# Sport Participation by Physically and Cognitively Challenged Young Athletes

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**KEYWORDS**

• Intellectual disability • Cerebral palsy • Myelomeningocele
• Spinal cord injury • Thermoregulation • Boosting

There is a wide spectrum of disabilities that affect the physical and intellectual domains of athletes (**Box 1**).[1–7] It is estimated that there are more than 3 million persons with physical and cognitive disabilities who are involved in organized sports in the United States, and many more in recreational sports.[8,9] Children and adolescents with disabilities are finding increasing opportunities to participate in various sport programs.[2,3,10–12] The health benefits of physical activity for athletes with disabilities are well recognized.[13,14]

Participation opportunities for physically and mentally challenged athletes have increased in the past several decades, with thousands of athletes participating in organized games such as the Paralympics (**Box 2**) and Special Olympics (**Box 3**).[6,15–17] The Paralympic Games include athletes with spinal cord injuries (SCIs), 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. Athletes with intellectual disabilities participate in Special Olympics, whereas Deaf athletes participate in Deaflympics (**Box 4**).

This review focuses on some common medical issues that relate to sport participation by athletes with physical and cognitive disabilities.[12] 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. The reader is referred to many comprehensive reviews and organizational resources (**Table 1**) for more specific detailed information on different sports, technical aspects, and rules.[12,16,18–35] An explanation of some common terms can be found in **Table 2**.

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| Box 1<br>Spectrum of disabilities |
|---|
| Amputations |
| Cerebral palsy |
| Myelomeningocele |
| Traumatic brain injury |
| Spinal cord injury |
| Visual impairment |
| Hearing impairment |
| Intellectual disability |
| Genetic syndromes |
| Neuromuscular disorders |
| Neurobehavioral disorders |

## CLASSIFICATION OF DISABILITY SPORTS ATHLETES

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 helps 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 twentieth century. In addition to medical doctors, athletic trainers and specially trained and certified classification specialists are responsible for classification.[12] Such a process involves 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.[20,36] A functional classification system (FCS) incorporates 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 SCIs, 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]

Athletes with disabilities can also be classified based on their previous level of performance. Special Olympics use such divisioning or grouping based on the athlete's previous best times or other performance data. For example, athletes who have not more than 10% difference in best times or performance levels in a particular sport can be grouped together.

## SPORT PREPARTICIPATION EVALUATION

Preparticipation evaluation (PPE) is an essential component of injury and illness prevention in athletes.[37,38] There are no guidelines specifically designed for the PPE of athletes who have different types of disabilities. The general approach to

**Box 2**
**Paralympics sports**

Archery
Basketball
Boccia
Curling
Cycling
Equestrian
Fencing
Goalball
Judo
Powerlifting
Rowing
Rugby
Sailing
Shooting
Soccer
Swimming
Table tennis
Tennis
Track and field
Volleyball
Wheelchair dance
Wheelchair rugby
Alpine skiing
Biathlon
Cross-country skiing
Sled hockey

Source: www.paralympics.org

the PPE of athletes with disabilities should be similar to that of athletes without disability. Often the focus is so much on the disability that the examiner may overlook common medical issues apart from the primary disability (diagnostic overshadowing).

A detailed history is the mainstay of any PPE. It has been suggested that PPE for the athletes with disabilities should preferably be done by a team of medical professionals who are involved in the longitudinal care of these athletes and who know their baseline physical and cognitive levels of 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 medical issues for the athlete. In addition to the history and physical examination, a careful evaluation of the prosthetics, orthotics, and assistive or adaptive devices being used should be

**Box 3**
**Special Olympics sports**

Track and field (athletics)
Badminton
Basketball
Bocce
Bowling
Cycling
Equestrian
Gymnastics
Roller skating
Sailing
Soccer
Swimming (aquatics)
Table tennis
Team handball
Tennis
Volleyball
Alpine skiing
Floor hockey
Nordic skiing
Speed skating

Source: www.specialolympics.org

accomplished by the knowledgeable health care professionals to ensure adequacy and proper fit.

### *Participation Guidelines*

Athletes with physical or cognitive disabilities participate in several 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. Several factors should be considered in matching the athlete to the right sport. These 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 contribution of sport participation to the psychosocial well-being of 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,

**Box 4**
**Deaflympic sports**

Track and field
Badminton
Basketball
Bowling
Cycling
Orienteering
Shooting
Soccer
Swimming (aquatics)
Table tennis
Team handball
Volleyball
Water polo
Wrestling
Alpine skiing
Ice hockey
Ice sledge hockey
Snowboarding

Source: www.deaflympics.org

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]

### *Therapeutic Medication Use*

Athletes with disabilities are likely to be on various therapeutic medications for associated medical disorders. The potential side effects of these medications and their 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. To assess the potential for drug interaction or other inadvertent effects, one should also inquire about over-the-counter drugs and nutritional supplements the athlete may be taking. 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 β-blockers and sedating effects of narcotic analgesics, muscle relaxants, and some antiepileptic drugs.

### *Use of Ergogenic Aids*

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

**Table 1**
**Disability sport and other related organizations**[a]

| Organization | Website |
|---|---|
| United States Paralympics | http://www.usparalympics.org |
| Disabled Sports USA | http://www.dsusa.org |
| Dwarf Athletic Association of America | http://www.daaa.org |
| National Disability Sports Alliance | http://www.ndsaonline.org |
| Special Olympics International | http://www.specialolympics.org |
| USA Deaf Sports Federation | http://www.usadsf.org |
| US Association of Blind Athletes | http://www.usaba.org |
| Wheelchair Sports USA | http://www.wsusa.org |
| International Paralympic Committee | http://www.paralympic.org |
| Comité Internationale des Sports des Sourds | http://www.ciss.org |
| International Sports Federation – Intellectual Disability | http://www.inas-fid.org |
| International Blind Sports Association | http://www.ibsa.es |
| International Stroke Mandeville Wheelchair Sports Federation | http://www.wsw.org.uk |

[a] Partial list.

autonomic dysreflexia 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.

## MUSCULOSKELETAL INJURIES

Several investigators have analyzed muscusloskeletal injuries in predominantly physically challenged athletes, and the key observations are summarized in **Table 3**.[8,11,13,15,24,41–55] Data on injuries in athletes who have predominantly cognitive disabilities are limited. In a review of epidemiologic studies of sport injuries in athletes with disabilities, Ferrara and Peterson[15] concluded that the injury incidence and patterns are similar for athletes with and without disabilities. Their analysis included athletes with SCIs, amputee athletes, athletes with cerebral palsy, and visually impaired athletes. They note that various investigators have used different definitions of the injury as well as the population studied. Ferrara and colleagues[15] in their study defined an injury that caused 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 investigators surmised that this may partly result from there being few contact sports in Paralympic Games. The site and type of injury depends on the particular sport and specific disability; for instance, lower-extremity injuries are more common in amputees and athletes with cerebral palsy, whereas upper-extremity injuries are more common among athletes with SCI. Use of prosthetics, orthoses, and adaptive equipment also influences the nature of injuries.

In a cross-disability study of 426 athletes with SCI, amputation, visual impairment, and cerebral palsy, Ferrara and colleagues[8] reported that 32% (n = 137) of the respondents reported at least 1 time-loss injury in past 6 months. Fifty-seven% of injuries reported by National Wheelchair Athletic Association (NWAA) athletes involved

**Table 2**
**Explanation of some common terms**

| | |
|---|---|
| Impairment | Any loss or abnormality of psychological, physical, or anatomic structure or function |
| Disability | Global term used to encompass problems with body functions, body structures, activity limitations, and participation restrictions resulting from impairment (World Health Organization); impairment that limits a major life activity (Americans with Disabilities Act) |
| Handicap | A disadvantage for a given individual resulting from impairment or disability that limits or prevents the fulfillment of a role that is normal (depending on age, sex, and sociocultural factors) for that individual |
| Adapted sport | Sport that is specifically modified or designed for the athlete who has disability; the athlete may participate with others without disabilities (integrated settings) or only with others with disabilities (segregated settings) |
| Paralympics | Sports for athletes who have predominantly physical disabilities; organized sports governed by the International Paralympic Committee |
| Special Olympics | International sports training and competition program for persons with intellectual disability who are aged 8 y and older, irrespective of their abilities; governed by the International Special Olympics |
| Deaflympics | Organized sports for Deaf athletes, in which the athletes and officials are deaf |

*Data from* Refs. [1–3,6,12,19,29,35]

the shoulder and arm/elbow; 53% 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[11] reported that most injuries were minor skin injuries; however, half of the participants reported symptoms of hyperthermia, whereas 9% of swimmers reported symptoms of hypothermia.

**Table 3**
**Epidemiologic characteristics of musculoskeletal injuries in physically challenged athletes**

| | |
|---|---|
| Incidence | Similar to those without physical disabilities |
| Acute injuries | Soft-tissue injuries (skin abrasions, sprains, strains, contusions) most common<br>Fractures and dislocations are uncommon |
| Overuse injuries | Most common injuries overall<br>Most are soft-tissue or connective-tissue injuries |
| Severity | Most injuries considered minor ($\leq$7 d time loss from sports) |
| Modifying factors | Sport<br>Level of competition<br>Type of disability<br>Associated conditions<br>Use of prosthesis, orthoses, other adaptive equipment<br>Use of wheelchair |

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 1 athlete participating in 1 practice or game in which 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 fewer days of time lost from sport) and 19% were major (22 or more days of time lost from sport).

Nyland and colleagues[55] 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. Sixty-seven percent of athletes reported acute soft-tissue injuries. Their study supported the observation 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.

## SCI

Sport-related SCIs are not common in children and adolescents; however, SCIs can have significant lifelong consequences for independent living and sport participation.[2,4,19,56] Athletes who have SCIs are predisposed to injuries related to the use of wheelchairs, prostheses, and other adaptive devices, not unlike other athletes who are wheelchair bound.[6,39,52,57,58] Persons with SCIs 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 SCI, especially with lesions above T8.[1,2,6,19] 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 condition can lead to increased body temperature and hyperthermia. Certain medications (eg, anticholinergics) taken by these athletes can also increase the risk of hyperthermia.

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]

### *Autonomic Dysreflexia*

Autonomic dysreflexia has been known to occur in athletes with SCIs above T6.[16,19,21,63] There is a loss of inhibition of the sympathetic nervous system that 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] Several stimuli below the level of the lesion can trigger such a response, including 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 the athlete should preferably be transported to an emergency facility for further management. In many cases, autonomic dysreflexia is a self-limited response; any persistent hypertension or cardiac dysrhythmia needs further treatment.

### *Boosting*

A phenomenon of self-induced autonomic dysreflexia, known as boosting, has been recognized in the past several years, especially in wheelchair athletes seeking to improve their race times.[9,67,68] These athletes will knowingly trigger autonomic dysreflexia by a self-induced noxious stimulus; the athlete may drink large amounts of fluids, strap legs 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 as a result of boosting is not known; however, it is hypothesized that it is partly due to increased blood flow to working muscles, and to glycogen sparing resulting from increased use of adipose tissue, which is induced by increased catecholamines.[9] Boosting 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 that is not sanctioned by sports-governing bodies.

## MYELOMENINGOCELE

Adolescents with myelomeningocele are at an increased risk for obesity (prevalence of up to 75%), so their participation in sports and other physical activities is especially encouraged.[1] In 75% of cases the lesions in myelomeningocele affect 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] Persons with myelomeningocele also have deficits in hand-eye and foot-eye coordination. They also 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] Persons with myelomeningocele 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 predispose persons with myelomeningocele 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] Persons with myelomeningocele lack optimal loading of their bones because of their lack of weight-bearing activities; this, often combined with nutritional inadequacy, may lead to osteopenia and an 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*

Persons with myelomeningocele, SCIs, and other neuromotor disabilities lack volitional 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 individual. In the context of sports participation, the 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. 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 significant concern in individuals with myelomeningocele, with a prevalence of 25% to 65%.[1,72] Because of the high prevalence of latex allergy, latex-free gloves should be used while working with persons who have myelomeningocele. 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 persons with myelomeningocele 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. Blount and colleagues,[73] in their survey of neurosurgeons, reported that broken shunt catheters and shunt dysfunction were the most common complications observed. The incidence of sport-related shunt complications is reported to be significantly less than 1%. Blount and colleagues[73] noted that 90% of pediatric neurosurgeons who responded (n = 92, 55% of the sample) will allow unrestricted participation in noncontact sports by patients who have shunts, whereas for contact sports, 33% will restrict participation in all sports, 33% will restrict some contact sports, and 33% will allow unrestricted participation.

### *Associated Conditions*

Several associated and secondary conditions (**Table 4**) should be considered when evaluating athletes who have myelomeningocele. Persons with Chiari type 2 malformations should be restricted from activities that have significant risk of injury to the cervical spine; this includes sports such as diving and football.[10] Persons with myelomeningocele who develop progressively worsening strength, increasing scoliosis, and bowel and bladder dysfunction should be evaluated for possible hydromyelia and tethered cord.[1,10,12] These athletes should be restricted from further sports

**Table 4**
**Associated and secondary conditions in myelomeningocele**

| | |
|---|---|
| Neurologic | Arnold-Chiari malformation<br>Hydrocephalus<br>Tethered cord<br>Syringomyelia<br>Seizures<br>Autonomic dysreflexia |
| Cognitive/behavioral | Intellectual disability<br>Learning disability<br>Nonverbal learning disability<br>Attention-deficit hyperactivity disorder (ADHD) |
| Urological/renal | Neurogenic bladder<br>Vesicoureteral reflux<br>Hydronephrosis<br>Frequent urinary tract infections<br>Urinary incontinence<br>Urinary retention<br>Secondary chronic kidney disease and failure<br>Nephrolithiasis |
| Gastrointestinal/nutritional | Neurogenic bowel<br>Bowel incontinence, rectal prolapse<br>Constipation<br>Obesity |
| Skin | Pressure sores<br>Ulcers |
| Endocrine | Growth hormone deficiency<br>Precocious puberty<br>Metabolic syndrome |
| Cardiovascular | Congenital heart disease<br>Secondary hypertension<br>Reduced aerobic capacity<br>Deep venous thrombosis<br>Lymphedema |
| Ophthalmologic | Strabismus<br>Esotropia<br>Papilledema<br>Nystagmus |
| Allergic | Latex<br>Sensitivities to certain foods such as bananas, water chestnuts, avocados, and kiwi fruit |
| Sexual | Sexual dysfunction in some men |

*From* Patel DR, Greydanus DE, Calles Jr JL, et al. Developmental disabilities across the life span, Disease A Month. New York: Elsevier; 2010; with permission.

participation until after appropriate orthopedic intervention and reassessment of their functional abilities. Examples of high-risk sports for persons with myelomeningocele include football, cheerleading, scuba diving, water skiing, polo, and bobsledding.[10]

## CEREBRAL PALSY

Cerebral palsy is primarily characterized by spasticity, athetosis, and ataxia. There is decreased musculotendinous flexibility, decreased strength, and considerable

muscle imbalance; flexor muscles usually have more strength than the extensors.[1,10,12,74–77] Progressively decreasing flexibility and muscle strength, and increased tone, contribute to the development of joint contractures. Persons 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.[74–83] Some individuals with cerebral palsy also have associated conditions such as perceptual motor problems, visual dysfunction, deafness, impaired hand-eye coordination, and intellectual disability (**Table 5**).[1,75] 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

**Table 5**
**Conditions associated with cerebral palsy**

| | |
|---|---|
| Neurologic | Seizures (30%–50%) |
| Pulmonary | Restrictive lung disease (secondary to scoliosis)<br>Chronic lung disease of infancy<br>Dysphagia (40%)<br>Obstructive sleep apnea<br>Excessive drooling<br>Recurrent aspiration |
| Gastrointestinal | Oral motor dysfunction and feeding difficulties (80%–90%)<br>Poor nutritional status and growth<br>Gastroesophageal reflux disease (GERD; 25%–80%)<br>Constipation (80%)<br>Bowel incontinence |
| Genitourinary | Bladder incontinence<br>Recurrent urinary tract infections |
| Skin | Decubitus ulcers |
| Vision (40%) | Refractive errors; myopia (75%)<br>Strabismus, amblyopia, cataract, nystagmus, optic atrophy, cortical visual impairment |
| Hearing | Hearing impairment (5%–15%) |
| Dental | Malocclusions |
| Communication | Speech and language impairment (40%); dysarthria |
| Pain from multiple causes | Migraine, corneal abrasions, temporomandibular joint dysfunction, GERD, constipation, hip dislocation, muscle spasms, progressive scoliosis |
| Sleep | Sleep disturbances (25%) |
| Endocrine | Delayed or precocious puberty |
| Psychosocial and behavioral | ADHD, self-injurious behaviors, depression (20%) |
| Intellectual disability | Intellectual disability (30%–65%) |
| Learning disabilities | Learning disabilities |
| Musculoskeletal | Scoliosis, hip dislocation, patella alta, multiple joint contractures, foot deformities, lower-extremity rotational deformities |

*From* Patel DR, Greydanus DE, Calles Jr JL, et al. Developmental disabilities across the life span, Disease A Month. New York: Elsevier; 2010; with permission.

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 50% are ambulatory.[6] The USCPAA classifies athletes on the basis of observed ability to function and formal testing of various abilities; athletes are categorized in 8 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 4 divisions according to age; a special division also allows activity for those who are less than 6 years of age, in which the 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 ATHLETES

Wheelchair athletes include those with cerebral palsy, spina bifida, and SCIs. Use of wheelchairs influences the occurrence and patterns of certain injuries in these athletes. 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 in wheelchair athletes, and shoulders and wrists are the most frequently injured regions.[19,36,49,52] Shoulder pain is a common complaint in wheelchair athletes. Specific shoulder injuries in these athletes 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 affect 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 SCIs and myelomeningocele, painless hip dislocations can occur.[2] Some athletes may develop progressive neuromuscular scoliosis that limits cardiorespiratory capacity.

### *Pressure Sores*

Athletes with SCIs or myelomeningocele 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.[6,12,36,49] Skin lesions remain asymptomatic because of lack of pain and touch sensations. With delay in recognition, pressure sores can become infected. 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 and assisted as needed to frequently change position. Stump overgrowth and improperly fitting prosthetics also predispose the amputee athlete to pressure sores.

## AMPUTEE ATHLETES

Use of assistive or 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 generally allow athletes to wear these devices in many sports, including football, wrestling, soccer, and baseball.[12] The factors considered in decisions to allow or disallow athletes to participate with prosthetic devices 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] Prosthesis technology has advanced greatly in the past 2 decades[58] not only allowing athletes increasing levels of sport participation but also possibly contributing to improved performance. This has raised questions about prostheses giving amputee athletes an advantage compared with able-bodied athletes in such sports as running. The effects of carbon fiber prostheses on the running technique and running time of transtibial amputees have come under scrutiny.[58]

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 altered station 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 the key to early detection because these athletes often lack pain sensation in extremities and may not be aware of the presence of 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]

## VISUAL IMPAIRMENT

Visual impairment is a general term that refers to 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.[12,84,85] 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).[12,85,86]

Visual impairment does not necessarily cause motor disabilities per se; it is the lack of experience in physical activities that may limit or delay the development or acquisition of specific motor skills.[85] Thus, sports participation is an important experience for the visually impaired to learn and improve movements and motor skills. Because of fear of fall or collision with other objects, persons who have visual impairment often exhibit certain characteristic patterns of movements and posture. They have a shuffling, slow-paced gait with shorter strides; they often have stiffer posture, hyperlordosis, and protruding abdomen.[85,86]

The USABA promotes various sport activities for visually impaired athletes 14 years of age and older.[86] The USABA classification for sports, based on residual vision, has 4 categories, as shown in **Table 6**. Visually impaired athletes compete in a variety of sports including skiing, track and field events, wrestling, swimming, tandem cycling, powerlifting, goal ball, judo, gymnastics, running, bicycling, baseball, bowling, and golf.[85] Sport participation is facilitated by the use of guides, such as a sighted guide, a tether or guide wire, or a sound source, depending on the degree of visual impairment.[85]

## DEAF ATHLETES

In the United States, Deaf individuals consider themselves to belong to a subculture of American society, and many do not consider themselves disabled.[87] Many prefer the term Deaf with an uppercase D, rather than the person-first terminology used to describe persons with other impairments.[87]

Hearing loss can range from mild (hearing threshold of 27–40 decibels [dB]) to profound (hearing threshold of >90 dB).[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 (postlingual 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 persons who have vestibular dysfunction and balance problems may have limitations in some activities such as climbing heights, jumping on a trampoline, diving into a pool, or tumbling activities that require rotation.[87]

**Table 6**
**USABA visual classifications**

| | |
|---|---|
| B1 | No light perception in either eye, to light perception, but inability to recognize the shape of a hand at any distance or in any direction |
| B2 | From ability to recognize the shape of hand to visual acuity of 20/600 or a visual field of less than 5° in the best eye with the best practical eye correction |
| B3 | From visual acuity more than 20/600 to visual acuity of 20/200 or a visual field of less than 20° and more than 5° in the best eye with the best practical eye correction |
| B4 | From visual acuity more than 20/200 to visual acuity of 20/70 and a visual field larger than 20° in the best eye with the best practical eye correction |

Source: www.usaba.org.

Deaf athletes can potentially participate in all sports with athletes who are not deaf. 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 correctly locate the direction of sounds or perceive other auditory cues.[87,88]

In the United States, USA Deaf Sport Federation promotes and organizes sports events for Deaf athletes. On an organized level, Deaf athletes participate in Deaflympics, in which the athletes and the officials are deaf. To be eligible to participate in Deaflympics, the athletes must have a hearing loss of at least 55 dB per tone average (PTA) in the better ear (3-tone pure tone average at 500, 1000, and 2000 Hz, air conduction ISO 1969 Standard).[88] Use of any type of hearing device, such as hearing aids or other external amplification devices, is prohibited during warm-up or competition within a restricted zone area.[88]

## INTELLECTUAL DISABILITY

According to the American Association of Intellectual and Developmental Disabilities (AAIDD), intellectual disability "is a disability characterized by significant limitations both in intellectual functioning and in adaptive behavior as expressed in conceptual, social, and practical adaptive skills."[89] An individual's age and culture should be taken into consideration in the assessment of intellectual and adaptive functioning.[89] Sensory, motor, communication, or behavioral factors should also be appropriately considered in cognitive assessment and interpretation of results of cognitive tests.[89]

According to the Diagnostic and Statistical Manual of Mental Disorders, fourth edition, text revision (DSM-IV-TR), intellectual disability (or mental retardation) is defined as an intelligence quotient (IQ) of approximately 70 or less on an individually administered standardized test of intelligence concurrent with deficits in adaptive functioning in 2 of the following areas: communication, self-care, home living, social or interpersonal skills, use of community resources, self-direction, functional academic skills, work, leisure, health, and safety. All definitions stipulate that the onset of disability must occur before the age of 18 years.[90]

Athletes who have intellectual disability generally participate on an organized level under the auspices of Special Olympics. There are an estimated 3 million Special Olympic athletes worldwide. The most popular sports for these athletes are track and field events, soccer, basketball, bowling, and aquatics.[4] Hearing and visual impairments are prevalent in persons who have intellectual disability.[91,92] Persons with mild intellectual disability can participate in most sports and perform close to peers who do not have intellectual disability. In general, persons who have intellectual disability have been shown to score lower than those who do not have intellectual disability on measures of strength, endurance, agility, balance, running speed, flexibility, and reaction time.[93–95] Persons who have intellectual disability also tend to have lower peak heart rate and lower peak oxygen uptake ($V_{O_2}$ peak) than those who do not have intellectual disability.

## DOWN SYNDROME

Atlantoaxial instability (AAI) has been reported in 15% of persons with Down syndrome.[2] Persons with Down syndrome have abnormal collagen that results in increased ligamentous laxity and decreased muscle tone.[1,2,96–107] Laxity of the annular ligament of C1 and hypotonia contribute to the AAI; approximately 2% of persons with AAI may be symptomatic because of subluxation. Symptoms suggestive of atlantoaxial subluxation (AAS) include easy fatigability, 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.[1,2,96–107]

It has been a common practice to obtain lateral cervical spine radiographs in flexion, extension, and neutral positions to screen for asymptomatic AAI. Atlantodens interval (space between the posterior aspect of the anterior arch of the atlas and the odontoid process) of less than 4.5 mm or neural canal width of less than 14 mm in asymptomatic individuals are considered to be within normal limits, tend not to change over time, and therefore repeat radiographs are not indicated in the absence of any emerging signs or symptoms.[2,98–101] Magnetic resonance imaging (MRI) or computed tomography (CT) scan is more informative in the assessment of neural compromise associated with AAI or AAS. Although technically difficult, a dynamic or observed MRI scan of the cervical spine is reported to be highly sensitive in identifying neural compromise.[99]

Asymptomatic AAI is a concern for athletes because of increased risk for subluxation resulting in SCI during sport participation. Periodic neurologic assessment for emerging symptoms and signs suggestive of AAS and spinal cord impingement or compression is essential to identify athletes early and prevent irreversible injury to the spinal cord. The natural history of AAI and AAS in individuals who have Down syndrome has not been clearly elucidated. Radiographic evidence of AAI has not been shown to correlate with later development of AAS or predicting neural compromise.[2,4,51,99–101]

Athletes with Down syndrome participate in sports under the umbrella of Special Olympics. Because of increased risk for SCI from AAS during excessive flexion-extension movements, certain sports are contraindicated for persons with AAI as listed in **Box 5**.[93–105] 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.[2,99,100]

In addition to AAI, persons who have Down syndrome also have a higher incidence of associated orthopedic and medical conditions (**Box 6**) that must be carefully considered and evaluated during sport PPE.[99–109] Fifty percent of individuals who have Down syndrome have congenital heart disease that is surgically treated in infancy and childhood and it is important to obtain detailed history during PPE.[102]

**Box 5**
**Sports contraindicated for persons who have Down syndrome**

- Contact/collision sports
- Gymnastics
- Diving
- Pentathlon
- Butterfly stroke
- High jump
- Heading in soccer
- Diving starts in swimming
- Certain warm-up exercises that involve neck flexion-extension

**Box 6**
**Specific conditions to be considered during PPE[a] of athletes with Down syndrome**

AAI and subluxation

Anomalies and disorders of the odontoid

Occipitoatlantal instability

Cervical spondylolysis

Developmental dysplasia of the hip

Hip dislocation

Patellar instability

Neuromuscular scoliosis

Slipped capital femoral epiphysis

Arthropathy of Down syndrome

Congenital heart disease

Visual impairment

Hearing impairment

Intellectual disability

Diabetes mellitus

Obesity

Hypothyroidism

Epilepsy

[a]PPE, preparticipation evaluation.

Persons who have Down syndrome tend to have lower $V_{O_2}$ peak values and lower peak heart rates than those who do not have Down syndrome or have intellectual disability without Down syndrome.[107,108] The response to exercise on heart rate and peak oxygen consumption is also attenuated in persons who have Down syndrome, although, some studies suggest that exercise training may improve these values.

## 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 and performance abilities is the key to fair participation. PPE of athletes who have disabilities is based on similar principles as for those without disability. Disability-specific medical and orthopedic conditions should be considered when working with these athletes. Sport participation recommendations are based on the specific disability and demands of the sport. Most athletes with disabilities can participate safely in several 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. However, many barriers remain: inadequate facilities, exclusion of persons 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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