American Academy of Pediatrics
DEDICATED TO THE HEALTH OF ALL CHILDREN™

POLICY STATEMENT

Baseball and Softball

abstract

FREE

Baseball and softball are among the most popular and safest sports in which children and adolescents participate. Nevertheless, traumatic and overuse injuries occur regularly, including occasional catastrophic injury and even death. Safety of the athlete is a constant focus of attention among those responsible for modifying rules. Understanding the stresses placed on the arm, especially while pitching, led to the institution of rules controlling the quantity of pitches thrown in youth baseball and established rest periods between pitching assignments. Similarly, field maintenance and awareness of environmental conditions as well as equipment maintenance and creative prevention strategies are critically important in minimizing the risk of injury. This statement serves as a basis for encouraging safe participation in baseball and softball. This statement has been endorsed by the Canadian Paediatric Society. *Pediatrics* 2012;129:e842–e856

COUNCIL ON SPORTS MEDICINE AND FITNESS

KEY WORDS

balls, bats, commotio cordis, elbow, equipment, helmets, injury, pitch count, safety, shoulder

ABBREVIATIONS

AED—automated external defibrillator
CPSC—Consumer Protection Safety Commission
NEISS—National Electronic Injury Surveillance System
NOCSAE—National Operating Committee on Standard for Athletic Equipment
UCL—ulnar collateral ligament

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INTRODUCTION

The pediatrician needs to have an understanding of baseball and softball. This will allow the pediatrician to offer appropriate counseling and guidance to the many boys and girls, their parents, and members of the sporting community who participate in baseball and softball each year.

Baseball is one of the most popular sports in the United States, with an estimated 8.6 million children ages 6 to 17 participating annually in organized and recreational baseball.[1] Although baseball is a relatively safe sport in comparison with many other athletic activities, highly publicized catastrophic impact injuries from contact with a ball or a bat frequently raise safety concerns.[2,3] These incidents, as well as the high frequency of shoulder and elbow injuries resulting from overload and overuse, provide the impetus for this review and new guidance to reduce injury risk and improve safety in baseball for 5- to 18-year-old participants. This policy statement replaces the previous statement written in 2001.[4] This statement has been endorsed by the Canadian Paediatric Society.

Beginning in the early 1990s, epidemiological and injury surveillance research in baseball and softball intensified. Data from these scientific efforts paved the way for organized baseball to create medical advisory committees, which generated policies designed to reduce the risks of injury in baseball and softball. Advances in equipment also continue to offer new opportunities to make the game safer for youth athletes; similarly, the dissemination and use of automatic lightning detectors (which produce a clear and loud warning signal) and automated external defibrillators (AEDs) provide additional means of reducing catastrophic events on the baseball field.[5,6] Moreover, organized youth baseball coaches, officials, and administrators must remain knowledgeable and

sensitive to the developmental and skill levels of young baseball players and continue to modify the rules, when necessary, for the safety of the players. This policy statement focuses principally on baseball, but softball will also be considered where relevant literature is available.

PARTICIPATION

There are over a dozen youth baseball organizations whose combined annual participation is nearly 5 million. Little League Baseball reports baseball participation at approximately 2.3 million annually and softball participation at 400 000 per year[7]; the Babe Ruth League (and its 12-and-under Cal Ripken Baseball division) has more than 1 million youth participants annually.[8] Over 2 million girls between the ages of 12 and 18 compete in fast pitch softball annually. The National Federation of State High School Associations 2009–2010 participation data counted 473 503 baseball players (ages 14–18) and 393 578 softball athletes.[9]

INJURY DATA

There are a variety of sources of data for injuries in youth baseball, which include hospital emergency departments, insurance claims, national catastrophic injury reporting system, and independent researchers.[1,10–13] Each of these sources captures a limited view of total injuries. Taken together, however, a fairly consistent pattern emerges on the overall injury incidence and relative frequency (prevalence) of baseball injuries compared with other sports. Comprehensive data also come from the high school level reporting systems using certified athletic trainers to record the key injury-related information on this 14- to 18-year-old population.[14–16]

Prevalence

The US Consumer Product Safety Commission (CPSC) maintains the National Electronic Injury Surveillance System (NEISS) through a network of approximately 100 participating US emergency departments. From the data collected from this cross section of national emergency departments, the CPSC extrapolates national estimates of injury prevalence in various age groups. The overall prevalence of all sports-related injuries in children younger than 15 years seen in an emergency department is just under a million per year; in 2007, the CPSC estimated that 109 202 baseball- and softball-related injuries among 5- to 14-year-old children were treated in US emergency departments nationally.[17] More specifically, in 2007, the CPSC/NEISS recorded exactly 3343 baseball injuries among 5- to 18-year-old children from the participating US emergency departments (T.J. Schroeder, MS, personal communication, 2009). The frequency distribution of injuries by age followed a bell-shaped curve for ages 5 to 18 years, with the highest number of injuries clustered in children from 11 to 14 years of age (more than 300 injuries per year of age).[17] Because 11- to 14-year-old children represent the majority of participants, valid injury risk comparisons with other age groups cannot be directly determined from these raw numbers alone. Nearly half of the 3343 injuries (44%) involved the head (25% to the face, including eyes and nose; 14% to the head and neck; and 5% to the mouth), with the highest frequency in children 9 to 11 years of age.[17] According to several years of annual NEISS reports, approximately one-fourth to one-third of all youth baseball injuries are to the upper extremities, including the fingers (10%–13%), wrists (4%–5%), and hands (4%–5%). Just under 20% of injuries were to the lower extremities, with knees (5%) and ankles (6%–7%) almost equally affected. Injuries to the trunk and pubic area accounted for approximately 6% to 10% of all injuries.[1,11,17]

Also in 2007, the NEISS recorded exactly 1188 youth softball injuries in the same 100 participating emergency departments. Girls accounted for 1062 injuries, and boys accounted for 126.[17] For girls, the frequency of injuries by age also followed a bell-shaped curve for ages 5 to 18 years, with the highest numbers of injuries clustered in children from 13 to 16 years of age (more than 130 injuries per year of age). The distribution of injuries by body region was more evenly distributed for girls playing softball compared with boys playing baseball, with 28% of girls' softball injuries involving the head and neck, 35% involving the upper extremities, 31% involving the lower extremities, and 5% involving the trunk and pubic area. The 5 most common areas for injury were the face (14%), ankle (14%), finger (13%), knee (11%), and head and neck (11%).[17] Thirty-nine percent of injuries were classified as contusions, abrasions, lacerations, or hematomas/hemorrhages; 31% were classified as sprains or strains; 21% were classified as fractures, dislocations, or avulsions; 4% were classified as internal organ injuries; and 4% were classified as concussions.[17]

Baseball is one of the safest high school sports in the United States with a reported injury rate of 1.26 injuries per 1000 athletic exposures.[14] Baseball athletes have the third lowest rates of injury lasting longer than 1 week among 18 different sports played in high school. However, although the overall injury rate is low, the degree of injury severity is relatively high. In baseball, fractures represent a larger percentage of total injuries than in other sports. Baseball also ranks second highest for the percentage of injuries resulting in a time loss from sport participation longer than 7 days.[14,15] In high school baseball and softball, as in youth baseball, most injuries to the head and face (48%) and mouth

and teeth (16.0%) are attributed to being hit by a batted ball.[14] More of these head and facial injuries also required surgery (18.0%), compared with other baseball-related injuries (6.8%).

USA Baseball, through its Medical and Safety Advisory Committee, sponsored injury-surveillance research and produced a report on injury patterns in youth baseball in 2008 which concluded that, in younger players, injuries are more often associated with lack of skill, whereas in older players, the greater skill, muscle power, and body size become injurious forces.[13] More detailed study findings were as follows:

1. Across all age groups, pitchers, catchers, and fielders have a relative frequency of injury in a season comparable to batters and base runners, with one exception: as age increases, the proportion of injuries to catchers increases, whereas the proportion of injuries to fielders decreases.
2. The younger the age group, the more frequently injuries occur during practice sessions, not games. Also, in younger age groups, relatively higher frequencies of injuries came from "before/after" baseball play, such as warm-ups or postgame horseplay.
3. Pitcher injuries are also age-related, with noncontact overuse injuries increasing in each older age group. Younger pitchers are more likely to be hit by a batted or thrown ball.
4. Catchers principally are injured in catching a pitch, getting hit by a foul tip, or tagging a base runner. Younger catchers are more frequently injured trying to catch the pitched ball, whereas older catchers are more likely to be injured by foul tips. Although home-plate collisions during a tag play generate a modest but constant pattern of injury for catchers of all ages, these collisions produce a greater injury risk to the older catcher.
5. Batters are most frequently injured by a pitched ball (and by a foul ball as they get older). The younger the batter, the more likely they are to be injured by a swung bat of another player while getting into position. Approximately 10% of batting injuries among older batters are of a noncontact nature, indicating some form of overswinging resulting in an injury to the muscles, bones, or connective tissues of the rib cage.
6. Injuries to base runners occurred almost equally at all bases, with slightly more injuries at home plate than at first base. Two-thirds of these injuries occurred from sliding, and one-third occurred from base running. Base running injuries are not related to age, occurring almost equally from collisions, being hit by a thrown ball, or simply running (such as falling, stepping wrong on the base, or straining a muscle).
7. Fielder injuries occur at the base (33%), in foul territory (10%), and in the field (57%). Younger fielders are more likely to be hit by a batted ball, whereas older fielders are more likely to be injured by colliding with a sliding opponent.

Catastrophic Injuries

Research from the National Amateur Baseball Catastrophic Injury Surveillance Program places the rate of catastrophic injury very low, at approximately 1 injury per 1 million participants annually. Such injuries may be caused by trauma related to participating in the skills of the sport, such as contact with a bat, baseball, or softball (direct catastrophic injury), by a body system failure resulting from exertion while participating in a sport or activity (eg, cardiac collapse or heat stroke) or by a complication that resulted from a nonfatal injury (indirect catastrophic injury). Catastrophic injuries are further classified according to outcome as fatal (athlete died), nonfatal (athlete left with permanent disability), and serious (athlete experienced severe injury but recovered, to be left with no permanent functional disability).[12] The National Amateur Baseball Catastrophic Injury Surveillance Program data revealed an annual fatality rate of 0.05 per 100 000 participants, 0.03 for nonfatal catastrophic injuries and 0.04 for serious catastrophic injuries.[18] Between 1996 and 2006, deaths in youth baseball averaged just over 2 per year.[18] These deaths occurred from impact to the head resulting in intracranial bleeding and from blunt chest impact, likely prompting ventricular fibrillation or asystole (commotio cordis).[11,12]

Another study based on statistics compiled by the CPSC[11] indicated that there were 88 baseball-related deaths (approximately 4 per year) to children 5 to 18 years old between 1973 and 1995.[11,19] The injury causing death in 38 cases (43%) was direct-ball impact with the chest (commotio cordis); in 21 cases (24%), the injury causing death was direct-ball contact with the head; in 13 cases (15%), the injury causing death was from impact from bat contact; in 9 cases (10%), the injury causing death was from direct contact with a ball impacting the neck, ears, or throat; and in 7 (8%), the injury causing death was unknown.[11,19]

Among high school baseball athletes (with approximately 475 000 participating annually), there have been 10 "direct" deaths, 14 "indirect" deaths, 17 nonfatal catastrophic injuries, and 22 serious catastrophic injuries between 1982 and 2008.[12] Direct injury rates are between 2 and 5 times greater in high school than in youth baseball (5–14 years of age) and 4 times greater in college than high school baseball (but still less than 1/100 000 participants annually in any of the 3 categories).

Among high school softball athletes (371 000 annual participants), there has been 1 direct death, no indirect deaths, 2 nonfatal catastrophic injuries, and 1 serious catastrophic injury in the 15 seasons from 1993 and 2008; these rates are approximately one-tenth of those for high school baseball.[12]

Commotio Cordis

Young baseball and softball players who receive direct ball impact to the anterior chest wall over the cardiac silhouette may develop cardiac arrest. Commotio cordis is the second highest cause of death in athletes younger than 14 years and is considered to be only a pediatric problem because of its unique occurrence in children, usually younger than 16 years.[20–22] Children 5 to 14 years of age may be uniquely vulnerable to this blunt chest impact, because their chest walls are more elastic and more easily compressed.[20–24]

Although protective gear can be a key preventive measure, it is not always effective. Research has shown that even with protective gear, the fatality rate for commotio cordis is alarmingly high at 90%.[19–24,25,26] Proper coaching and execution can augment protective equipment. Batters who learn to avoid the ball and turn away from an inside pitch can greatly reduce their risk. This is particularly difficult, however, while bunting and, thus, requires special attention and instruction. The risk to pitchers can also be reduced by teaching proper fielding position after ball release as well as ball avoidance when necessary.[19] The capacity to recognize that a batted ball is coming at you quickly and the ability to react to that event before the ball arrives are crucial traits for protecting these athletes. Speed of processing and reaction time are commonly measured during the computer-based neuropsychological tests given to high school athletes as a baseline in concussion management programs. Presumably, these are skills that can be improved marginally with proper training and sufficient repetitions. It is estimated that 400 milliseconds is required for a pitcher to complete a protective movement, such as lifting a hand to the chest or face; this corresponds to a batted ball speed of 42 m/second.[27] Because balls hit from some metal bats may exceed 42 m/second, performance standards for composite metal bats were developed in 2003 to limit their capacity to transfer force (velocity) to the batted ball.

It is noteworthy that cardiac death caused by commotio cordis is potentially preventable. If cardiac arrest occurs, an immediate and appropriate response may, in many cases, save a young player's life. AEDs are becoming more prevalent in the sports world at athletic complexes and certainly in patrol cars and emergency medical vehicles. The use of these devices, along with cardiopulmonary resuscitation, has become a standard first step in treating cardiac arrest.[6,28] If no AED is available near the affected child, the emergency medical care system should be activated by using 911 to get an AED to the athlete's side as soon as possible (ideally within 3 minutes). Baseball coaches should be routinely reminded to have a local cellular phone and emergency medical numbers at every youth baseball and softball game and practice in the event of a medical emergency.

Concussion

Concussion in sports continues to garner ever-increasing public attention and concern. Data on high school concussion rates in baseball and softball were generated through the Reporting Information Online system, developed from the National High School Sports-Related Injury Surveillance Study, over the 5-year period from the 2005–2006 to 2009–2010 school years. The rate of concussions for baseball was 0.2 per 1000 athletic exposures, and for softball the rate of concussions was 0.5 per 1000 athletic exposures. Of the 9 sports surveyed (including football, wrestling, soccer, and basketball), baseball had the lowest rate, and softball was seventh. The top 2 activities associated with concussion in high school boys playing baseball were batting (36.7%) and running the bases (21.5%), whereas for girls playing softball, the top 2 activities were catching (33.3%) and fielding (25.0%).[29] The most recent concussion recommendations, including the AAP Clinical Report published in 2010, stress removing an athlete suspected of sustaining a concussion from play immediately with no return to play on the day of injury. Resting the brain is the key to the most rapid resolution of the concussion; such rest includes no physical activity, with minimal cognitive and social activity. The concussed athlete should seek prompt medical attention from an appropriate health professional. Once the athlete is fully free of symptoms and cleared by a physician knowledgeable in the treatment and management of concussion, the athlete should enter a graduated return-to-play protocol to ensure a safe return to sporting activity.[30]

Summary of Acute Injuries

Although the rates of injury for baseball and softball are low in comparison with other sports, the combination of relatively high severity of injuries that do occur and the very large number of participants in these sports produces a substantial number of individuals with significant injuries each year. Focused media attention on these cases often produces a groundswell for action, even when the scientific evidence for change is lacking.

OVERLOAD CAUSING OVERUSE INJURY OF THE SHOULDER AND ELBOW IN BASEBALL

Overuse arm injuries in youth baseball primarily affect pitchers. The repetitive stress of throwing can lead to muscle fatigue and then to muscle, tendon, and ligament damage. To control the number of these injuries, it is critical that pediatricians, coaches, athletes, and parents understand the anatomy, biomechanics, and kinetics of throwing a baseball pitch.[31–33]

In throwing, especially pitching, the arm force and speed generated during the full windup motion is astonishingly high (7200 degrees, or 20 revolutions of a circle, per second for professional pitchers). At ball release, the rotator cuff muscles and long head of the biceps contract to decelerate arm motion and prevent the arm from following the ball ("throwing one's arm out").[34]

The shoulder girdle (including the clavicle [collarbone], scapula [shoulder blade], glenohumeral joint, humerus, and all of the various muscular attachments to the thorax and scapula) permits the arm to enjoy remarkable freedom of movement. Greater joint range of motion sacrifices the inherent joint stability that is usually provided by bony articulation or ligamentous limitation. Unlike other joints, such as the knee and ankle, the glenohumeral joint of the shoulder acquires nearly all of its stability during activity from the muscles of the shoulder with little or no assistance from bones or ligaments. Therefore, when the muscles become fatigued (and cannot do their job properly), the shoulder becomes an unstable joint. Pitchers who continue to throw when the arm is fatigued risk serious and possibly permanent injury to their muscles, ligaments, capsules, labra, and bones.[35]

The scapula plays a critical role in the functioning kinetic chain of the upper extremity. The scapula is attached to the distal end of the clavicle by the broad acromioclavicular ligament and the 2 coracoclavicular ligaments that arise from the hooklike coracoid. The clavicle attaches proximally to the sternum at the sternoclavicular joint; the sternoclavicular joint is the only joint connection of the entire upper extremity to the main skeleton of the body. The scapula rests on the thorax (chest wall) and is connected through numerous muscles (scapulothoracic joint) that permit the shoulder blade to rise (shrugging shoulders), to glide around the body (protraction), and to glide back toward the spinal column (retraction). Strength and endurance of these extrinsic shoulder girdle muscles, especially the serratus anterior, are essential to ensure safe pitching. These muscles must move the scapula to its appropriate position and stabilize its base before the acceleration phase of the throwing motion can proceed. With excellent scapular muscular control, the athlete can then use the long lever of the upper extremity to throw with power, speed, and accuracy.[36]

It also has long been recognized, however, that the source of power (velocity) in throwing is part of a larger kinetic chain, which begins in the legs, travels through the pelvis into the torso ("the core"), and finally comes out through the scapula into the upper extremity. Strong legs and especially a strong core help generate a majority of the force behind a pitched ball.[37]

Relative weakness of the serratus anterior muscle is often responsible for injuries to the rotator cuff muscles, biceps, and elbow (farther down the kinetic chain). Scapular winging (being able to slide one's hand under the medial or inferior edge of the scapula when relaxed), scapular depression (inferior pole sits lower than the other side or below T-7), and protraction (sits farther away from the vertebral spines than the opposite side) are noted on inspection. Observing an athlete (from behind) performing the arm component of a "jumping jack" approximately a dozen times will demonstrate poor movement patterns, or scapulothoracic dyskinesis. A second test entails forward flexing the arm to the fully overhead position and slowly lowering the arm 180 degrees to its natural position. Scapulothoracic dyskinesis consists of unsmooth or uncontrolled scapular motion while bringing the arms up or down, including marked scapular winging during descent. Although the athlete may perform the first few repetitions well, scapulothoracic dyskinesis may become evident toward the end of the set, when fatigue sets in.[36,38]

The scapula also forms part of the glenohumeral joint (true shoulder joint). The scapula's glenoid is a shallow socket surrounded by a cuplike rim called the labrum, which provides additional stability. The 2 main ligaments of the glenohumeral joint perform most of their stabilizing function when the shoulder is not being used dynamically. During sporting activity and especially during throwing, the 4 rotator cuff muscles and the long head of the biceps are responsible for keeping the humeral head in the glenoid socket. The larger muscles (deltoids, trapezius, pectorals, latissimus dorsi, short head of the biceps, and triceps) provide the powerful dynamic forces to move the arm and generate ball velocity.

The term "Little League shoulder" refers to the widening of the proximal humeral physis resulting from chronic recurrent traction stress across the growth plate. This lesion is felt to be primarily the result of throwing a large number of pitches or maximum-effort throws or insufficient rest between pitching assignments, but can also be related to improper mechanics or premature attempts with certain pitch

types. When unrecognized, or when recognized in an advanced stage of overuse, Little League shoulder can lead to chronic pain with throwing, early shoulder instability, or degenerative arthritis.[39]

The term "Little League elbow" refers to medial elbow pain in skeletally immature athletes resulting from throwing issues similar to those mentioned in the description of "Little League shoulder." Pitchers are most likely to be affected by this condition, but it can also occur in other players at positions requiring frequent and forceful throwing. Traction forces occur on the medial elbow and compression forces laterally. The medial traction forces can cause separation or avulsion of the humeral medial epicondyle apophysis and overuse injury to the common flexor tendon. The compression forces laterally can cause collapse and deformity of the distal humerus (capitulum), also known as osteochondritis dissecans in adolescents and Panner disease in children younger than 10 years. Early recognition of symptoms is important to avoid chronic elbow pain, instability, and arthritis.[35] The inability to fully straighten the elbow is usually an indication of an overuse elbow injury. Complete tears of the ulnar collateral ligament (UCL) are repaired by "Tommy John" surgery, which is followed by nearly a year of rehabilitation before return to pitching is allowed. UCL tears have risen to nearly epidemic proportions in the past 5 years among youth and high school pitchers, increasing almost 20-fold from the previous decade.[35,40] When the pitch velocity exceeds 80 miles per hour, the forces experienced at the UCL are near the point of failure (32 Newton meters).[35,41]

Prevention of Shoulder and Elbow Overuse Injuries in Baseball

In 2006, the Medical and Safety Advisory Committee of USA Baseball set pitching limits for a season and a calendar year, based on age.[42] In 2007 and 2008, on the basis of extensive research, Little League Baseball released its pitch count regulation guide in an attempt to reduce the risk of overuse injuries to elbows and shoulders.[43,44] This guide for parents, coaches, and league officials sets a maximum number of pitches to be thrown in a day on the basis of age as well as the number of rest days between pitching assignments on the basis of number of pitches thrown and age. It replaces the previous regulations, which set a maximum number of innings pitched in a calendar week. Beginning in 2010, Little League tournament pitching regulations became the same as for regular season play, as shown in Tables 1 and 2.[44,45] It is the responsibility of the coach to know when an athlete has reached his or her pitch count limit. When pitchers exceed recommended pitch count maximums for age for an entire season or a full year, the injury rates for shoulders and elbows increase dramatically.[41]

Young pitchers should avoid pitching on multiple teams with overlapping seasons; the guidelines for rest requirements must be enforced across all teams. Youth pitchers should not pitch competitively in more than 8 months in any 12-month period; 3 consecutive months of complete rest from pitching each year is recommended. A pitcher should also not be a catcher for his or her team. Catchers throw even more frequently than pitchers, and although the return throws are only moderately stressful, catchers also make many hard throws to the bases during a game. Thus, playing both positions greatly increases the repetitive stress to the arm.[35,46]

A preseason conditioning program that includes strengthening the core, the rotator cuff, and the shoulder-stabilizing muscles (scapular stabilizers) also may help reduce throwing injuries. A prospective epidemiological research study among asymptomatic adolescent and preadolescent tennis athletes found those with decreased scapula stabilizing muscular strength (noted by scapula winging, protraction, and depression) demonstrated a higher rate of shoulder injury during the subsequent season.[47]

Teaching proper pitching mechanics may also prevent serious overuse injuries.[35,42,43,48] Allowing sufficient time during the early part of the season to gradually increase the amount and intensity of throwing may provide young arms an opportunity to adapt to the stresses of throwing. During the off-season and preseason, after allowing for a period of several months of complete rest from throwing, daily throwing of a strictly limited number of pitches may enhance strength development (as regular strength training does for other muscle regions) with little risk of overuse injury or fatigue.[35,49] A core-stabilizing exercise program will improve strength and should also be adopted for pitchers and hitters.[35,37,47]

Four keys to successful pitching within the 5- to 14-year age group are (1) the development of a fastball; (2) accuracy of locating pitches (control); (3) development of an off-speed pitch (change-up); and (4) changing pitch speeds and plate locations to keep batters guessing. Conventional wisdom has long considered the curve ball and slider to be stressful to the young elbow, and recommendations to delay their introduction until later years (when the skeletal maturity is more significantly advanced) were common.[43] Recent studies challenge those theories and indicate that, when properly thrown, the curve ball may not overly stress the elbow.[35,50,51] Nevertheless, on the basis of those

TABLE 1 Little League Baseball 2010 Pitching Guidelines: Maximum Pitches per Game

10 y and younger	75 pitches per d
11–12 y	85 pitcher per d
13–16 y	95 pitches per d
17–18 y	105 pitches per d

Source: Little League (http://www.littleleague.org/media/newsarchive/2009/Sep-Dec/LLTournamentRegularSeason-PitchingRulesMadeSame.htm).

studies that show increased injury among those who throw curve balls and sliders at early ages, researchers currently continue to recommend delaying introduction of the curve ball until after age 14 or when pubertal development has advanced to the stage when the athlete has started to shave (sliders should be delayed until age 16).[41] The American Academy of Pediatrics endorses this recommendation. Finally, on the basis of the increasing number of elbow ligament surgeries in younger and younger pitchers, it is clear that players, parents, and coaches require more respect for the limits of the developing child's arm to withstand the forces incurred while pitching and should understand that the consequence of overload causing overuse injuries which can permanently damage anatomic structures.[35]

OVERUSE INJURY FROM SOFTBALL PITCHING

Data on softball injuries were included in the previous sections; in general, these demonstrate injury patterns similar to baseball with several minor variations. One unique feature of softball, however, is the nature of pitching; pitchers throw underhand from a flat mound. Although the softball windmill pitching motion may be less stressful to the pitcher's shoulder and elbow than throwing a hardball overhand, there are still significant forces placed on various body structures to cause overuse injury.

The same concerns exist for arm safety: do not throw when fatigued. As of 2011, inning limitations and rest days for softball windmill pitchers in the various age divisions of Little League apply to tournament play only. Many softball teams rely on fewer pitchers per team than baseball. Before such inning limitations, some pitchers pitched in multiple games during weekend tournaments, running up pitch counts between 1500 and 2000 pitches in a 3-day period.[52]

The driving force of the windmill softball pitch is in the lower body[53]; 1 study reported more than 50% of the total kinetic energy of upper extremity during overhead movements is supplied by the trunk and legs.[54] The softball pitcher engages the gluteal muscles to achieve stabilization of the pelvis, which in turn helps the scapula achieve adequate control.

The lower extremity supports the mechanics of the upper body during the softball windmill pitch, especially during the single-leg support component; however, the site of failure (injury) may not be located where the problem originates, but at a more remote site (the weakest link). This kinetic chain theory produces "culprits" and "victims" in describing injuries. For example, although 70% of 131 injuries to collegiate softball pitchers were from overuse, only 13% were reported in the lower extremity.[55] The majority occurred in the shoulder or elbow. Thus, although the "culprit" may be weak gluteal muscles and lack of pelvic stabilization, the athlete may present with shoulder pain, because the "victim" shoulder is inherently "the weakest link."

The pelvis and torso work to accelerate the segments of the upper extremity in a sequential manner. Scapular retraction is stimulated by ipsilateral hip extension and trunk extension. A stable scapula is vital for optimal rotator cuff function that helps to keep the humerus in the glenoid fossa (thus avoiding impingement).

Accordingly, examination and treatment of shoulder pain in softball windmill pitchers should include an assessment of and rehabilitation for pelvic stability and gluteal strength. Scapular stabilization must also be evaluated and treated as well as the affected shoulder or elbow. Off-season and preseason conditioning programs for softball windmill pitchers should include gluteal strengthening and pelvic stabilization exercises.

TABLE 2 Little League Baseball 2010 Pitching Guidelines: Rest Requirements for Pitchers

Pitchers 14 y and younger	
66 or more pitches in a day	Four (4) calendar days
51–65 pitches in a day	Three (3) calendar days
36–50 pitches in a day	Two (2) calendar days of rest must be observed
21–35 pitches in a day	One (1) calendar day of rest must be observed
1–20 pitches in a day	NO (0) calendar day of rest must be observed
Pitchers 15–18 y	
76 or more pitches in a day	Four (4) calendar days
61–75 pitches in a day	Three (3) calendar days
46–60 pitches in a day	Two (2) calendar days of rest must be observed
31–45 pitches in a day	One (1) calendar day of rest must be observed
1–30 pitches in a day	NO (0) calendar day of rest must be observed

Source: Little League (http://www.littleleague.org/media/newsarchive/2009/Sep-Dec/LLTournamentRegularSeasonPitching-RulesMadeSame.htm).

ROLE OF EQUIPMENT IN INJURY RISK AND PREVENTION

Playing Equipment

The game of baseball requires playing equipment (ball, bat, gloves, bases), as well as equipment to dress and protect the athlete. Although there are overarching concerns about equipment

performance and safety that apply to every athlete who plays baseball, some concerns typically apply to only a small segment of players depending on age, developmental level, and skill.[56,57]

The ball is the cause of most baseball injuries, through being hit by a pitched ball, being struck while attempting to field a batted ball, trying to catch a thrown ball, or being hit by a thrown or batted ball while running the bases. Accordingly, modifications in the hardness and compressibility of baseballs (and softballs) were developed by equipment manufacturers several decades ago for use by children of different ages with the intent of reducing the force of impact by the ball while maintaining adequate performance characteristics; they were known as reduction-in-force balls. These softer balls, however, are alleged to possess a more "lively" bounce than traditional baseballs.[56–58] The National Operating Committee on Standard for Athletic Equipment (NOCSAE) has developed standards for these softer baseballs (levels 1, 2, and 3),[59,60] and an expert review panel and other researchers have indicated that softer balls meeting the NOCSAE standard are less likely to cause injury, specifically serious head injury or commotio cordis by impact.[22–24,60,61] Children with the lowest skill level (in general, those younger than 10 years) should use the lowest-impact NOCSAE-approved balls (level 1). Level 2 low-impact balls are designed for children 10 to 12 years of age with moderate skill levels. Children younger than 10 years of age with moderate skills may use either level 1 or level 2 balls. Level 3 balls are designated for youths older than 12 years and those 10 to 12 years of age with advanced skills.[61]

Baseball has the highest number of sports-related eye injuries in children, with the highest incidence in 5- to 14-year-olds (T.J. Schroeder, MS, personal communication, 2009).[11,13] Approximately one-third of baseball-related eye injuries result from being struck by a pitched ball; other common causes of eye injuries are attempting to field a batted ball or catch a thrown ball.

The composition of the bat has provoked much discussion in recent years, especially for baseball players older than 15 years. Composite (metal) bats have largely replaced wooden bats.[62] Initially, the introduction of metal bats led to an increased velocity of the batted ball, putting fielders at greater risk of injury, especially pitchers and third basemen.[62] Considerable research has been conducted comparing both types of bats, but no consensus exists regarding safety of composite metal bats compared with wooden bats in youth baseball.[62,63] All bats, wooden or metal, are momentarily deformed upon contact with the baseball; the recoil or restitution characteristics of the bat to its usual shape result in imparting additional velocity to the batted ball. Industry performance standards for composite metal bats were developed in 2003 through the leadership of the National Collegiate Athletic Association and National Federation of State High School Associations. These standards limit the dimensions of the bat and its capacity to transfer force (velocity) to the batted ball (ball exit speed ratio). Bat composition for National Collegiate Athletic Association baseball was required to meet the Batted Ball Coefficient of Restitution guidelines in 2011, and high school baseball will follow suit in 2012.[64] For Little League Baseball, the maximum bat length is 33 inches and maximum barrel diameter may not exceed 2 1/4 inches. Since 2009, all Little League bats must be labeled with a bat performance factor of 1.15 or lower.[65,66] Bat performance factor is a measure of a nonwood bat's performance relative to wood bats. For 2011, Little League International has imposed a moratorium on the use of composite bats for all baseball divisions citing research that found that "composite bats, while they meet the standard when new, can exceed that standard after a break-in process."[67] Although the media continue to report anecdotal stories of significant head and facial injuries associated with metal bats, epidemiological injury surveillance studies do not show an increase in the rate of such injuries since metal bats were introduced.[62]

Equipment-related injuries also include those caused by bases and cleats. Foot and ankle injuries occur regularly in baseball and softball, especially during sliding. Early studies showed that at least 35% of all injuries in softball occurred while sliding feet first into a base, and, in one study, 82% of those injuries resulted in ankle fractures or dislocations.[68,69] Subsequently, a 2-year study comparing traditional stationary bases and bases capable of disengaging noted a greater than 95% reduction in foot and ankle injuries with breakaway bases.[70–74] In 2008, Little League baseball and softball mandated the use of breakaway bases.[74] Youth softball leagues have also incorporated the use of a separate "runner's base" at first base to avoid collisions; the orange "runner's base" sits adjacent to the white regular base, but in foul territory, providing the runner and fielder separate, equal-size bases. Metal spikes are dangerous to basemen covering bases; rubber spikes are preferred for youth baseball.

Protective Equipment

Protective equipment should always be properly fitted, well maintained, and clean; equipment hygiene is important to prevent infections, such as methicillin-resistant *Staphylococcus aureus*. Although not all equipment adaptations have been tested scientifically for

efficacy, experts believe those mentioned in this article will help reduce injuries in softball and baseball players.[24]

Padded sliding pants worn underneath the baseball pants provide good protection against contusions and abrasions to the hips and thigh when athletes slide feet first into a base. For athletes who slide head and hands first, wearing gloves can reduce hand abrasions; similarly, use of batting gloves improves the grip on the bat and reduces the risk of blisters. Head-first sliding creates the risk of head injuries from collisions with the fielder or from being hit by a thrown ball; upper-extremity injuries can occur from the contact and deceleration forces that occur when the hands of the diving body encounter the stationary base. According to current Little League Baseball rules, a runner may not slide head-first except when retreating to a previously held base.[75]

Chest protectors for batters were introduced in the 1990s to protect the heart from ball impact, which can cause commotio cordis.[19] However, this protective barrier has not been shown to be reliable in either the human experience or in animal laboratory studies.[22–25,28,63] More study is required to develop and target equipment that will better prevent commotio cordis.[24] Recent design modifications indicate that progress is being made, but these advances have not been validated in evidence-based peer-reviewed scientific journal articles or abstracts presented at professional meetings.[76] Even the chest protectors for catchers, which are effective for blunting the usual forces encountered from pitches, foul tips, throws, and collisions do not reliably prevent commotio cordis.[24,77]

Hard plastic shell batting helmets have long been an integral part of protecting baseball and softball players from head injuries while batting and running the bases. The NOCSAE developed standards for helmets and their testing decades ago.[59] Their design and characteristics have been modified over the years to better protect the eyes, ears, face, mouth, and nose.[78] In 2009, a new batting helmet was introduced with the capacity to withstand the impact of a 100-mph fastball; it has a layer of expanded polypropylene, the hard, foamlike material used in bicycle helmets.[79,80]

Face and eye protection can be achieved by securing additional protection to the batting helmet, such as a polycarbonate plastic face guard, metal cage, or a polycarbonate full-face shield. Although full plastic face shields have been demonstrated to reduce injury risk significantly, their acceptance by players and league officials has been mixed, primarily because of compromised visibility through the shield over time.[56] More recent epidemiological research among high school baseball athletes has led to a call for infielders and pitchers to wear face shields.[14]

Eye protection may be worn to reduce the risk for eye injury.[81–84] This protection may be particularly important for young athletes who have undergone eye surgery or experienced a previous serious eye injury.[85] Polycarbonate face guards and shields must meet the F910 standard of the American Society of Testing and Materials.[84,86] Face guards cover the lower part of the face from the tip of the nose to below the chin, directly protecting the teeth and facial bones; the space between the top of the guard and the brim of the helmet is less than the diameter of a baseball, thereby indirectly protecting the eyes without impairing vision. Functionally one-eyed athletes (best corrected vision in the worse eye of less than 20/50) must use one of these protectors when batting and also must protect their good eye when fielding the ball by using polycarbonate sports goggles that meet American Society of Testing and Materials standard F803.[86] Some parents may also prefer the use of a face guard or eye goggles when their children are in the field. All athletes who wear glasses or sunglasses while playing baseball or softball should make sure that the lenses and frames meet appropriate safety standards, thus minimizing the risk of breaking or shattering on contact with a baseball or softball.[86]

An essential piece of equipment for all boys playing baseball or softball is use of a hard plastic athletic cup to protect the testicles. Although catchers, pitchers, and infielders are at the greatest risk, testicular injuries can occur to any player while in the field, batting, or running the bases.

The development of triangular-shaped foam pads ("knee savers") for catchers is another advance in safety equipment that has enjoyed widespread use since its introduction.[87] These pads fit into the popliteal fossa behind the knee and are designed to minimize the strain on the knee joint while the catcher is in the crouched position. Some batters opt for shin guards to protect their medial distal tibia; another innovation gaining notice is the elbow protective pad for batters.

ENVIRONMENTAL RISKS

Environmental risks include weather-related concerns and field conditions and boundaries (perimeters).

Baseball and softball players are at risk for injury from weather-related factors, including lightning, sun, and heat. Recreational facilities managers, coaches, and umpires need to be well-versed in lightning safety guidelines[5,88] and prepare an emergency action prevention plan in advance. In particular, lightning presents a unique challenge because of the difficulty in

predicting and appreciating the presence of electrical storms. More and more facilities are installing automatic lightning detectors and alarm systems to ensure that everyone responds appropriately to the presence of lightning. In the absence of an automated warning system, estimating the distance of the storm from the fields can be accomplished by counting the number of seconds between seeing lightning and hearing thunder. Divide the number of seconds by 5 to estimate the distance in miles. A "flash-to-bang" of 30 seconds or less is an indication to move athletes and spectators to a safe area. A preassigned individual should be responsible for the decision to evacuate. In general, a period of 30 minutes should elapse from the last sound of thunder and from the last visible lightning flash before play should be resumed.

Hot and/or humid weather conditions pose significant risk for heat-related illness in children and adolescents. Ambient temperature, relative humidity, wind speed, and solar radiant heat all affect risk for heat illness.[89,90] The ability to dissipate body heat into the surrounding environment decreases as the ambient temperature rises closer to body temperature. Similarly, as the humidity rises and the air becomes more saturated with water, the ability to cool oneself through evaporation decreases. Wind and sun exposure can damage the skin and eyes. Being acclimatized to the environment, ensuring adequate hydration, wearing a baseball cap, and having a covered dugout are important features of minimizing the risk of sun- and heat-related illness. Recommendations regarding sunscreen, sunglasses, and proper uniforms for practice and games are appropriate for players of all ages. Similarly, in cold weather, athletes need to be properly dressed. When necessary, games should be postponed or game times altered when weather conditions are extreme.

Fields need to be inspected regularly for hazards, including problems with sprinkler heads, gopher holes in the outfield, or rocky infields. A warning track (usually 15 feet wide) should surround the entire grass or artificial turf playing surface and should meet all recommended specifications; the change in surface texture serves to alert fielders that they are nearing the perimeter barriers, such as when outfielders are going back on long hits to the fence. All fences should be in good repair, especially the backstop and the fence along both foul lines. If a chain-link fence is curled up and the grass becomes high, an athlete may receive a laceration when reaching down to pick up the ball (not noticing the hazard produced by the defective fencing).

Elimination of the on-deck circle, placing dugouts behind a fence, and the wearing of batting helmets by the first-base and third-base coaches have further reduced the risk of injury on the playing field.

DEVELOPMENTAL CONSIDERATIONS

The pediatrician needs to have an understanding of developmental considerations as they apply to baseball and softball participation at various ages. This will allow the pediatrician to offer appropriate counseling and guidance to the many boys and girls, their parents, and members of the sporting community who participate in baseball and softball each year.

Compared with older players, children between 5 and 10 years often have less coordination, slower reaction times, a reduced ability to pitch accurately, and a greater fear of being struck by the ball.[91,92] Some developmentally appropriate rule modifications, therefore, are advisable for this age group, including the use of batting tee, a pitching machine, or an adult pitcher. The avoidance of head-first sliding for children younger than 10 years is especially important, because there have been anecdotal reports of rare but serious cervical spine injuries occurring when a young player slides head-first, hitting an opponent with the top of the helmet. This injury is similar to that caused by "spearing" (using the head as the lead object) in football. Feet-first sliding should be taught consistently (as players become developmentally ready) so that all players become comfortable with this key technique of the game. The use of softer balls, as described in a previous section of this statement, is also recommended in this age group to reduce serious impact injury.

Youth baseball has long recognized that the game must be modified to meet the developmental level and skills of its players. The distance between bases begins at 45 feet for Tee Ball, moves to 60 feet for Minor League and Little League (Majors) for ages 10 to 12 years, goes to 70 to 75 feet for ages 13 to 15 years, and eventually advances to 90 feet for boys 16 to 18 years of age; similarly, the pitcher's mound increases from 46 feet, to 50 feet, to 60.5 feet from home plate, respectively. The distances of the outfield fences also grow as the field enlarges. The length and weight of bats is another variable that changes as the youth grow in size, strength, and ability.

Some children are able to track ball movement at early ages and can accurately move to and catch a fly ball or hit live pitching as early as 5 years old; most children, however, do not achieve these capabilities until ages 8 or 9.[91] Therefore, it is appropriate to begin introduction to baseball batting for 5- to 7-year-olds using a ball that is not moving but placed on a tee. For

children who are capable of hitting a thrown pitched ball, however, being forced to hit the tee ball may not enhance their skill development.

Coaches who are not knowledgeable in child development may become frustrated trying to teach basic skills to young boys and girls who are simply not ready to acquire these skills, no matter how many balls are pitched to them or how many fly balls they are asked to catch during practice. For these reasons, Little League baseball tracks its athletes into the minors and the majors for boys 10 through 12, separating those children who are developmentally advanced from those who are developing at the typical rate. It must be remembered, however, that "late bloomers" may ultimately turn out to be the finest athletes of all, despite their slower beginning. Proper instruction and persistent repetition in the fundamentals of baseball are essential for youth to develop the talent and skills required to perform proficiently at a high level during late adolescence and adulthood.

RECOMMENDATIONS

The American Academy of Pediatrics recommends the following:

1. Because baseball and softball for children 5 through 18 years of age are relatively safe sports, participation should be encouraged by pediatricians.
2. Preventive measures should be used to protect young baseball pitchers from throwing injuries. Adequate core strength and scapular muscle strength provide a critical foundation; proper instruction in throwing mechanics, conditioning, and training is another essential component. Delay introduction of the curve ball until after age 14 and the slider until age 16. Three key elements in preventing overuse injuries in pitchers include: (a) age guidelines regarding the number of pitches thrown daily; (b) rest requirements between pitching assignments; and (c) season and yearly total pitch limits.[38,42,44] Young pitchers should avoid pitching on multiple teams with overlapping seasons; the guidelines for rest requirements must be enforced across all teams. Youth pitchers should not pitch competitively in more than 8 months in any 12-month period; 3 months of rest from pitching are recommended each year. A pitcher should also not be a catcher for his or her team.
3. Parents, coaches, and players should be educated about the early warning signs of elbow and shoulder overuse injuries as well as the importance of parascapular muscle strength. Athletes should cease pitching immediately when signs of arm fatigue or pain occur; they should be encouraged to seek timely and appropriate treatment of significant or persistent pain.[35]
4. Serious and potentially catastrophic baseball injuries can be minimized by the proper use of available safety equipment. This safety equipment includes: (a) for hitters, approved batting helmets with face protection; (b) for catchers, helmets, masks with throat guards, chest protectors, and shin guards; (c) for all male players, hard plastic athletic cup; and (d) for all baseball and softball players, rubber-spiked soles. In light of the relatively high percentage and severity of head, face, and mouth injuries in baseball, strong consideration should be given to head and facial protection for pitchers and infielders, especially in younger age groups and for less-skilled players. Protective equipment should always be properly fitted, well maintained, and clean.
5. Current data show that chest barriers or protection are not sufficiently effective in preventing commotio cordis; thus, the routine use of these heart protectors is not recommended for baseball players at this time. Catchers must continue to wear approved chest protectors.
6. Coaches and officials must be prepared to activate the emergency response system (call 911) and to obtain rapid access to an AED, ideally in less than 3 minutes, to assist young baseball or softball players who are experiencing cardiac arrest or another medical emergency. Coaches should have a local cellular phone and emergency medical phone numbers available for use at all times.
7. Coaches, parents, umpires, and league officials need to be knowledgeable regarding the cause, prevention, recognition, and response to concussion. New policies exist with excellent free educational and prevention materials, especially from the Centers for Disease Control and Prevention. Furthermore, free on-line trainings are available through the Centers for Disease Control and Prevention (http://www.cdc.gov/concussion/) and the National Federation of State High School Associations (www.nfhs.org).
8. Youth baseball and softball players should wear polycarbonate eye protection guards or shields or metal cages on their batting helmets to reduce the risk of eye injury. For functionally one-eyed athletes (best corrected vision in the worse eye of less than 20/50) and those who have undergone eye surgery or experienced previous severe eye injuries, eye protection (one of the 3 types of

face shields or polycarbonate sports goggles) should be required at all times while the athlete is batting or fielding.

9. Children with the lowest skill level (in general, those younger than 10 years of age) should use the lowest-impact NOCSAE-approved balls (level 1). Level 2 low-impact balls are recommended for children 10 to 12 years of age with moderate skill levels. Children younger than 10 years with moderate skills may use either level 1 or level 2 balls. Level 3 balls are designated for youths older than 12 years and those 10 to 12 years of age with advanced skills.
10. Continued research into the relative safety of composite metal versus wooden bats is appropriate and necessary.
11. Awareness of heat and lightning safety is essential for all coaches and officials of Little League baseball and softball. The Web site http://www.lightningsafety.noaa.gov/outdoors.htm[88] and weather forecasts are critical resources for prevention of lightning injuries. When necessary, games or practices should be postponed or game times altered when weather conditions are extreme.
12. Protective fencing of dugouts and benches and the elimination of the on-deck circle are recommended during games and practices in organized and informal participation. Proper field maintenance is required to minimize injury risks.
13. New developmentally appropriate rule modifications should continue to be implemented when indicated.
14. Surveillance of baseball and softball injuries should be continued. Continual strong support of research is essential to develop other new, improved, and efficacious safety equipment and rule modifications.

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