risks of children’s sports, (3) the psychology and sociology of children and adolescents, and (4) the physiology of growth and development as it relates to physical activity during childhood and adolescence as well as common medical related issues.

Addressed to Health Professionals

- Health professionals must take steps to improve their knowledge and understanding of the organized sports environment as well as the risk factors and safety factors inherent to this type of sports participation.
- Physicians should monitor the health and safety of children involved in organized sports whenever possible, in particular, those involved in elite sports training.

Sports Training

- Sports training for children and adolescents encompasses the age range from five to 18 years. In the early stages of training, every emphasis should be given to broad-based participation opportunities to enhance general motor development.
- Sports specialization should be avoided before the age of 10.
- During specialized training, the nutritional status should be monitored carefully. In particular, care should be taken to ensure that
child athletes are given adequate diets for the high-energy demands of sports. In addition, avoid marginal dietary practices, in particular caloric deprivation, in an attempt to delay maturation of physical development during sports training. (Such dietetic manipulations to attain competitive advantages must be viewed as a form of child abuse.)

Addressed to Parents

- The Ad Hoc Commission stresses the importance and responsibility of parental participation in the education process regarding the benefits and risks of sports training in childhood.
- Parents must increase their knowledge and awareness of the benefits and risks of competitive sport.
- Parents must be active participants in the process of the coaching and training of their children in sports.

Research

- More research is needed to ascertain the specific benefits and risks of organized sport for children. This information is essential to maximize the benefits while minimizing the risks that the children may incur in organized sports.

The Inter-Association Guidelines for the Appropriate Care of Spine Injured Athletes, a consensus paper of 26 professional organizations was developed at a summit initiated by the National Athletic Trainers Association in Indianapolis, Indiana, May 30–31, 1998. These guidelines were developed for the prehospital management of the physically active participant with a suspected spinal injury.

Another work of great significance was the guidelines for the preparticipation physical examination endorsed by five medical societies4: American Academy of Family Physicians, American Academy of Pediatrics, American Medical Society for Sports Medicine, American Orthopaedic Society for Sports Medicine and the American Osteopathic Academy of Sports Medicine. Primary objectives of the preparticipation physical evaluation are to detect conditions that may predispose an athlete to injury; to detect conditions that may be life threatening or disabling; and to meet legal and insurance requirements. Secondary objectives are to determine general health, to counsel on health-related issues, and to assess fitness level for specific sports.

BARRIERS TO PREVENTION

There are many barriers to injury-prevention efforts that greatly affect the outcome of safety programs. These include misinformation,
lack of dissemination, tradition-bound resistance, and attitude and priorities.

Misinformation

Perhaps the most important barrier to progress in injury control is the perception that injuries are random occurrences that cannot be predicted or prevented.\(^3\) The reality is, however, that injuries are no more likely to occur by chance than are diseases.\(^2\)

Common examples of misinformation are typified by statements such as, "injuries are part of the game," and "our organization will be held to a higher standard if we are informed."

Many injuries may be prevented through educational programs, but there has to be a perceived need for these programs. Many program administrators and coaches believe injuries are not a problem and there is no reason to address the issue. In addition, some administrators believe their coaches will be held to a higher standard if they become involved in litigation resulting from an injury sustained in their program, if their group has had a presentation on safety, or if they have safety educational resources available to their coaches.

Dissemination

Another barrier is dissemination. The structure of sports in the United States makes the dissemination of injury prevention information a challenging task. There are collegiate sports programs governed by the NCAA; interscholastic sports programs governed by the National Federation of State High Schools Associations and the Association of Independent Schools; competitive sports programs run by national governing bodies of sport; recreational sports programs run by parks and recreation departments, boys and girls clubs, gyms, YMCAs, and many community independent programs that have no affiliation with a national organization.

At the high school level, as many as 50% of coaches are not certified teachers and are termed "walk-ons" (individuals not currently employed by the schools as teachers), making the dissemination of information to them, according to high school athletic directors, difficult, if not impossible. In 1994, the NYSSF Education Committee sent a survey to the executive directors of the state high school athletic associations to determine the effectiveness of an injury prevention program to prevent catastrophic neck and spinal injuries in football. A video, "Prevent Paralysis: Don't Hit with Your Head," was distributed through the National Federation of State High School Associations to its member state associations, who were, in turn, supposed to distribute materials to their local high schools. It was recommended by the National Federation of State High
School Associations that the video be mandatory viewing for all football coaches and students. Of the 51 state high school athletic associations surveyed, 37 responded. Fourteen state high school athletic associations said they never received a copy of the program. Twenty-three responded they had received the program, and of those, only two states made the viewing of the video mandatory for players, and six states made it mandatory for football coaches. Eleven states had catastrophic injuries that year, and whether those injuries could have been prevented if the video had been shown will not be known.

The results of the survey clearly define the need for program administrators at the highest levels to advocate injury prevention as a high priority when they disseminate information on prevention programs and to have evaluation procedures.

Community-organized sports programs are independent groups formed with the objective of giving youth an opportunity to participate in sports activities. Groups may multiply out of parents' dissatisfaction with existing programs because their children did not have enough competition or enough opportunity to play. Each program independently addresses rules and safety, without consulting national guidelines or resources. Often they run without an emergency plan, an immediate first-responder in case of injury, and have little access to injury prevention resources.

Tradition-Bound Resistance

*Tradition-bound resistance* is a term dubbed by injury prevention professionals to describe a mind-set against change. Examples of this have appeared in headlines and articles of newspapers across the country: “Debate: Protection vs. tradition. Safety equipment has hard time gaining acceptance” (USA Today, April 23, 1990) and “Baseball, or safe ball” (Garden City Telegram, Garden City, KS, February 5, 1992).

Equipment manufacturers have determined the safety needs of children and youth based on their liability claims. They have been rebuffed, however, by rules committees who await additional, confirming evidence that the equipment will promote greater safety or are concerned that the equipment will alter the traditional nature of the sport.

Attitude and Priorities

Some sports medicine committees of national governing bodies, such as USA Hockey, believe one death in a sport is one death too many, and circumstances must be addressed so it never happens again. Another national governing body may justify their catastrophic injury statistics by the number of youth participating in their sport. The cost-benefit ratio is another barrier to sports safety. At a program on commotio cordis (sudden death as a result of nonpenetrating chest wall impact...
in the absence of structural injury to the ribs, sternum, and heart) convened by USA Hockey and the American Society for Testing and Materials, in 1995, in Denver, Colorado, it was reported that the cost of safety equipment for each team must be considered in relationship to the number of deaths, number of participants, and the cost to society. The example presented was: "Four chest protectors for a youth baseball team would cost approximately $200. There are five million children participating in youth baseball, with an average of several deaths each year. In youth baseball deaths there is very little cost to society because the victim died, whereas helmets could be justified because of the huge expense involved in maintaining a brain-injured child."

**SUMMARY AND FUTURE DIRECTIONS**

Sports injuries are a significant problem for children and adolescents and a great cost to society. With the growth of sports has come a growing number of injuries. More data are needed to make the issue a national public health priority, and more funding is needed for research and injury prevention programs. Education is at the core of sports safety: for program administrators, so they will become strong advocates of sports safety; for coaches, so they will understand the risks for injury and how to prevent them; for parents, so they will understand how to be good support systems for their children; and for the athletes, so they will understand how to stay in the game. Although some injury prevention programs have been developed, their success has been hampered by a lack of dissemination, lack of recognition of need by program administrators, and by tradition-bound resistance. An effective injury program requires effective leadership, dissemination, follow-up, and evaluation systems in place. Until these happen, millions of children will be injured each year resulting from their participation in sports, and at a cost of billions of dollars to the US public.

**References**


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