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The pediatric athlete with disabilities

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There is a wide spectrum of disabilities that affect the physical and intellectual domains of athletes (Box 1) [1–5]. An estimated 12% of school-aged children in the United States are physically challenged; there are approximately 40 million physically challenged persons in the United States [6,7]. It is estimated that there are more than 3 million persons with physical and mental disabilities who are involved in organized athletic competition in the United States, and many more in recreational sports [8,9]. Increasingly more children and adolescents with disabilities are finding opportunities to participate in various sport programs [2,3,10–12].

Box 1. Spectrum of disabilities

- Amputations
- Cerebral palsy
- Traumatic brain injury
- Spinal cord injuries
- Spina bifida
- Neuromuscular disorders
- Neurodevelopmental disabilities
- Visual impairment
- Hearing impairment
- Disabilities associated with chronic medical diseases

Participation opportunities for physically and mentally challenged athletes have increased over the past several decades, with more than 3000 athletes participating in the 1996 Summer Paralympic Games in Atlanta [6,13–15]. The

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Paralympic Games include athletes with spinal cord injuries, limb amputations, cerebral palsy, blindness, and other visual impairments. To a lesser extent, athletes with short stature, neuromuscular disorders, and learning disabilities have also participated. The health benefits of physical activity for athletes with disabilities have been increasingly recognized [16,17].

This review focuses on some common clinical issues that relate to sport participation by athletes with predominantly physical disabilities such as spinal cord injury, cerebral palsy, meningomyelocele, visual impairment, and deafness. It is not possible in this review to also discuss all the disabilities that predominantly affect cognition and intellectual function, such as autism, learning disorders, and mental retardation [12]. The reader is referred to many comprehensive reviews and organizational resources (see Appendix) for more specific information [12,16, 18–32] because it is not possible to cover all aspects of the broad field of sports for the disabled, adapted sports, and physical education in this review.

Sports medicine research has not paralleled the increased interest and participation in various sports by athletes with disabilities. Research on pediatric athletes with disabilities is even more limited. A literature search by Hutzler and Felis [33] on sports for disabled persons in the MEDLINE (*Index Medicus*) and the SPORTDiscus databases yielded 253 records published during the years 1983 to 1997. Their search did not include persons with intellectual or hearing deficits. Of these, 41% of the records were categorized under physiology, 28% under psychology, and 20% under biomechanical. Sports medicine and sports injuries as a category constituted only 8% of all articles. Seventy percent of the articles were classified as databased experimental research; only ten percent of these articles had children as exclusive subjects. These authors [33] note that their findings were similar to those of Reid and Purpas' [34] review of 10-year research that included descriptive and other nondatabased articles. Overall, most literature has reflected studies in wheelchair and spinal cord–injured athletes.

Explanation of terms

According to the World Health Organization, *impairment* refers to any loss or abnormality of psychological, physical, or anatomical structure or function; *disability* refers to any restriction or lack (resulting from impairment) of an ability to perform an activity in the manner or within the range normal for a human being; and a *handicap* is a disadvantage for a given individual which results from impairment or a disability that limits or prevents the fulfillment of a role that is normal (depending on age, sex, and social/cultural factors) for that individual [1–3,19,35]. The Americans with Disabilities Act defines a disability as an impairment that limits a major life activity; other evidence of disability includes a record of such impairment in the preparticipation or doctor's notes, or a perception by the public that the impairment limits major activity of life [35].

The term *adapted sport* refers to a sport that is modified or especially designed for an athlete with disability [12,29]. The athlete may either participate with

others who have no disabilities (integrated settings) or only with other athletes with disabilities (segregated settings) [12]. Paralympic Games include athletes who have physical disabilities or visual impairment, while Special Olympics is a sports training and competition program for persons with mental retardation who are ages 8 years and older, irrespective of their abilities [6,12].

Classification

Classifying athletes with disabilities helps level the playing field so that athletes with similar functional abilities can compete with each other [2,19,36]. This will help ensure fairness in competition. The classification must also take into account the nature of the specific sport and any adaptive equipment used by the athlete [12,29,36]. The methods for classifying athletes with various disabilities have evolved during the 20th century. In addition to medical doctors, athletic trainers and specially trained and certified classification specialists are responsible for classification [12]. Such a process involves both medical and technical classifications. Medical classification delineates the basic disability present and does not necessarily provide information on the functional ability of the athlete for a given activity [12].

Functional or technical classification is based on observation of the athlete while playing his or her sport. Such a functional classification system (FCS) is shown in Table 1 [20,36]. A FCS incorporates the medical information with the ability of the athlete to perform specific skills of the sport. The function and strength of the muscle groups are determined on the basis of tests and assigned point values for each class. In this system, each class is identified by a letter (eg, T, track; S, swimming) followed by a number; a higher number denotes a more advanced ability by the athlete [36]. FCS has been used for shooting, swimming, table tennis, and track and field events; it also includes athletes with spinal cord injuries, cerebral palsy, amputation, and visual impairment [36]. Each disability sport organization may also use its own disability-specific classification system for sponsored events [12,29].

Preparticipation assessment

Preparticipaton evaluation (PPE) is an essential component of injury and illness prevention in athletes. Pediatricians and other physicians working with athletes are quite familiar with the Preparticipation Physical Evaluation Monograph (1997), which provides detailed guidelines for conducting PPE [37]. There are no specific guidelines especially designed for the PPE of disabled athletes. The general approach to the PPE of disabled athletes should be similar to that of athletes without disability. Often the focus is so much on the primary condition that the examiner may overlook common medical issues apart from the primary disability (or diagnostic overshadowing).

Table 1
Functional classification system categories and classes

Visually impaired (Athletics)	
T10	No light perception; unable to recognize hand shapes
T11	2/60 and/or visual field of $<5^\circ$
F11	
T12	2/60-6/60 and visual field of $>5^\circ$ and $<20^\circ$
F12	
Amputee	
T42	Single above the knee; combined lower and upper limb amputations; minimum disability
T43	Double below the knee; combined lower and upper limb amputations; normal function in throwing arm
T44	Single below the knee; combined lower and upper limb amputations; moderate reduced function in one or both limbs
T45	Double above the elbow; double below the knee
T46	Single above the elbow; single below the elbow; upper-limb function in throwing arm
F40	Double above the knee; combined lower- and upper-limb amputations; severe problems when walking
F41	Standing athletes with no more than 70 points in the lower limbs
F42	Single above the knee; combined lower- and upper-limb amputations; normal function in throwing arm
F43	Double below the knee; combined lower- and upper-limb amputations; normal function in throwing arm
F44	Single below the knee; combined lower- and upper-limb amputations; normal function in throwing arm
F45	Double above the elbow; double below the elbow
F46	Single above the elbow; single below the elbow; upper-limb function in throwing arm
Cerebral palsy	
T30	Severe to moderate involvement; uses one or two arms to push wheelchair; control is poor; affects both arms and legs
T31	Severe to moderate involvement; foot-propelled wheelchair push; affects both arms and legs
T32	Limited control of movements; some throwing motion
F32	Full upper strength in upper extremity; propels wheelchair independently; affects both arms and legs or same-side arm and leg
T33	Good functional strength with minimal limitation or control problems in upper limbs and trunk; affects lower legs
F33	
T34	May use assistive devices; slight loss of balance; affects lower legs or both legs and one arm
F34	
T35	Walks or runs without assistive devices; balance and fine motor control problems
F35	
T36	Good functional ability in dominant side of boy; affects arm and leg on same side of body
F36	
T37	Minimal involvement; could be present in lower legs, arm and leg on same side of body, one leg, or demonstrate problems with balance
F37	
Wheelchair	
T50	Uses palms to push wheelchair; may have shoulder weakness
T51	Pushing power comes from elbow extension
T52	Normal upper-limb function; no active trunk

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Table 1 (*continued*)

T53	Backwards movement of trunk; uses trunk to steer; double above-the-knee amputations
F50	No grip with nonthrowing arm; may have shoulder weakness
F51	Difficulty gripping with nonthrowing arm
F52	Nearly normal grip with nonthrowing arm
F53	No sitting balance
F54	Fair to good sitting balance
F55	Good balance and movements backwards and forwards; good trunk rotation
F56	Good movements backwards and forwards; usually to one side (side-to-side movements)
F57	Standard muscle chart of all limbs must not exceed seventy points
Functional (Swimming)	
S1	Unable to catch water; restricted range of motion; no trunk control; leg drag; assisted water start
S2	Unable to catch water; restricted range of motion; no trunk control; slight leg propulsion; unassisted water start
S3	Wrist control limited; limited arm propulsion; minimal trunk control; hips below water; water start
S4	Wrist control; arms not fully fluent; minimal trunk control; hips below water; better body position
S5	Full propulsion in catch phrase; limited arm movement; trunk function; leg propulsion; sit or stand starts
S6	Catch phrase present; arm movement efficient; trunk control; leg propulsion; push start, sit or stand
S7	Good hands; good arms; good trunk; hips level; stand or sit dive start
S8	Hand propulsion; arm cycle good; trunk good; hips and legs level; use of start blocks
S9	Full hand propulsion; full arm propulsion; full trunk control; propulsive kick; dive start from blocks
S10	Full hand and arm propulsion; full arm propulsion; full trunk control; strong leg kick; dive start and propulsion in turns
Visually impaired (Cycling, goalball, judo, and swimming)	
B1	No light perception; unable to recognize hand shapes
B2	Visual acuity of 2/60 with $<5^\circ$ field of vision
B3	Visual acuity of 2/60-6/60 and field of vision $5-20^\circ$

From Booth DW. Athletes with disabilities. In: Harries M, William C, Stanish W, et al, editors. Oxford textbook of sports medicine. New York: Oxford University Press; 1998. p. 634–45; with permission.

A detailed history is the mainstay of any PPE. It has been suggested that PPE for the athletes with disabilities should be preferably done by a team of medical professionals who are involved in the longitudinal care of these athletes and who know their baseline functioning [6]. These athletes should be examined in an office setting, and the mass or station method should be avoided. Examiners should be cognizant of disability-specific issues for the athlete. In addition to the history and physical examination, careful evaluation of the prosthetics, orthotics, and assistive/adaptive devices being used should be accomplished by the knowledgeable health care professional to ensure adequacy and proper fit.

Jacob and Hutzler have described a protocol for the evaluation of athletes with a disability, a Sports-Medical Assessment Protocol (SMAP) [38]. Their purpose for developing this protocol was to identify medical problems, provide baseline data, and to identify training goals. The protocol was based on 14 male athletes with various neurological disorders who qualified to participate at the 1996

Table 2
Sports participation possibility chart

	Archery	Bicycling	Tricycling	Bowling	Canoeing/ kayaking	Diving
Amputations						
Upper extremity	RA	R	R	R	RA	R
Lower extremity AK	R	R	R	R	R	R
Lower extremity BK	R	R	R	R	R	R
Cerebral palsy						
Ambulatory	R	R	R	R	R	R
Wheelchair	R	I	I	R	R	I
Spinal cord disruption						
Cervical	RA		RA	RA	IA	
High thoracic: T1-T5	R		R	R	R	
Low thoracolumbar: T6-L3	R		R	R	R	
Lumbosacral: L4-Sacral	R	R	R	R	R	R
Neuromuscular disorders						
Muscular dystrophy	RA	I	R	R	I	I
Spinal muscular atrophy	RA	I	R	R	I	I
Charcot-Marie-tooth Syndrome	R	R	R	R	R	R
Ataxias	R	I	I	R	I	I
Others						
Osteogenesis imperfecta	R	I	R	R	R	I
Arthrogryposis	R	I	I	R	R	I
Juvenile rheumatoid Arthritis	RA	I	I	RA	R	I
Hemophilia	RA	R	R	R	R	R
Skeletal dysplasias	R	R	R	R	R	R

Abbreviations: A, adapted; I, individualized; R, recommended; X, not recommended; blank indicates no information or not applicable.

From Chang FM. The disabled athlete. In: Stanitiski CL, Delee JL, Drez, D, editors. Pediatric and adolescent sports medicine. Philadelpia: W.B. Saunders; 1994. p. 48–75; with permission.

[a] Clubthrow, discus, javelin, shot put.

Atlanta Paralympic Games. The protocol included clinical interview, cardiopulmonary testing, and physical and functional assessments. On the basis of their results, the authors concluded that use of such an assessment protocol may increase awareness of medical problems of athletes with various disabilities and help develop appropriate prevention and training programs.

Participation guidelines

Athletes with physical disabilities participate in a number of sports, depending on their specific disabilities and the demands of the sport [2,10,12,14, 16,18,19,39]. Use of adaptive equipment and modification of rules further enhance the sport participation experience for these athletes. The American Academy of Orthopaedic Surgeons developed a sport participation possibility chart that may provide initial guidance for the athlete regarding which sports are appropriate (Table 2) [2,39]. A number of factors should be considered in

Fencing	Field events[a]	Fishing	Golf	Horseback riding	Rifle shooting	Sailing	Scuba diving	Skating (roller and ice)	Skiing (Downhill)
R	R	R	RA	R	RA	R	R	R	R
I	R	R	R	R	R	R	R	I	RA
R	R	R	R	R	R	R	R	R	R
I	R	R	R	R	R	R	I	R	RA
I	I	R	I	I	R	R			
	I	R		X	RA	R			IA
RA	R	R	RA	I	R	R	R		IA
RA	R	R	RA	R	R	R	R		RA
R	R	R	R	R	R	R	I	R	R
	R	R	R	I	RA	R	I	I	I
	R	R	R	I	RA	R	I	I	I
R	R	R	R	R	R	R	R	R	R
	R	R	I	I	R	R	I	I	I
R	R	R	I	I	R	R	I	I	I
I	R	R	I	R	R	R	I	I	I
I	I	R	I	I	R	R	I	I	I
R	R	R	R	R	R	R	R	I	I
R	R	R	R	R	R	R	R	R	RA

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matching the athlete to the right sport, not unlike those for the athlete without disabilities. The many factors to be considered in determining the eligibility of a given athlete to participate in a particular sport include current health status of the athlete, level of competition and position played, psychological maturity of the athlete, adaptive and protective equipment, modification of the sport, and parents' and athlete's understanding of the inherent risks of injury. Thus, considering the disability and functional level of the athlete in conjunction with all other factors, the athlete should be matched to an appropriate sport.

Psychosocial considerations

The value of sport participation for the athlete with disability is well recognized. Sport participation provides a positive social experience for these athletes. It is an opportunity for athletes and their families to share their experiences with others. Sports participation can positively affect psychological,

Table 2 (*continued*)

	Skiing (cross-country)	Swimming	Table tennis	Tennis	Tennis (wheelchair)	Track
Amputations						
Upper extremity	R	R	R	R		R
Lower extremity AK	RA	R	R	I	R	
Lower extremity BK	R	R	R	R	I	R
Cerebral palsy						
Ambulatory	RA	R	R	R		R
Wheelchair		I	R		R	
Spinal cord disruption						
Cervical	IA	R	RA		IA	
High thoracic: T1-T5	IA	R	R		R	
Low thoracolumbar: T6-L3	RA	R	R		R	
Lumbosacral: L4-Sacral	R	R	R	R		R
Neuromuscular disorders						
Muscular dystrophy	I	R	R	I	I	I
Spinal muscular atrophy	I	R	R	I	I	I
Charcot-Marie-tooth Syndrome	R	R	R	R		R
Ataxias	R	R	R	R	R	I
Others						
Osteogenesis imperfecta	R	R	R	R	R	R
Arthrogryposis	R	R	R	R		R
Juvenile rheumatoid Arthritis	I	R	R	I	I	I
Hemophilia	R	R	R	I		R
Skeletal dysplasias	R	R	R	R		R

social, and moral developmental domains for the child and the adolescent, regardless of the presence of disability. Participation can enhance personal motivation, foster independence, improve coping abilities, allow athletes opportunity for social comparison, foster competitiveness and teamwork, and build self-confidence [4,40].

Persons with disability should be referred to appropriately to maintain respect and dignity. A preferred way to address these individuals is the "person first" approach (eg, a "person with cerebral palsy" instead of a "cerebral palsy victim"); in this manner, one refers to a person with a disability rather than to a disabled person [1–3,12]. There are also differing views for the athletes with disabilities, as represented by the medical model and the social minority model (Rice EL. Course Lecture, American Academy of Family Physicians: Sports Medicine Syllabus, 1995). In a traditional medical model, a disability is equated with being defective or inferior, a wide spectrum of defects are described, the athlete is a passive participant following recommendations, and the athlete with

Track (wheelchair)	Weight lifting	Wheelchair poling	Baseball	Softball	Basketball	Basketball (wheelchair)	Football (tackle)	Football (touch)
	R		R	R	R		R	R
R	R	R	RA	RA		R	I	I
I	R	I	R	R	R	I	R	R
	R		R	R	I		I	I
		R	R	R	R	I	I	
R		I				I		
R	R	R	RA	RA		R		
R	R	R	RA	RA		R		
	R		R	R	R	I	I	R
I		R	I	I	I	I		
I		R	I	I	I	I		
	R		R	R	R		R	R
R	I	R	I	I	I	R		I
R	I	R	I	I	I	R	X	I
X	I	X	R	R	R		X	R
I	I	I	I	I	I	I	I	I
	I		I	R	R		X	I
	I		R	R	R		I	R

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a disability is represented by a passive graphic. In a social minority model, the disability is equated with being different rather than being inferior; in this model, there is only one shared experience of "social stigma" rather than multiple defects. Thus, the athlete is an active participant and the graphics depict an active athlete.

Therapeutic medication use

Many athletes with disabilities are likely to be on various therapeutic medications for associated medical disorders. The potential side effects of these medications and effects on performance should be considered while working with these athletes [21]. The coaches, athletes, parents, and other staff should be familiar with the athlete's treatment regimen and potential medication side effects. One should also inquire about over-the-counter drugs and nutritional

Table 2 (*continued*)

	Football (wheelchair)	Ice hockey	Sledge hockey	Soccer	Soccer (wheelchair)	Volleyball
Amputations						
Upper extremity		R		R		R
Lower extremity AK	R		R	I	R	R
Lower extremity BK	I	I	I	R	I	R
Cerebral palsy						
Ambulatory		I		R		R
Wheelchair	R		I		R	I
Spinal cord disruption						
Cervical	I		I			IA
High thoracic: T1-T5	R		R		R	RA
Low thoracolumbar: T6-L3	R		R		R	RA
Lumbosacral: L4-Sacral	I	I		R		R
Neuromuscular disorders						
Muscular dystrophy	I	I	I	I	I	I
Spinal muscular atrophy	I	I	I	I	I	I
Charcot-Marie-tooth Syndrome		I		R		R
Ataxias	I	I	I	I	R	I
Others						
Osteogenesis imperfecta	I	X	X	X	R	I
Arthrogryposis	I	I		I		R
Juvenile rheumatoid Arthritis	I	I	I	I	I	I
Hemophilia		X		I		R
Skeletal dysplasias		R		R		R

supplements the athlete may be taking to assess the potential for drug interaction or other inadvertent effects. Thermoregulation can be adversely affected by sympathomimetics and anticholinergics; volume depletion and dehydration is a potential problem with diuretics and excessive caffeinated beverage usage.

Potential considerations include cardiovascular side effects of beta blockers and sedating effects of narcotic analgesics, muscle relaxants, and some anti-epileptic drugs.

Use of ergogenic aids

Just like athletes with no disability, the athletes with disabilities are not immune from pressure to succeed and enhance their performance by various means. One unique example is noted later as the self-induced autonomic dysrflexia or ''boosting.'' No specific data are available on the prevalence of

drug or supplement use for performance enhancement by athletes with disabilities. One should still be cognizant about such a possibility while working with these athletes, so they should also be screened for using ergogenic drugs and supplements (see the article by Greydanus and Patel in this issue).

Musculoskeletal injuries

Several investigators have analyzed the injuries in athletes with disabilities, mainly for sports of the Summer Paralympics and, to a lesser extent, for winter sports [8,11,13,24,41–54]. In a recent review of epidemiological studies of sport injuries in athletes with disabilities, Ferrara and Peterson [13] concluded that the injury incidence and patterns are similar for athletes with and without disabilities. Their analysis included athletes with spinal cord injuries, amputee athletes, athletes with cerebral palsy, and visually impaired athletes. They note that various investigators have used different definitions of both the injury as well as the population studied. Ferrara et al [13] have defined an injury as any injury that causes an athlete to stop, limit, or modify participation for 1 day or more. Acute soft-tissue injuries were the most common injuries; these included skin abrasions, soft tissue contusions, sprains, and strains. Acute fractures and dislocations were uncommon, and the authors surmise that this may partly result from the fact that there are few contact sports in Paralympic Games. The site and type of injury depends upon the particular sport and specific disability; for instance, lower-extremity injuries are more common in amputees and athletes with cerebral palsy, while upper-extremity injuries are more common among athletes with spinal cord injury. Use of prosthetics, orthoses, and adaptive equipment also influences the nature of injury.

In a cross-disability study of 426 athletes with spinal cord injury, amputation (AMP), visual impairment (VI), and cerebral palsy (CP), Ferrara et al [8] reported that 32% (n = 137) of the respondents reported at least one time-loss injury in past 6 months. Fifty-seven percent of injuries reported by National Wheelchair Athletic Association (NWAA) athletes involved the shoulder and arm/elbow; fifty-three percent of injuries reported by athletes from the United States Association for Blind Athletes (USABA) were to a lower extremity. The injuries reported by United States Cerebral Palsy Athletic Association (USCPAA) athletes involved knee (21%), shoulder (16%), forearm/wrist (16%), and leg/ankle (15%). In a study of pediatric athletes (n = 83) who participated in Junior National Wheelchair Games, Wilson and Washington reported that most injuries were minor skin injuries; however, half of the participants reported symptoms of hyperthermia while 9% of swimmers reported symptoms of hypothermia [11].

In a 3-year cross-disability study (n = 319), Ferrara and Buckley [45] reported an injury rate of 9.30 per 1000 athlete exposures (defined as one athlete participating in one practice or game where there is the probability of sustaining an athletic injury), a rate similar to other able-bodied sports [45]. Fifty-two percent

of injuries were considered minor (7 or less days of time lost from sport) and 19% were major (22 or more days of time lost from sport).

Nyland et al analyzed soft-tissue injuries sustained by athletes of Disabled Sports USA (n = 66), the USABA (n = 53), the USCPAA (n = 56), and Wheelchair Sports USA (n = 129) who participated at the 1996 Paralympic Games [55]. Sixty-seven percent of athletes reported acute soft-tissue injuries. Their study supported the observation by others that injury patterns depend on the specific sport and the type of appropriate assistive or adaptive equipment used. The epidemiology of musculoskeletal injuries in children and adolescents with disabilities remains to be more clearly delineated.

Spinal cord–injured athlete

Fortunately, spinal cord injuries in children and adolescents are not common; however, they have significant lifelong consequences for independent living and sport participation [2,4,19,56]. These athletes are predisposed to injuries related to the use of wheelchairs, protheses, and other adaptive devices, not unlike other athletes who are wheelchair bound [6,39,52,57,58]. Persons with spinal cord injuries are also at risk for specific medical problems related to loss of motor and sensory function as well as lack of control of autonomic function (dysautonomia) below the level of the lesion, including impaired thermoregulation and autonomic dysreflexia [6,19,59–66].

Thermoregulation

Temperature regulation is impaired in athletes with spinal cord injury, especially with lesions above T8 [1,2,6,19]. Both hyperthermia and hypothermia have been reported to be serious problems in these athletes. Impaired sweating below the lesion level reduces the effective body surface area available for evaporative cooling. There is also venous pooling in lower limbs and decreased venous return, which also reduces heat loss by convection and radiation [21]. This can lead to increased body temperature and hyperthermia. Certain medications (eg, anticholinergics) taken by these athletes can also increase the risk of hyperthermia.

On the other hand, in cooler conditions such as swimming, there is increased risk for hypothermia. Impaired vasomotor and sudomotor neural control, decreased muscle mass below the lesion, and possible impaired central temperature regulating mechanisms all contribute to the development of hypothermia [6,21]. There is a lack of shiver response below the level of the lesion. These athletes also lack sensation below this level and thus may not be aware of wet clothes. Problems with appropriate temperature regulation can occur even within milder ambient temperature ranges. Adequate hydration must be maintained, and the athlete should be removed from sports activity at the first sign of any problem [6]. Awareness of these issues and education of these athletes and coaches is important.

Autonomic dysreflexia

Autonomic dysreflexia has been known to occur in athletes with spinal cord injuries above T6 [16,19,21,63]. There is a loss of inhibition of the sympathetic nervous system, which leads to an acute uncontrolled sympathetic response; this is manifested by sweating above the lesion, chest tightness, headache, apprehension, acute paroxysmal hypertension, hyperthermia, cardiac dysrhythmia, and gastrointestinal disturbances [6,21]. A number of stimuli below the level of the lesion can trigger such a response; this includes urinary tract infection, bladder distension, bowel distention, pressure sores, tight clothing, and acute fractures [21]. Awareness of the potential for autonomic dysreflexia is the key to prevention. At the first signs of this syndrome, the athlete should be removed from the sports activity, any recognized offending stimulus should be eliminated, and this athlete should preferably be transported to an emergency facility for further management. In many cases, this is a self-limited response; any persistent hypertension or cardiac dysrthymia needs further treatment.

A phenomenon of self-induced autonomic dysreflexia, known as "boosting," has been recognized over the past several years, especially in wheelchair athletes seeking to improve their race times [9,67,68]. These athletes will knowingly trigger such a response by inducing a trigger, such as distending the bladder. They may drink large amounts of fluids, strap legs very tightly, or clamp their catheters to induce bladder distention [9]. Self-induced lower leg fractures have also been reported. The exact mechanism of performance enhancement effects is not known; however, it is hypothesized that it is partly caused by increased blood flow to working muscles and by glycogen sparing resulting from increased use of adipose tissue, which is induced by increased catecholamines [9]. This has been shown to reduce race time and give the athlete an advantage. It is important to recognize that self-induced dysreflexia poses serious health risks for the athlete, and that this practice is considered an ergogenic aid, which is not sanctioned by sport-governing bodies.

Meningomyelocele

Children with meningomyelocele are at an increased risk for obesity (prevalence of up to 75%), so their participation in sports and other physical activities is especially therapeutic [1]. About 75% of these lesions occur at the lower lumbar and sacral levels, with loss of motor and sensory function below the lesion level. The presence of hydrocephalus can adversely affect cerebral function; increased intraventricular pressure and dilatation can damage the motor cortex and lead to development of spasticity above the level of the lesion [1,2,10,12]. Children with meningomyelocele also have deficits in both hand–eye and foot–eye coordination. Similar to others with neuromuscular disorders, they have decreased aerobic power, decreased endurance, decreased peak anaerobic power, and mechanical inefficiency [9,12,69–71]. The level of the lesion and severity of hydrocephalus

are important factors influencing the ability to participate in sports [2,10]. Children with meningomyelocele are categorized according to the functional level of the spinal cord lesion.

Poor soft-tissue support, increased local pressure, and lack of sensation below the lesion level make these children prone to develop localized skin breakdown with resultant pressure sores and ulcers [10]. They are also at an increased risk for ligament sprains because of lack of strong musculotendinous units around the involved joints; decreased muscle strength and strength imbalance increase the risk for muscle strains in these athletes [2,6,12,36]. Children with meningomyelocele lack the appropriate loading of their bones because of their lack of weight-bearing activities; this, often combined with nutritional inadequacy, may lead to osteopenia and increased risk for fractures [2,6,10,21]. Fracture may occur after minimal trauma and may initially be mistaken for localized infection because of erythema and swelling [2]. These athletes may not feel pain because of lack of sensation, further delaying the diagnosis of a fracture.

Bowel and bladder control

Children with meningomyelocele, spinal cord injuries, and other neuromuscular disabilities have difficulty with bladder control (neurogenic bladder) and bowel control [1,2,6,10,12]. Different bowel and bladder routines, accidents, and odor may be a cause for embarrassment for the child. In the context of sports participation, this athlete may be too preoccupied with the sport to adhere to a prescribed bladder or bowel regimen. Some athletes may be on a scheduled voiding regimen that requires intermittent catheterization, or they may have an indwelling catheter. There is also the problem of access to appropriate facilities in a timely fashion. These factors and others (as inadequate hydration) lead to an increased risk for urinary tract infections in these athletes. A regular regimen of voiding, ensuring adequate hydration (before, during, and after the sports activity), and using appropriate sterile voiding techniques are helpful in preventing urinary retention and associated complications. In addition to a neurogenic bladder, these athletes also have problems with constipation and stool retention; this requires regularly following a bowel regimen.

Latex allergy

Latex allergy is a known problem for spina bifida persons, with a prevalence range of 25%–65% [1,72]. Thus, latex allergy is an important consideration while working with athletes who have spina bifida. This information should be ascertained from the athlete or the family so one can avoid using latex gloves with these athletes during a medical emergency. Other articles containing natural rubber latex should also be avoided. Sources of latex in the medical setting include gloves, stethoscope tubing, blood pressure cuffs, catheters, wound drains, bandages, and bulb syringes; household sources include balloons, condoms, shoe soles, erasers, some toys, and sport equipment [72].

Hydrocephalus and shunt

The presence and severity of hydrocephalus and a ventriculoperitoneal (VP) shunt in children with meningomyelocele are major factors that affect the functional level and ability of these athletes to participate in sports [2,10]. The VP shunt system is generally protected under the skin; however, it is at risk of injury if the overlying skin sustains sufficient impact to cause a laceration [10]. Such an injury requires immediate evaluation by a neurosurgeon. Athletes with cerebrospinal fluid shunts are not necessarily restricted from sport participation simply because of the presence of this shunt [10]; however, they should wear an appropriate helmet or headgear for protection.

Associated conditions

Children with the associated Arnold-Chiari malformation should be restricted from activities that have significant risk of injury to the cervical spine; this includes sports such as diving and football [10]. Children with progressively worsening strength, scoliosis, and bowel and bladder function should be evaluated for possible hydromyelia and tethered cord [1,10,12]. These athletes should be restricted from further sports participation until after appropriate orthopedic intervention and reassessment of their functional abilities. Examples of high-risk sports for children with spina bifida include football, cheerleading, scuba diving, water skiing, polo, and bobsledding [10].

Cerebral palsy

Cerebral palsy is characterized by spasticity, athetosis, and ataxia. There is decreased musculotendinous flexibility, decreased strength, and considerable muscle imbalance; flexor muscles usually tend to have relatively more strength than the extensors [1,10,12,80,81]. Progressively decreasing flexibility, muscle strength, and tone imbalances contribute to the development of joint contractures. Children with cerebral palsy have a high-energy cost of movement (or decreased mechanical efficiency) and decreased peak anaerobic power; they may also have an increased cost of breathing (caused by decreased lung volume and a stiff thoracic cage) and decreased aerobic power [73–82]. Some children with cerebral palsy also have associated conditions such as perceptual motor problems, visual dysfunction, deafness, impaired hand–eye coordination, and mental retardation [1,81]. All these factors influence the risk for injury and ability to participate in sports, and have implications for developing training programs for athletes with cerebral palsy.

Athletes with cerebral palsy are at increased risk for overuse syndromes, muscle strains, chronic knee pain, patellofemoral problems, and chondromalacia patellae [2,6,10,16]. Progressively decreased flexibility of hamstrings and quadriceps contributes to proximal patellar migration [2,6]. Normal hip development is affected because of decreased flexibility and muscle imbalance around the hips;

this eventually contributes to the development of coxa valga, acetabular dysplasia, and hip subluxation [2]. Hip flexion contractures and tight hamstrings can lead to increased lumbar lordosis, chronic back pain, and spondylolysis. Some athletes find it difficult to control rackets and bats because of impaired hand-eye coordination; athletes with perceptual problems may also have difficulties in throwing and catching [2,6,12]. Many will develop ankle and foot deformities that affect sport participation and require orthopedic management. The presence of tonic neck reflexes can adversely affect effective development of certain sport skills such as use of bats, hockey sticks, or rackets [12].

Fifty percent of athletes with cerebral palsy participate in wheelchair sports and the other fifty percent are ambulatory [6]. The United States Cerebral Palsy Athletic Association (USCPAA) classifies athletes on the basis of observed ability to function and formal testing of various abilities; athletes are categorized in eight classes from the most severely affected to the least affected. The USCPAA competition events include archery, bocce, bowling, cross-country, cycling, equestrian sports, powerlifting (bench press), slalom, soccer (modified), swimming, shooting, table tennis, and track and field events [12]. The USCPAA sponsors special junior athletic events for athletes who are 7 to 18 years old and categorizes these events into four divisions according to age; a special division also allows activity for those who are under the age 6 years, where emphasis is on participation rather than competition [12].

Athletes with cerebral palsy benefit from carefully designed conditioning programs that should include appropriate strength training and flexibility exercises [10,12,16,27]. Strength training should take into account the differential tone and spasticity in different muscle groups so that training is directed to appropriate muscle groups to optimize muscle balance. Stretching, started after a period of warm-up, should be slow and sustained to prevent activation of stretch reflex. Specific training will also help improve ataxia and coordination.

Wheelchair athlete

Wheelchair athletes include those with cerebral palsy, spina bifida, and spinal cord injuries. Halpern et al note that the average wheelchair athlete trains for 6 to 10 hours per week and participates in sports on a weekly basis [6]. Sports with descending order of injury risk for wheelchair athletes are track, basketball, road racing, tennis, and field events [6]. Overuse injuries are the most common injuries, and shoulders and wrists are the most frequently injured regions [19,36,49,52]. Shoulder pain is a common complaint; specific shoulder injuries include rotator cuff impingement, rotator cuff tendonitis, biceps tendonitis, and tear of the long head tendon. Soft-tissue injuries (most commonly seen in track, road racing, and basketball) include lacerations, abrasions, and blistering that affects the arm and hand [19]. Peripheral entrapment neuropathy is common in wheelchair athletes, the most common of which is carpal tunnel syndrome, which is reported in 50% to 75% of the athletes [6,42,44,49]. In athletes with spinal cord

injuries and meningomyelocele, painless hip dislocations can occur [2]. Some athletes may develop progressive neuromuscular scoliosis that limits cardiorespiratory capacity. As noted above, athletes with spinal cord injuries can also develop autonomic dysreflexia, impaired thermoregulation, and lack of bladder and bowel control.

Pressure sores

Athletes with spinal cord injuries are especially at risk for developing pressure sores [10,19]. The wheelchair athlete's knees are at a higher level than the buttocks, a position that leads to increased pressure over the sacrum and ischial tuberosities for prolonged periods of time [6,12,36,49]. Skin lesions remain asymptomatic because of lack of pain and touch sensation. With delay in recognition, pressure sores can become infected. Thus, frequent, meticulous skin examinations are necessary for early detection of problem pressure areas.

Any sores must be promptly treated to prevent complications. There must be adequate local padding to relieve pressure. The athlete should have appropriate chair size and fit, and should be educated to frequently change position. Stump overgrowth and improperly fitting prosthetics also predispose the amputee athlete to pressure sores.

Amputee athlete

Use of assistive/adaptive devices, prostheses, and orthoses is common in athletes with limb amputations; these devises should be of proper fit and checked and adjusted regularly as the physical growth of the child or adolescent progresses [2,26]. Sports-governing bodies have rules that allow or disallow participation of athletes with prosthetic devices; high school interscholastic athletics currently allow athletes to wear these devices in many sports, including football, wrestling, soccer, and baseball [12]. The factors considered include the type of amputation and prosthesis as well as the potential for harm to others or unfair advantage for the athlete because of the prosthetic device [12,25,26]. Prostheses can increase local skin pressure and contribute to abrasions, blisters, and skin rash. Prepatellar, infrapatellar, and pretibial bursitis in the below-knee amputee can result from socket irritation [6,25,26].

Athletes with lower-limb amputation compensate by increasing lateral flexion and extension of the lumbar spine, which can potentially lead to back pain [6]. Amputees are also prone to hyperextension injuries of the knee. Skills that require balance are adversely affected in persons with amputation of a limb because of alteration of the center of gravity, especially in lower limb amputees [12].

In the skeletally immature athlete, overgrowth of the stump is a common problem [2,16]. The overlying skin and soft tissue may break down because of friction and pressure during sports. Awareness of this problem is key to early detection because these athletes often lack pain sensation in extremities and may

not be aware of the presence of these skin lesions. Increased bony prominence and local erythema indicate consideration of stump overgrowth and further evaluation. A skeletally immature child and adolescent may need periodic stump revisions until skeletal growth is complete [2].

Athlete with visual impairment

Visual impairment is a general term that refers to both partial sight and total blindness. A person with partial sight is only able to read using large print or proper magnification. A person who is not able to read large print even with magnification is considered blind; a person with total blindness is unable to perceive a strong light shone directly into his or her eyes [12]. Legal blindness refers to visual acuity of 20/200 or less in the better eye even with correction, or a field of vision so narrowed that the widest diameter of the visual field subtends an angular distance no greater than 20° (20/200) [12].

Visual impairment does not necessarily cause motor disabilities per se; rather, it is the lack of experience in physical activities that may limit or delay the development or acquisition of specific motor skills [12,36,83]. Thus, sports participation is an important experience for the visually impaired to learn and improve movements and motor skills.

The United States Association for Blind Athletes (USABA) promotes various sport activities for visually impaired athletes 14 years of age and older. The USABA classification for sports, based on residual vision, has these three categories: B1 (from no light perception at all in either eye up to light perception and inability to recognize objects or contours in any direction and at any distance); B2 (from ability to recognize objects or contours up to a visual acutity of 20/60 and /or limited visual field of 5°); and B3 (2/60 to 6/60 (20/200) vision and/or field of vision between 5° and 20° [12].

Visually impaired athletes compete in a variety of sports including skiing, track and field events, wrestling, swimming, tandem cycling, power lifting, goal ball, judo, gymnastics, running, bicycling, baseball, bowling, and golf [12,18]. Sport participation is facilitated by use of guides, such as sighted guide, a tether or guide wire, or a sound source, depending on the degree of visual impairment [6,12,19].

Deaf athlete

In the United States, Deaf individuals consider themselves to belong to a subculture of American society, and many do not consider themselves disabled [12]. Many prefer the term *Deaf* with an uppercase D, rather than the person-first terminology used to describe persons with other impairments [12,23]. Hearing loss can range from mild (hearing threshold of 27 to 40 decibels) to profound (hearing threshold of >90 decibels) [1,12]. The age at which deafness occurs is

an important factor in developing communication strategies for the Deaf. A child may be deaf since birth and thus before the development of speech (prelingual deafness) or may develop deafness later in childhood, after the phase of speech development (post lingual deafness, usually after first 3 years of life) [12]. Some Deaf persons may have associated damage to the vestibular apparatus, affecting balance; otherwise, most Deaf persons do not have any motor or physical deficits.

Deaf athletes can potentially participate in all sports with athletes who do not have deafness. Sometimes, as is true for those with unilateral deafness, some minimal additional visual cues may be helpful; athletes with unilateral and bilateral deafness may be at some disadvantage in team sports because they are not able to perceive voice directions from teammates. Coaches should be made aware of this issue as well. In the United States, USA Deaf Sport Federation promotes and organizes sports events for Deaf athletes.

Atlanto-axial instability in Down syndrome

Atlanto-axial instability (AAI) has been reported in 15% of persons with Down syndrome [2,85]. Children with Down syndrome have abnormal collagen that results in increased ligamentous laxity and decreased muscle tone [1,2,84]. Laxity of the annular ligament of C1 and hypotonia contribute to the AAI; approximately 2% of children with AAI may be symptomatic because of subluxation. Symptoms suggestive of atlanto-axial subluxation (AAS) include easy fatigueability, abnormal gait, neck pain, limited range of motion of the cervical spine, torticollis, incoordination, spasticity, hyperreflexia, clonus, extensor plantar reflex, sensory deficits, and other upper motor neuron and posterior column signs [1,2,12,85]. Asymptomatic AAI is a concern for athletes because of increased risk for spinal cord injury during sport participation.

It has been a common practice to obtain lateral cervical spine radiographs in flexion, extension, and neutral positions to screen for asymptomatic AAI. A 4.5-mm or more space between the posterior aspect of the anterior arch of the atlas and the odontoid process (*atlanto-dens interval*) is considered evidence of instability [2,85,86]. Magnetic resonance imaging or computed tomography is more informative in the assessment of AAI and AAS. Radiologic studies in asymptomatic AAI may not identify all at-risk athletes, and it is difficult to predict those who are at risk for future spinal cord injury [2,4,51]. Past and current history of symptoms is the most important part of AAI assessment.

Athletes with Down syndrome participate in sports under the umbrella of Special Olympics. Because of increased risk for spinal cord injury from atlantoaxial subluxation during excessive flexion-extension movements, certain sports are contraindicated for persons with AAI: contact/collision sports, gymnastics, diving, pentathlon, butterfly stroke, high jump, soccer, diving starts in swimming, and certain warm-up exercises tht involve neck flexion-extension [85]. Special Olympics require that all athletes with Down syndrome be

screened by lateral neck radiographs before participating in sport programs. Some recommend periodic reassessment every 3 to 5 years, although some experts doubt the value of periodic screening if the initial screening was normal [2]. The highest risk for AAS has been reported to be between 5 and 10 years of age [2,85].

Summary

There have been increased opportunities and sports participation by athletes with disabilities during the past decades. Research on pediatric athletes with disabilities remains limited. Appropriate classification of athletes on the basis of their functional abilities is key to fair participation. Preparticipation evaluation of these athletes is based on similar principles as for able-bodied athletes. The prevalence, nature, evaluation, differential diagnosis, and treatment principles for injuries are similar for athletes with disability and for those without. There are few disability-specific medical and orthopedic issues to be considered in working with these athletes. Sport participation recommendations are based on the specific disability and demands of the sport. The vast majority of athletes with disabilities can participate safely in a number of sports if appropriately matched; such participation should be encouraged and facilitated at all levels because of well-recognized psychological and medical benefits. Significant progress has been made in increasing sports participation opportunities for persons with disabilities; this is especially true for adults and, to a lesser extent, for children and adolescents. Many barriers remain, however: inadequate facilities, exclusion of children with disabilities, medical professional overprotection, lack of trained personnel and volunteers to work with children with disabilities, lack of public knowledge about disabilities, and lack of financial support for sport and physical education in schools [9,12].

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Appendix: organizations for diabled sports

- United States Cerebral Palsy Athletic Association

  E-mail: scpaa@mail.bbsnet.com
  Website: http://www.uscpaa.org

- Wheelchair Sports USA

  E-mail: wsusa@aol.com
  Website: http://www.wsusa.org

- United States Association for Blind Athletes

  E-mail: usaba@usa.net
  Website: http://www.usaba.org

- American Athletic Association of the Deaf

  E-mail: aaadeaf@aol.com

- Disabled Sports USA

  E-mail: dsusa@dsusa.org,
  Website: http://www.dsusa.org

- Special Olympics

  E-mail: SOImail@aol.com
  Website: http://www/specialolympics.org

- USA Deaf Sports Federation

  E-mail: usadsf@aol.com
  Website: http://www.usadsf.org

- American Athletic Association of the Deaf

  E-mail: aaadeaf@aol.com

- The United States Olympic Committee Disabled Sports Services Department

  E-mail: mark.shephard@usoc.org
  Website: http://www.olympic.usa.org

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