SPINAL CORD INJURY

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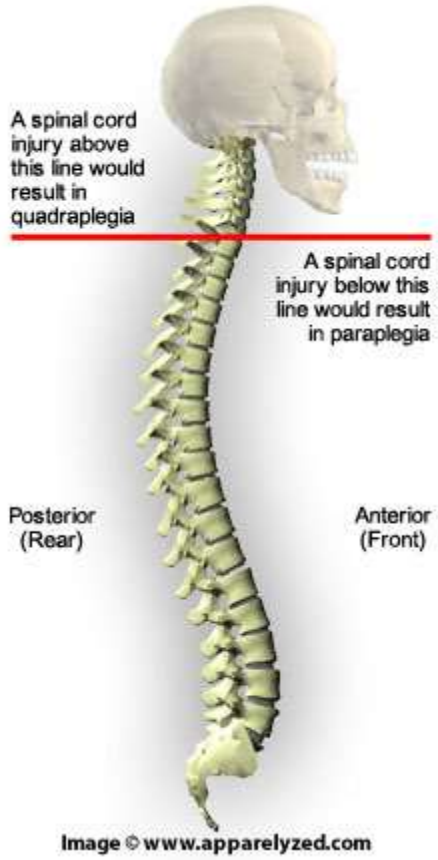
WHAT IS SPINAL CORD INJURY?

Spinal cord injury (SCI) is a major medical problem worldwide. SCI is a devastating injury which involves an initial mechanical damage followed by a series of cellular and molecular secondary events resulting in the progressive destruction of spinal cord tissue. Neuropathic pain (NP) is one of the most debilitating sequelae of neurotrauma and remains an unmet clinical need for at least 40% of patients with SCI.
http://peoria.medicine.uic.edu/cms/One.aspx?portalId=513437&pageId=14729105

Quadriplegia and Tetraplegia



The term Quadriplegic is derived from two different words from two different languages, Latin and Greek. The word “Quadra”, when translated from Latin means “four”, this relates to the number of limbs. “Plegic”, is derived from the Greek word “Plegia”, which when translated, means "paralysis".

When the two words are combined together, you have “Quadriplegia”. “Tetra” is derived from the Greek word for “Four”. “Para” is derived from the Greek word for "two" Hence: Tetraplegic and Paraplegic.
In Europe, the terminology for 4 limb paralysis has always been tetraplegia. The Europeans would never dream of combining a Latin and Greek root in one word.

Quadriplegic and Quadriplegia are the terms used mainly in America to describe paralysis of all four limbs. In 1991, when the American Spinal Cord Injury Classification system was being revised, the difference in names was discussed. The British are more aware of Greek versus Latin names. Since Plegia is a Greek word and quadri is Latin, the term quadriplegia mixes language sources.
Upon review of the literature, it was recommended that the term tetraplegia be used by the American Spinal Cord Association so that there are not two different words in English referring to the same thing.

QUADRIPLEGIA / TETRAPLEGIA

Quadriplegia or Tetraplegia is when a person has a spinal cord injury above the first thoracic vertebra (T1), paralysis usually affects the cervical spinal nerves, C1 to C8 resulting in paralysis of all four limbs. This may result in partial or complete paralysis of the arms as well as complete paralysis of the legs.
There are 7 cervical vertebrae in the neck, but 8 spinal nerves as the spinal nerves exit the spinal cord above the vertebrae.
In addition to the arms and legs being paralyzed, the abdominal and chest muscles will also be affected resulting in weakened breathing and the inability to properly cough and clear the chest. Breathing will be dependent on the diaphragm, or in severe cases, a ventilator. People with this type of paralysis are referred to as Quadriplegic or Tetraplegic.

Level of injury (Lesion)

The level of injury, otherwise known as a lesion, is the exact point in the spinal cord at which damage has occurred. Damage may take the form of scar tissue, or the cord may be compressed due to a damaged vertebrae or inter vertebral disc. The levels of spinal nerves are determined by counting the nerves from the top of the spine downwards, and these nerves are grouped into four different areas. These are the Cervical, Thoracic, Lumbar and Sacral parts of the spinal cord.

These areas are important, as damage to the spinal cord at these points directly determines how groups of muscles, organs and sensations will be affected.

Determining how the spinal cord has been damage is also a consideration when evaluating a spinal cord injury. There are two types of lesion, these are a complete injury and an incomplete injury. Someone with a complete injury will have a complete loss of muscle control and sensation below their level of lesion. An incomplete injury is where maybe only the muscles have been paralyzed, or where there is impaired sensation.

FUNCTIONALITY AFTER A SPINAL CORD INJURY

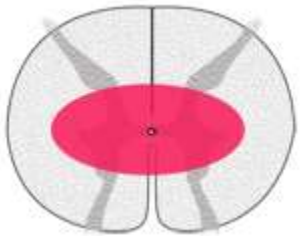
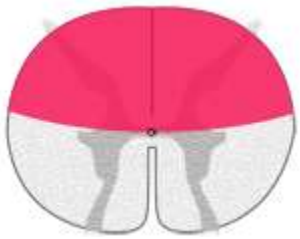
The functionality of a person's body following a spinal cord injury, will depend on the level of injury, and whether the injury was complete of incomplete. In order to show what functionality will be possible following a complete spinal cord injury, we have put together the most common abilities for varying degrees of paralysis. The age and weight of a person will also have a negative factor on the person's abilities.

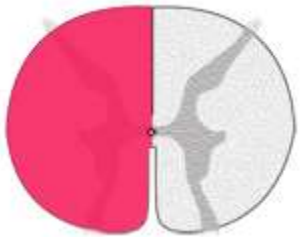
Click the spinal levels below for a comparison of injury levels and abilities.

C1 - C3 : C4 : C5 : C6 : C7 - C8 : T1 - T4 : T5 - T9 : T10 - L1 : L2 - S5

These abilities are not definitive, and slight variations may be present.

Incomplete Spinal Cord Injuries

Anterior Cord Syndrome: is when the lesion is towards the front of the spinal cord, this can leave a person with the loss or impaired ability to sense pain, temperature and touch sensations below their level of injury. Pressure and joint sensation may be preserved. It is possible for some people with this injury to later recover some movement.	
Central Cord Syndrome: is when the lesion is in the center of the spinal cord. This typically results in the loss of function in the arms, but some leg movement may be preserved. There may also be some control over the bowel and bladder preserved. It is possible for some recovery from this type of injury, usually starting in the legs, gradually progressing upwards.	
Posterior Cord Syndrome: is when the lesion is towards the back of the spinal cord. This type of injury may leave the person with good muscle power, pain and temperature sensation, however they may experience difficulty in coordinating movement of their limbs.	

Brown-Séquard syndrome: is when lesion is towards one side of the spinal cord. This results in impaired or loss of movement to the injured side, but pain and temperature sensation may be preserved. The opposite side of injury will have normal movement, but pain and temperature sensation will be impaired or lost.	
Cauda equina lesion: The Cauda Equina is the bundle of nerves which spread out of the spinal cord at between the first and second Lumbar region of the spine. The spinal cord ends at L1 and L2 at which point a bundle of nerves travel downwards through the Lumbar and Sacral vertebrae. Injury to these nerves will cause partial or complete loss of movement and sensation. It is possible, if the nerves are not too badly damaged, for them to grow again and for the recovery of function.	

http://www.apparelyzed.com/quadriplegia.html

HOW IS SPINAL CORD INJURY DIAGNOSED?

Diagnostic tests may include the following:

- CT scan—computers form a series of cross-sectional images showing location and extent of damage and reveal problems such as blood clots
- MRI scan—"takes a picture" of the injured area using strong magnetic field and radio waves and creates an image of the spine to reveal abnormalities which may include herniated disks
- Myelogram—a dye is injected into the spine and then an x-ray is taken
- Somatosensory evoked potential (SSEP) testing—show if nerve signal can pass through the spinal cord
- Spine x-rays—show fracture of damage to bones

http://www.nichd.nih.gov/health/topics/spinalinjury/conditioninfo/Pages/diagnosed.aspx

A few days after these tests, doctors also provide a complete neurological test that include testing muscle strength and sensitivity to pinpricks.
http://www.nichd.nih.gov/health/topics/spinalinjury/conditioninfo/Pages/diagnosed.aspx
http://www.mayoclinic.org/diseases-conditions/spinal-cord-injury/basics/tests-diagnosis/con-20023837

http://www.facingdisability.com/expert-topics/spinal-cord-injury-101

WHAT ARE THE TR IMPLICATIONS?

Objective

To investigate associations of therapeutic recreation (TR) interventions during inpatient rehabilitation for patients with traumatic spinal cord injury (SCI) with functional, participation, and quality of life outcomes.

Methods

In this prospective observational study, data were obtained from systematic recording of TR services by certified TR specialists, chart review, and patient interview.

Results

TR interventions, including exposure to community settings and leisure activities, add to the variance explained (in addition to the strong predictors of injury classification, admission motor Functional Independence Measure (FIM), and other patient characteristics) in outcomes at the time of rehabilitation discharge (FIM, discharge to home) and at the 1-year injury anniversary (FIM, working or being in school, residing at home, and societal participation as measured by the Craig Handicap Assessment and Reporting Technique (CHART)). They also are associated with less rehospitalization and less pressure development after discharge. In addition, more time spent in specific TR activities during rehabilitation is associated with more participation in the same type of activities at the 1-year injury anniversary.

Conclusion(s)

Greater participation in TR-led leisure skill and community activities during rehabilitation is a positive predictor of multiple outcomes at rehabilitation discharge and the 1-year injury anniversary demonstrating that TR activities are associated with a return to a productive and healthy life after SCI. Further research should focus on the impact of TR on longer-term outcomes to determine whether relationships continue or change as persons continue to adapt to their life after SCI.

SPINAL CORD INJURIES: MANAGEMENT AND REHABILITATION: CHAPTER NINETEEN

http://www.sciencedirect.com/science/article/pii/B978032300699610019X
http://www.sciencedirect.com.erl.lib.byu.edu/science/article/pii/B978032300699610019X

Before I became paralyzed at the age of 15, I had dreams and aspirations of either playing basketball at the University of North Carolina in Chapel Hill or running the wishbone offense as quarterback for the University of Oklahoma Sooners' football team. One way or another, I was determined to get there…What I found, over time, is that I've made wonderful friends [of the folks] I've met over the years. Each has played a vital role in helping me become the man I am today, including the many friends I've made through wheelchair sports.

Scott (T8 SCI)

Sports and recreation are an important modality in the rehabilitation of individuals with a spinal cord injury (SCI).[1., 2. and 3.] Because the length of stay for inpatient rehabilitation has become so short, there is little time for people who have recently been spinal cord injured to gain much experience with sports and recreation. This makes it critical to expose people to sports and recreation opportunities through community-based sports organizations or outpatient recreational therapy services. Adjusting to SCI and the changes in lifestyle associated with it can be mitigated by exposing the individual to healthy activities that build strength, stamina, self-confidence, and a sense of belonging.[4] There are many appropriate activities for individuals with wide-ranging interests and abilities. As with any recreational activity, it will take time and commitment to attempt and become proficient in and find those sports that most interest and meet the needs of each individual, but it is worth the journey.

The recreational interests and abilities of each individual vary because of multiple factors. It is important to recognize that maintenance of a healthy lifestyle and regular participation in exercise and recreational activities have been shown to reduce the detrimental effects of SCI.[5] Some people have an innate talent or natural drive to participate in sports and to pursue competitive activities. For those interested, sporting competitions are available on regional to international levels. Indeed, athletes with SCI must dedicate considerable time when desirous of being competitive at the national and international levels. The Paralympics are the pinnacle of many competitive sports with a long and rich history of affiliation with the Olympic Games.[6] This chapter discusses training techniques for both recreational and organized sports, a variety of sports activities, the structure of sports organizations for people with SCI, and research related to wheelchair sports. The intent is to provide resources for individuals with SCI and their clinicians to expand participation in and enjoyment from sporting activities that range from croquet to rock climbing. Whether spending time with friends, conquering a personal goal, or setting a world record, sports and recreation can play a vital role in life.

TRAINING TECHNIQUES

A carefully designed training program can help athletes reach their full potential. Training programs specific to wheelchair athletics are not unlike the training regimens performed by able-bodied athletes. For wheelchair athletes competing in individualized competition such as racing, attaining peak performance at the appropriate time is crucial. Maintaining peak conditioning during an entire competitive season is unrealistic: it is difficult for a racer to go into competitive situations earlier in the season with enough fitness to handle all of the elements of a race course. Therefore, athletes tend to construct their training and competition schedule to peak for a particular event. Often wheelchair racers will use smaller competitions to prepare for the more important races, and preliminary races may also serve to qualify athletes through to events requiring time or place standards such as the Boston Marathon or World Championships and Paralympics.

During any given racing season, hand cyclists and wheelchair racers will work at different levels of exertion at different times. During early season workouts, hand cyclists commonly train in the small chain ring or gear to maintain

a high cadence of 90 to 100 revolutions per minute at relatively slow speeds. If an athlete trained this way all year long, his fitness would be incomplete. He would be unable to meet the demands of actual events, which generally are diverse topographically. To truly peak and be prepared for a major race, an athlete must be able to handle large gears with frequent accelerations of pace, including sprinting, surging, hill climbing, drafting, and coasting. As a result, training must gradually take on more intense and diverse aspects, incorporating as many racing scenarios as possible.

Team sports such as rugby or basketball require a slightly different training approach because every game is important to the ultimate success of the team. Given the logistics of team sports, it is necessary for athletes to peak before the season while maintaining high levels of performance throughout the season.

Periodization

Athletes involved in team sports can achieve these types of results through a training technique called periodization. This technique divides the year into training intervals. Defining the term simply, it uses a process of training that varies the timing and intensity of workouts to achieve specific results. Periodization also allows for changes in the intensity (e.g., heavy, moderate, and light resistance) and changes in the volume of exercise (e.g., sets × repetitions), which theoretically keeps the exercise stimulus effective.[7] For example, the year can be divided into a preseason, in-season, main-season, and end-season. Teams use similar divisions when training for a specific event: precompetition, initial competition, main competition, and postcompetition (macrocycle).

The five training regimens that an athlete should implement into his periodization program include endurance, speed, skill, strength, and flexibility. Realizing that each athlete and sport has different needs, time allocated to each regimen will differ; however, implementing all five can help facilitate peak performance.

Common Errors

When designing an appropriate training program, some of the common errors made by athletes should be considered. Harre[8] summarized typical errors made by athletes while designing a training program, and more recently other authors have expanded his work.[9] and [10] Common errors in training may neglect recovery and include excessive demands on speed, loads, and volume (Box 19-2).

BOX 19-2.
Common Errors in Training

- Recovery is often neglected with mistakes in the microcycle and macrocycle sequence. The macrocycle is the division of a year into phases of training periods where the emphasis is different in each phase. A microcycle is one week of specialized training within a macrocycle. There is inadequate use of general exercise sessions for recovery purposes.
- Demands on an athlete are made too quickly relative to capacity, compromising the adaptive process.
- After a break in training for illness or injury, the training load is increased too rapidly.
- High volume of both maximal and submaximal intensity training
- The overall volume of intense training is too high when the athlete is primarily engaged in an endurance sport.
- Excessive attention and time are spent in complex technical or mental aspects without adequate recovery or down time.
- Excessive number of competitions with maximum physical and psychological demands combined with frequent disturbance of the daily routine and insufficient training
- Bias of training method with insufficient balance
- The athlete lacks trust in the coach as a result of high expectations or goal setting, which has led to frequent performance failure.

The underlying theme reflected by these errors is one of imbalance between intensity and adequate recovery, which, with an inappropriate lifestyle or social environment, can lead to a situation of overtraining. Workout strategies that avoid overtraining have been summarized by several authors; Box 19-3summarizes steps described by Pyne.[9]

BOX 19-3

Workout Strategies to Avoid Overtraining
Data from Pyne D: Designing an endurance training program. In *Proceedings of the National Coaching and Officiating Conference* (1996 Nov 30–Dec 3), Brisbane, 1996, Australian Coaching Council Inc.

- Formulate a long-term performance goal for the season as the basis on which the training program is designed.
- Use a progressive and cyclical increase in training load.
- Use a logical sequence to the order of the training phases.
- Use a training process supported by scientific monitoring.
- Use intensive recovery techniques throughout the training program.
- Emphasize skill development and refinement throughout the training program.
- Use an underlying component for the improvement and maintenance of general athletic abilities.

Endurance Training

Endurance training typically focuses on training for a particular event because it involves elevating the heart rate over a prolonged period of time. A wheelchair road racer preparing for a 5K or 10K event, for example, would train that particular distance at least 3 days a week. This approach may vary among athletes; some may train more frequently and others less, depending on their capabilities and levels of ambition. Some will find that training for a 12K event is a good way to prepare for an actual 10K event. The extra 2000 meters prepares the athlete for every weather condition and terrain while also creating a mindset wherein the athlete, knowing he can easily complete a 10K, will push even harder during the competition.

On days when athletes do not do endurance training they should do interval training. This type of training stresses the cardiovascular and neuromuscular systems and thus prepares the body for competition (Box 19-4). In addition, athletes who compete in endurance events should also train in speed, skill, strength, and flexibility to reach the highest possible physical condition.

BOX 19-4.

Components of Interval Training for 400-Meter Sprinter

- Sprint a given distance: sprint 200 meters, coast or lightly propel for 100 meters, perform interval over again 5 to 10 times.
- Dramatically reduce speed for a shorter distance.
- Perform the interval over again.
- Approaching competition: increase the sprinting intervals and decrease the rest intervals.

Speed Training

Speed training is part of a well-thought-out periodization program. Athletes who participate in sports such as basketball, rugby, track and field events, swimming, and weight training will benefit from speed training. Speed training can increase reaction time, which can be a vital component related to performance and ultimately success in competition.

Sprint training, in which the athlete performs short sprinting intervals, is the best method to train for speed. For example, when an athlete is competing in 100-meter events, a single training session would be separated into four different distances. A typical training day for a 100-meter athlete is shown in Box 19-5. The last set of repetitions is 10% longer than the event itself. Because the athlete has have trained to sprint for 110 meters, he will be able to drive through the entire 100 meters during competition. An athlete's performance often fades or slows during the last portion of a workout, so this method can ensure quality production and performance through an entire workout.

BOX 19-5

Typical Training Day for a 100-Meter Athlete

Distance (m)	Repetitions
80	3
90	3
100	3
110	3

Plyometrics

Another aspect of speed training is a technique called plyometrics. Plyometric exercise integrates strength and power into a single training session, resulting in explosiveness. Plyometrics relies on an external force to store energy within the musculature. The stored energy is immediately followed by an equal and opposite reaction, using the natural elastic tendencies of the muscles to produce energy. Wheelchair sprinters can use a medicine ball or plyoball to perform upper body plyometrics. The athlete performs plyometrics by quickly catching and explosively passing the ball to a partner for multiple repetitions. The goal of plyometric exercises is to minimize the time the body has to recover from the external force (e.g., the thrown ball), thereby increasing the amount of energy stored within the muscle for optimal performance.[11]

Skill Training

Skill training is also applicable to sports. Skill training in the context of this chapter essentially is equivalent to specificity training, which many athletes overlook because they think it encompasses only the competitive event itself. Athletes, however, should regularly examine and break down the mechanics of their movements. For example, wheelchair sprinters should dissect stroking techniques into distinct phases—preparatory, propulsion, and recovery phase—and examine each phase for proper form and execution. Movements used by throwers in field events are also extremely technical. Consequently, athletes can benefit from analyzing the component parts of these movements. For example, research by Chow and Mindock[12] relates success in the discus throw to the inclination and angular speed of the upper arm at release, the ranges of motion of the shoulder girdle, upper arm, and forearm during the forward swing, and the average angular speed of the shoulder girdle during the forward swing. Knowledge of proper form in executing these types of movements undoubtedly can help an athlete to increase his performance. Usually, the athlete needs advice from a physical or occupational therapist or an individual who understands movement biomechanics to improve performance and efficiency.

Strength Training

Strength training techniques typically refer to resistance training, which can be accomplished through the use of free or machine weights, surgical tubing, body weight exercises, manual resistance, or any other form of activity that follows basic strength training principles. The wheelchair athlete can apply exercise principles that are similar to those

unimpaired athletes use, but the wheelchair athlete does have some unique characteristics. The wheelchair athlete with SCI depends on relatively smaller muscle groups of the upper body than does the unimpaired athlete who relies on his legs to produce movement. Seiler[13] has commented on the physique of elite, able-bodied marathon runners compared with elite wheelchair marathon racers. He explained that, although both athletes were endurance and cardiovascular athletes, the wheelchair racers were extremely bulky compared with the runners. Wheelchair marathoners have a much smaller total volume of muscle to do the work of the marathon race. It is possible that wheelchair athletes may possess the ability to have greater hypertrophy response to endurance training, independent of supplemental strength training in a weight room.[13]

Free Weights versus Machines

Strength training can be accomplished by using free weights or machines (e.g., Universal, Cybex, Nautilus). Resistance training should not focus solely on free weights or machines: it is best to use both methods to provide a comprehensive workout. Table 19-1 compares the advantages and disadvantages of free weights versus machines.

TABLE 19-1.

Advantages and Disadvantages of Free Weights versus Machines

	Advantages	Disadvantages
Free weights	Permit small increments of weight Teach coordination and balance Allow creation of specific exercises for specific sports	Requires a spotter at all times
Machines	Controls the direction of movement Does not allow extraneous movements that can contribute to injury	Coordination and balance are minimized Cannot be modified to become sport specific because they are usually created to perform one basic exercise

Although both machines and free weights produce strength gains, to a large extent the magnitude of gains in maximum strength as a result of resistance training depends on the similarity between the strength tests and the training exercise. This aspect of movement specificity has been noted in longitudinal studies and in reviews of the literature.[14., 15. and 16.] In addition, there is evidence that resistance exercise machines can improve sports performance. For example, hip sled exercises produced improvements in both vertical jump distance and leg power. Training on machines has also improved the 40-yard dash, softball and baseball throw, shot put, and vertical jump. Circuit training both with and without machines has been widely used in athletic training programs supervised by professional coaches in sports such as swimming, track and field, and baseball.[16]

Sets and Repetitions

The number of sets and repetitions per exercise depends on the purpose of the training program. Generally, sets should remain between two to five per exercise, with 6 to 15 repetitions per set. Conditioning programs often entail three sets per exercise with 10 to 12 repetitions. The weight allocated to each set should be moderate.

For more intense strength training, the repetitions should be reduced to six per set. The repetitions are reduced so higher weights can be used. Sets should typically be on the higher side (five) to properly overload the muscle. Endurance athletes should focus on lighter weights with higher repetitions (13 to 16), with the number of sets

remaining around three to four. It is important to remember that these recommendations have been generalized. Each athlete must determine the optimal number of sets and repetitions on the basis of his personal experience. It is best to begin a weight-training program by implementing a general conditioning program, moving to a more strenuous program only after general conditioning is completed. Most important, athletes should implement weight-training programs that complement their athletic events.[11]

Popular Training Regimens

The principles of specific adaptation to imposed demands (SAID) include progression, overload, volume, frequency, intensity, documentation, motivation, and specificity (Box 19-6). These principles, which are often used with able-bodied people, can be applied similarly in disabled people.[17] The SAID principles describe the adaptation that occurs within muscle tissue when it is progressively stressed or overloaded.[17]If an individual physically stresses a muscle or muscle group to the point at which fatigue occurs while performing the exercise movement, he can adapt to that stress in the sense that the body will respond to the exercise more favorably the next time. If this physical stress is repeated and increased, the body will continue to increase strength by adapting neurological pathways,[18., 19., 20., 21. and 22.] increasing muscle size,[23. and 24.] and increasing the mineral content of bone.[25] Opinions differ, however, regarding optimal weight-training regimens.

BOX 19-6.

Principles of Specific Adaptations to Imposed Demands

- Progression
- Overload
- Volume
- Frequency
- Intensity
- Documentation
- Motivation
- Specificity

There is no one program that will suit every athlete. Athletes must consider their age, sex, weight, position, and particular sport when conditioning for the upcoming season. It is best initially to change training routines every few weeks to get an idea of what training program works best for an individual's particular needs. This should be done in the early preseason so that the athlete's training program will be established before the preseason is well underway, allowing him to train hard for the greater part of the preseason.

Box 19-7

Common Training Routines

- Training the entire body in 1 day
- Dividing the body into upper and lower portions
- Exercising only one body part per day
- Three primary training days (push-pull workout)

Athletes tend to use four common training routines (Box 19-7). The first consists of training the entire body in 1 day in which the athlete performs fundamental exercises that train every major muscle of the body. A comprehensive weight-training program can include exercises such as the bench press, overhead/military press, seated rows, lat-pulls, squats, and standing calf raises. To prevent overtraining, at least 1 day should be spaced between each of these comprehensive workouts, allowing the athlete to devote off days to training regimens for skill, flexibility, endurance, or speed.

The second training routine consists of dividing the body into upper and lower portions. The individual dedicates one day to an upper body workout and focuses on the lower body on the second day. Although this training program focuses on the fundamental exercises previously mentioned, it uses a more intense workout because only one half of the body is exercised per workout. The higher intensity occurs by use of heavier weights or by performing more sets or repetitions. The training regimen should include at least one off day to allow the body to recover from a more intense workout.

The third (and least commonly used) weight training routine consists of exercising only one body part per day. This type of program allows the athlete to focus his training on a single body part. A sample chest workout would include exercises such as bench press, incline press, decline press, or close-grip chest press, thus overloading the chest musculature to facilitate strengthening. The remaining days should be dedicated to the back, arm, shoulder, and leg musculature. Although this type of workout is very taxing to the body, it allows each body part to rest for at least 3 or 4 days, ensuring proper recuperation of the muscles. This routine is useful not only for novice weightlifters but also, because of its taxing nature, well-conditioned athletes should use it when they are concentrating on building their strength.

The last (and very popular) routine is commonly referred to as the push-pull workout. The push-pull workout divides the training program into three primary training days. The first day focuses on the chest and triceps area (the push day). The second day focuses on the back and biceps musculature (the pull day). The last day exercises the leg and shoulder musculature. This program permits very intense workouts because each body part has at least 3 days to recuperate. Yet even with 3 days of muscle recuperation, individuals should dedicate at least one day to other training regimens after the last day of the entire push-pull routine.[11]

Flexibility Training

Flexibility training should be an integral part of every athlete's daily workout. Everyone should stretch before and after every workout, with static stretches held for at least 30 seconds. In addition, everyone should avoid ballistic stretching, which can injure muscles.

Before each training session begins, an athlete should complete a warmup session. This can consist of lightly pushing around the track a few times or performing high-repetition and low-weight sets in a weight room. After the warmup session, the athlete should perform a number of upper and lower limb stretches, especially those specific to the competitive activity.

After every training session, athletes should cool down and stretch. Cool downs can be similar to the exercises used to warm up and can help alleviate muscle tightness and prepare the body for stretching. Stretching sessions after a workout should be comprehensive: both the upper and lower body requires stretching after workouts. To ensure that all muscles are properly stretched, a post exercise stretching session should last at least 20 minutes.[11]

RECREATIONAL AND COMPETITIVE SPORTS

Any number of recreational and competitive sports may be of interest to individuals with SCI. Although this chapter cannot cover every sport, a variety are discussed. Athletes should review relevant literature and consult coaches for training in specific activities.

Archery

Archery was included as a sporting event in the first Paralympic Games in Rome, Italy, in 1960. The first international wheelchair archery competition, however, was held in 1948 in Stoke Mandeville, England, because of the efforts of Sir. Ludwig Guttman.[26] Paralympic archery consists of an Olympic round only, which measures 70 meters in both the qualification and finals. Both men and women compete with the option of either standing or sitting in a wheelchair. Depending on the severity of the disability, archers may use a body support to stand, an authorized strapping system, a mechanical release aid, an approved compound bow, elbow or wrist splint, and an assistant to load arrows into the bow if they are unable to so themselves independently. All devices must be approved for use on the basis of the individual's disability.[27]The sport allows for competition in singles and team events, with the scoring procedures identical to those used by athletes competing in the Olympic Games.[27] Adaptive archery equipment can be found

through organizations, including Adaptive Shooting, American Wheelchair Archers, National Wheelchair Shooting Federation, and Outdoor Buddies Hunting Program. In addition, local and national tournaments exist and are available regularly to recreational and competitive athletes seeking competition.

Athletics

Athletics includes track and field events, pentathlons, and marathons. The field throwing events allow competitors to use specially designed throwing chairs attached to a holding device, offering stability and support beyond what an individual's personal wheelchair could provide. Throwing chairs are much higher and do not have large wheels that could potentially interfere with the dynamic upper body movements required in throwing events. According to competition rules, the seat of an athlete's chair (including the cushion) for field events must not exceed 75 cm in height.[28] For wheelchair athletes, the chair design is important because it can significantly enhance performance depending on how well it matches the thrower's body and functional abilities. Consequently, athletes use chairs with different seat heights and configurations within the allowed parameters, to optimize support, positioning, and ultimately throwing execution.

Competitors in wheelchair athletics are classified on the basis of the neurological level of injury and the athlete's ability to effectively carry out movements necessary to complete a throwing task.[28] For the field events, there are nine different functional classes: F1 to F9. An F1 class equates to a neurological level of injury at roughly the C6 level. In contrast, the F9 class would have an extremely low level SCI in the sacral region or an incomplete cord lesion resulting in the ability to partially weight bear.[28] In addition, not all functional classes compete in the same events. For example, the javelin throw is not held for the F1 class because of the absence of sufficient hand function to control a javelin safely. F8 to F9 athletes are allowed to throw from a standing position and use an 800-g javelin. Wheelchair athletes in the other classes use a 600-g javelin and perform throws from throwing frames.[29] Therefore wheelchair athletes completing throws from throwing frames must rely entirely on the upper body and the support of the throwing frame to successfully execute throws. Any variations in throwing techniques used by wheelchair athletes are not specifically defined but are likely attributed to the differences in disability, chair design, and sitting position.[29]

Athletes with diminished hand function tend to use resin or adhesive-like substances to improve their grip. In addition, throwing implements such as the club and the shot vary in weight depending on the functional classification and sex of the athlete. The athletes having the highest neurological level of injury, roughly C6, compete in club throwing rather than the javelin.[28]

Track racers can compete in distances from 1000 meters through the marathon (Figure 19-1). The racing wheelchairs used by the athletes are customized and designed to fit the body of each user. This equipment, used in combination with correct propulsion biomechanics, can result in an extremely efficient means of movement.[30., 31., 32. and 33.]

FIGURE 19-1.
Elite paraplegic and amputee racers drafting in track competition.

The design of a racing wheelchair optimizes the abilities of each user, incorporating features such as three-wheeled design, use of high pressure tubular tires, lightweight rims, precision hubs, carbon disc/spokes wheels, compensator steering, small push rings, ridged frame construction, and 2 to 15 degrees of wheel camber. The camber in a racing chair makes the chair more stable and allows the athlete to reach the bottom of the push rims without hitting the top of the wheels or push rim (see Figure 11-31). The fit of the racing chair to one's body and abilities is critical to overall performance as well. Most racing chair manufacturers require a number of anatomical measurements when a chair is ordered.[34] Typical body measurements include hip width, chest width, thigh length, arm length, trunk length, height, and weight. Wheelchair racers tend to sit in a position that promotes biomechanical efficiency and aerodynamics (Figure 19-2). Racers position themselves in a way in which the weaker portions of the body are brought close to those under voluntary control, which helps increase stability for wheelchair control and propulsion.[35]

FIGURE 19-2.
Individual with C7 tetraplegia using the kneeling position in his racing chair.

The frame and seat cage of a racing chair are made to fit each individual, including different disability etiologies and levels as well. Both experience and etiology determine the location of rear axles with respect to the seat cage. Although experienced athletes with paraplegia prefer 15 to 25 cm from the seat back to the rear axles inserts, those with tetraplegia prefer 5 to 20 cm. Novice athletes generally choose more stable configurations. The seat cage upholstery adjustment and rear axle positions are fitted to allow athletes to position their shoulders over the front edge of the push rims, also creating room to reach the bottom of the push rims with both arms. Individuals with upper-level SCI tend to pull their knees up higher toward the chest (Figure 19-3) than do lower-level-injured athletes to further enhance stability, balance, and breathing.

FIGURE 19-3.
Individual with C6 tetraplegia using the cage position with foot plate on racing chair.

Athletes with paraplegia, tetraplegia, or amputated limbs have different positioning preferences and each person has unique abilities and body structure. Generally speaking, there are three basic racing body positions available to racers: kneeling bucket, kneeling cage, and upright cage. The kneeling positions tend to be the lightest setup and the most aerodynamic and have allowed paraplegic and tetraplegic athletes to make tremendous performance gains over the years. Athletes inexperienced with the kneeling position may benefit from a kneeling cage, which affords them the flexibility of sitting upright or kneeling and permits more adjustment of body position. Upright cage seats work well for athletes with lower limb amputations and for athletes with low levels of paraplegia (i.e., those who have the trunk control to adjust body position while racing).[34]

A properly fitted racing chair can allow the user to make minor steering adjustments by swinging the upper body or hips. Racers often refer to this maneuver as “hipping” the chair. A racing chair's primary steering, however, is controlled by the upper body's interaction with the front wheel, where pressure can be applied to handle bars, which turn the front wheel left to right. When racing on a track an athlete should not rely on primary steering: an additional steering component called a compensator can be engaged with one hand while taking the chair around the curve of a track and then disengaged to accommodate the strait section of the track. Wheelchair racers can maintain chair control at high rates of speed for long distances not only because of the precision equipment and its fit but also because athletes use highly specialized propulsion strokes (Figure 19-4). The racing stroke is in part dependent on the athletes using special gloves available commercially or constructed independently by each racer. These gloves are often built using a combination of leather, foam, rubber, and self-molding plastics. Racing gloves promote solid contact between the glove surface and the push ring, which generally has a rubber-coated surface. This setup allows skilled athletes to keep up with the wheel at very high speeds and to deliver more force per stroke to the wheel, minimizing slips and other contact and release related inefficiencies. The motion of a propulsion stroke can best be described as a punching motion and it can take years to master.[31] Furthermore, aerodynamic positioning, as mentioned before, has initiated a propulsion technique where extensive shoulder extension and abduction during the back swing lead to increased hand speed at the impact energy transfer phase.[36.] and [37.]

FIGURE 19-4.
Wheelchair racers can maintain chair control at high rates of speed not only because of their precision equipment and its fit but also because they use highly specialized propulsion strokes.
(Courtesy PVA Publications, Phoenix, Ariz.)

Given the multitude physical and mechanical elements relevant to racing in combination with the reality that the propulsion technique can take substantial time to develop, new racers often find racing daunting. Novice racers typically enter the sport using previously owned equipment. Used equipment generally is loose fitting but can be adjusted with foam pads and additional upholstery to accommodate the new occupant. It is important that athletes, particularly beginners, be able to reach brakes from a comfortable position, and the brake levers must be long enough and at the proper angle so that the athlete can apply sufficient leverage to stop the racing chair.[34] In addition, new racers are often relieved to know that racing competition separates athletes by functional class and sex to keep the playing field level. Most major road running races across the world have wheelchair divisions separated into tetraplegic and paraplegic events and tend to pay the top finishers in each class. Because racing can be profitable to the top athletes, many racers take training very seriously.

Marty Morse and Adam Bleakney[37] from the University of Illinois have collaborated to write a series of exercise training articles for wheelchair athletes for the magazine *Sports'n Spokes*. One article in particular describes training methods for the wheelchair marathon. They describe wheelchair marathons as a series of sprints run off a steady pace. Successful training is therefore built around speed development. It presents drills for five areas of training for improved marathon performance. Each is based on the goals of developing maximal speed, acceleration, and the ability to sustain a high percentage of maximal speed for an extended period of time.

Basketball

Wheelchair basketball began in the 1940s because of interest among veterans to pursue sports and recreational activities.[38] Qualification tournaments are held before the Paralympic Games. Wheelchair users comprise the basketball team and have various diagnoses, including paraplegia, cerebral palsy, amputations, postpolio syndrome, or a disabling injury. Participants in wheelchair basketball are not required to use a wheelchair as their primary means of mobility or in their activities of daily living. Athletes compete on a court for 40 minutes with the same dimension and hoop height as specified by the International Basketball Federation.[39]

The player classification system used in wheelchair basketball covers each player and is based on his observed trunk movement during performance of basketball skills such as pushing the wheelchair, dribbling, passing, receiving, shooting, and rebounding. Point classes are 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, and 4.5 with each player assuming a point

value equal to his classification. A 1.0 player is on the lowest end of relative function and is equivalent to that of a mid to upper thoracic SCI. A 4.5 point value would indicate a great degree of relative function (e.g., a sacral-level SCI or single leg amputee). The point values of the five participating players are combined to yield a team total. For International Wheelchair Basketball Federation world championships, Paralympic competitions, zonal championships, and the qualifying events leading up to these competitions, this team total may not exceed 14 points. The starting team and all subsequent player combinations by substitutions may not exceed this 14-point total. Each player is issued a player classification card that must be used during team play. The card indicates both the player's classification and describes any modifications to sitting position, the player's use of straps, and orthotic and prosthetic devices.

The varying degrees of disability among players require that they follow a basic rule of remaining firmly seated in the wheelchair at all times and not using a functional leg or leg stump for physical advantage over an opponent—a rule that is strictly enforced. An infraction of this rule during rebound or jump ball constitutes a physical advantage foul and is recorded in the official score book. Three such fouls disqualify a player from the game. Two free throws are awarded and the ball is given to the opposing team out of bounds. Additional rules of the game include (1) a player in possession of the ball may not push more than twice in succession with one or both hands in either direction without tapping the ball to the floor and (2) taking more than two consecutive pushes constitutes a traveling violation.

A player may, however, wheel the chair and dribble the ball simultaneously just as an able-bodied player runs and dribbles the ball simultaneously. There is no double dribble violation in wheelchair basketball. Furthermore, a player may remain within the opponents' restricted area (key) for no longer than 3 seconds. Staying in the area for a longer time will result in a 3-second violation. This restriction does not apply while the ball is in the air during a shot, during a rebound, or while the ball is dead.[40]

The type of wheelchair used in basketball is similar to an individual's personal wheelchair but incorporates other features that enhance its maneuverability.[4, and 41,] Basketball wheelchairs are designed to be lightweight to allow for speed, acceleration, and quick braking (Figure 19-5). Although basketball is not a contact sport, some incidental contact is inevitable. Consequently, basketball wheelchairs use spoke guards to cover the rear wheel spokes to prevent wheel damage and illegal ramming and picking from the opposition. Made of high-impact plastic, spoke guards provide several additional benefits: they make it easier for players to pick up the ball from the floor by pushing it against the spoke guard and rolling it onto the lap; they protect hands and fingers from aggressive play when reaching for the ball; and they provide space to identify team affiliations and sponsor names.

FIGURE 19-5.
Basketball wheelchairs are designed to provide optimal speed, acceleration, and quick braking, as well as protect the player and chair from contact injuries.
(Courtesy PVA Publications, Phoenix, Ariz.)

Figure options

The wheelchair must have four wheels, two large rear wheels and two front casters for front steering. The front casters tend to be made from extremely hard plastics, similar to in-line skate wheels, with precision roller bearings and are 5 cm in diameter. The rear wheels can be no large than 66 cm in diameter, and there must be a hand rim on each wheel. The seat height is limited to 53 cm from the floor, and the footrest should be no higher than 11 cm when the front wheels are in their forward movement position. In addition, players use high-pressure tires (i.e., 120 to 200 psi) with minimal or very low profile tread to maximize speed and maneuverability. High-pressure tires make it easier to push the wheelchair and help to make it faster on the court.

The footrest must also be designed to avoid damage to the playing surface. A cushion may be used, if it is made of flexible material and is no more than 10 cm thick, unless the player is classified as a 3.5-, 4.0-, or 4.5-point player, in which case it must be no thicker than 5 cm. The cushion must be the same size as the seat of the wheelchair. No black tires, gears, breaks, or steering devices are allowed on the chair. Camber is an important feature of basketball wheelchairs as well. Camber makes a wheelchair more responsive during turns and protects players' hands when two wheelchairs collide from the sides by limiting the collision to the bottom of the wheels and leaving a space at the top to protect the hands.[4]

Basketball wheelchair seats typically have a drop or seat bucketing of 5 to 15 degrees. Because basketball rules limit the maximum height of any portion of the seat, athletes usually try to make their seats as high as possible. Guards are an exception because lower seat heights and greater seat angles can make chairs faster and more maneuverable for ball handling. Referees check the players' wheelchairs before each game to ensure they meet these requirements.

Cycling

Adaptive cycling allows an individual living with SCI to enjoy a form of exercise and recreational activity that has traditionally been a popular form of leisure as well. It is one of the fastest growing recreational activities for people

with disabilities. The adaptive equipment consists of a handcycle that allows individuals with limited use of their lower limbs to use the strength of their upper limbs.[42, and 43.] Relatively minimal modifications can be implemented to accommodate individuals with lower-level tetraplegia. Some of these modifications include hand cuffs that can be mounted to the arm crank handles and elastic abdominal binders that can be fitted around the user and the handcycle seat to increase trunk stability. A handcycle typically consists of a three-wheel setup to achieve the balance that a two-wheeled bicycle requires to function. Two-wheeled handcycles do exist but require a great deal of skill and balance. In addition, handcycle design allows the user to propel, steer, break, and change gears, all with the upper limbs and trunk.

Two types of handcycle designs are typical: upright and recumbent models. In an upright handcycle, the rider is in an upright position similar to a wheelchair. Upright handcycles use a pivot steer where only the front wheel turns while the cycle remains in an upright position. Transferring and balancing tend to be easier in the upright cycle. In a recumbent handcycle, the rider's torso may be reclined with legs positioned forward. These cycles may be lean-to-steer handcycles, where the rider leans to turn, causing the cycle to pivot at hinge points. Leaning to turn can be challenging if the rider lacks trunk stability, in which case it is better to use a pivot steering recumbent handcycle. Recumbent handcycles are lighter and faster, making them the choice for handcycle racing.

Fencing

Wheelchair users participate in fencing with their wheelchair secured to the floor to allow for safe, free movement of the upper body.[44] The sport consists of male and female athletes, with male athletes competing in the epee, foil, and saber, whereas women athletes participate in the epee and foil only. The foil has a flexible rectangular blade, approximately 35 inches in length, weighing less than 1 pound. The epee is similar in length to the foil, but is heavier, weighing approximately 27 ounces, with a larger guard and a much stiffer blade. The saber is the modern version of the slashing cavalry sword and is similar in length and weight to the foil.

Individuals participating in fencing are arranged into five functional classes that range from C5 to C6 level to sacral level. Individuals with high-level SCI may use bandages to fix the weapon to the hand if they lack sufficient grip strength. In terms of equipment, fencers compete from their wheelchairs, fixed into a fencing that is firmly attached to the ground. The frame positions athletes opposite one another at an angle 110 ± 2 degrees to a central axis bar connecting opponents. The inside front caster wheel of each athlete must be touching the central axis bar in the forward direction, and the wheelchairs are secured to ensure they do not move. The wheelchair back must be set at a 90-degree angle and the back height must be a minimum of 15 cm from the seat or seat cushion, which must have even thickness rather than be wedge-shaped. Fencers may use an armrest that is a minimum of 10 cm from the seat height, but only on the nonfencing arm side.

Protective clothing is mandatory and specific to the weapon being used. Protective gear includes protective plastrons, metallic jackets, lame apron, and hand protection (Figure 19-6). Fencers score points by hitting their target, which includes the whole of the upper body for the epee and saber. The saber also includes a lower target area, which includes any part of the body above a horizontal line drawn between the top of the folds formed by the thighs and the trunk of the fencer. Any portion of the chair or cushion above this line is also included in the target area.

FIGURE 19-6.
In fencing, protective clothing is mandatory and specific to the weapon being used.
(Courtesy PVA Publications, Phoenix, Ariz.)

Figure options

The main objective of wheelchair fencing is for the first fencer to score 15 points (direct elimination) or 5 points (preliminary pool play) against the opponent. A point is awarded each time a fencer touches the opponent in the target area and direct elimination matches consist of three 3-minute periods.[44] Team events are composed of both male and female athletes who compete in the epee and foil. In addition, athletes are restricted to a maximum of two different weapons per event in the individual and team competitions.

Fishing

Fishing is an activity that can be adapted to meet the needs of a wide range of SCI levels. Many individuals prefer to transfer and fish from a boat while others may choose to fish from their wheelchairs. Fishing equipment can be hand-held or mounted to power and manual wheelchairs. In addition, there are numerous companies that sell adapted equipment designed to compensate for hand and upper limb weakness. Some of these devices include one-handed reel designs, knot ties, and rod holders.[45]

Football

Wheelchair football is played with manual chairs, power chairs, or scooters and typically requires five to fourteen players to hold a game. Players can use a standard football and may elect to wear protective equipment including bicycle helmets, eyewear, and gloves. Because of the equipment requirements, wheelchair football is played on a hard surface such as a gymnasium or parking lot. The game is considered touch football, but the players can decide on the level of contact before the game begins. This sport, like most team sports, uses a functional player classification system.[46]

Golf

Golf has become a popular sport for many active individuals living with an SCI. Consequently there are many assistive devices on the market that enable golfers with disabilities to play the game. These include golf clubs designed specifically to be swung from a seated position, mobility devices, gripping aids, practice facility equipment such as automated ball teeing devices, and ball retrieval aids. In addition, the Americans with Disabilities Act has allowed individuals with disabilities greater access to a wide range of recreational opportunities including golf courses. A number of golf associations also exist in the United States and internationally with the sole purpose of support for and

to provide information to golfers playing with disabilities. Some of these organizations include the United States Golf Association, the Resource Center for Individuals with Disabilities, and the National Alliance for Accessible Golf.

Horseback Riding

Depending on the rider's ambition, horseback riding offers many opportunities as both a recreational sport and a therapeutic activity. As a sport, it provides the rider with the opportunity to master skills necessary to confidently maneuver a horse through various outdoor courses and terrain. Adaptive riding equipment is available in the form of modified saddles and positioning devices, designed to provide additional support and stability of the rider when on the horse. Mechanical lifts are also available to assist individuals with physical disabilities to safely mount the horse. Therapeutic riding involves teaching a rider the necessary skills and techniques to ride a horse as independently as possible and facilitates confidence and positive self-esteem through acquisition of these skills. Hippotherapy, a division of therapeutic riding, uses the rhythmical and repetitive movement of the horse (similar to human movement patterns of the pelvis when walking) and the body's natural tendency to adjust to this movement to focus on developing balance, body awareness, posture, coordination, and muscle tone in the rider. The North American Riding for the Handicapped Association (NARHA) is a nonprofit organization that promotes safe therapeutic riding for individuals with disabilities. The organization provides accreditation to therapeutic horseback riding centers in the United States to ensure that standards are established and maintained. Currently, the NARHA has more than 600 centers across the United States and more than 30,000 people with disabilities participate in their programs.

Off-Road Downhill

A variety of outdoor adventure activities exist for individuals with SCI. Ultimately, any individual interested in hiking, camping, or off-road navigation can do so with adaptations to the basic everyday manual and power wheelchairs. Mountain bike tires and other related off-road technologies allow for increased traction on soft, wet, or rough terrain. In addition, front casters have become larger to decrease rolling resistance, which reduces the likelihood of getting caught on obstacles.

In recent years additional highly specialized off-road wheelchairs have been developed by enthusiasts and engineers in the field (see Figure 11-40). Some of these wheelchair designs have independent wheel suspension and configurations that allow athletes to compete side by side with mountain bikers in dual slalom and downhill events, reaching speeds in excess of 50 miles per hour.[47]

Paddle Sports

Kayaking, canoeing, and rowing are sports that individuals with mobility impairments can participate in along with unimpaired individuals. Family and friends can benefit from this challenging exercise because it is safe and affordable and can be accessed in many different places. There are several ways for an individual with SCI to participate in paddling. Kayaks and canoes can accommodate a wide range of SCI levels using common adaptations for balance, kayak exit and entry, grip options for paddles, and overall kayak stability with use of outriggers. For individuals requiring more assistance, tandem kayaks are available. A paddling partner or instructor seated in the stern of tandem kayaks can help with steering and paddling when necessary. This type of kayak benefits beginners, individuals with limited paddling strength, and those with a variety of other impairments.

Power Lifting

Athletes competing in power lifting, which include the bench press and power lift, are classified by weight rather than by disability; hence, it is considered a cross-disability sport.[48] Athletes, however, must have at least 10% loss of function of their lower limbs to be eligible. All competitors lift against athletes in their weight class, which may include individuals with paralysis, lower limb amputations, or cerebral palsy. Regardless of the disability, athletes are

required to have a maximum loss of 20 degrees of full extension in either elbow.[48] People with limitations of extension of joints require special approval from the classification officials to compete.

A lifter may be strapped to the bench with an official belt that is 10 cm wide. A competitor may wear a leather belt not exceeding 120 mm at its widest part with a thickness not exceeding 13 mm. The belt may not have any additional padding, bracing, or supports, leather or metal, either interior or exterior. The belt may be laminated, however, providing that each section of the leather is of the same width and extends the full length of the belt and it must be worn over the athlete's lifting costume.

Lifts are carried out on a square area measuring four meters on each side. If the lower part of the bench is too narrow for the lifter's legs, because of anatomical deformities, the referees may use a piece of wood to increase the width of the lower part of the bench, but only with agreement from an official jury. Any additional strapping used for support is allowed only on the legs, around the ankles, or just above the knees. For the bench press, the bar is lowered horizontally until it is 2.5 cm above the lifter's chest. The measurement must be made with a measuring stick 2.5 cm wide and 30 cm long. For the power lift, the lifter must lower the bar to his chest. Once the bar is motionless on the lifter's chest, the lifter presses upward to straight-arm length and holds the bar motionless until signaled a fair lift by the referee.[48]

Power Soccer

Indoor wheelchair soccer is a fast-paced game that can be played by individuals using primarily power wheelchairs. The sport is usually played inside in a gymnasium on a regulation basketball court although occasionally there are outdoor parking lot competitions (Figure 19-7). Many of the same skills required for wheelchair basketball are used in wheelchair soccer, such as quick movement, passing, dribbling, and shooting. In wheelchair soccer, a player may use hands, feet, or the wheelchair to move the ball. Team makeup is dependent on factors such as age, functional ability, and years of experience. Power soccer is a team sport played by individuals with various disabilities. It is unisex by design, and male and female participants are often on the same team.

FIGURE 19-7.
Power soccer is a fast-paced game played by individuals primarily using power wheelchairs on a smooth interior court.

The game's objective is to outscore the opponents by driving an oversized soccer ball (diameter 50 cm, pressure equal to 0.6 to 1.1 atmosphere) across the opposing team's goal line. A goal is scored when the ball passes over the goal line between the goal panels. If the ball crosses the line as a direct result of a drop ball or a kick-in, however, it is not considered a goal. Foot guards are temporarily attached to chairs to help in controlling the ball and to prevent damage to wheelchairs. There are restrictions on the number and speed of electric wheelchairs (EW) used by the players: a

maximum 2 EWs with a top speed of 6 km/h or a maximum 4 EWs with a top speed of 4.5 km/h. A team may use a combination of EWs during a match.

The game is similar to the nonstop action seen in a typical indoor soccer game. The match is played by two teams, with no more than four players on the court at any time. There is no goalkeeper. The match consists of two halves of 20 minutes each, with a 10-minute half-time break. If the scores are equal at the game's completion, the match is decided by extra time and eventually a penalty shootout if the scores are still drawn. A successful team uses court position, blocking, picking, and keeping the ball in the opponents' half.[49]

Rock Climbing

Rock climbing is an adventure sport that has attracted a significant number of individuals with SCI. Climbers can enjoy indoor rock climbing gyms as well as large-scale mountain expeditions. Climbing harnesses and other equipment have been designed to maximize upper limb efficiency while climbing; ascending gear tends to be extremely supportive and keeps a climber's body upright. Notable climbers with disabilities have successfully completed climbs at Mt. Rainier and Mt. McKinley, among other challenging heights.

Rugby

Quad rugby was originally called murder ball because of the aggressive nature of the game. Brad Mikkelsen teamed up with University of North Dakota's Disabled Student Services to create the first team, called the Wallbangers, and ultimately introduced rugby to the United States in 1981. In 1988, the United States Quad Rugby Association was formed to regulate and promote the sport on both national and international levels. Since its introduction, rugby has grown to become an international sport, with teams from around the world. Currently there are more than 45 organized teams in the United States with many new teams surfacing each year. Rugby first joined the Paralympics in 1996 as a demonstration event and then officially as a full medal sport at the 2000 Sydney Paralympic Games.

Players must have a combination of upper and lower limb impairment to be considered eligible to participate. Most of the players have sustained cervical-level spinal injuries and have some degree of tetraplegia as a result. Players are given a classification number, similar to basketball, based on a system that contains seven distinct classifications ranging from 0.5 to 3.5. A 0.5 player has the greatest impairment and is comparable to someone with C5 tetraplegia. Of those eligible to participate, the 3.5 player has the least impairment (i.e., C7 to C8 incomplete tetraplegia). Both men and women are encouraged to play and, because of the classification process, sex advantages are minimal. In addition, a team may have players with no more than a combined eight points out on a floor at any one time.

Played indoors, the game consists of two teams composed of four players—male or female (Figure 19-8). The objective of wheelchair rugby is for the players to cross the opponent's goal line (i.e., two wheels must cross the goal) while the player has possession of the ball. At the same time that the team on offense is trying to advance the ball, the defense tries to halt their progress by creating turnovers. When a player is in possession of the ball, he must bounce the ball every 10 seconds and a team must get the ball across midline in 15 seconds or less. In addition, certain restrictions apply in the key area. Three defensive players are allowed in the key, and if a fourth enters, a penalty can be assessed or a goal awarded. An offensive player can only stay in the key area for 10 seconds or a turnover is awarded.[50]

FIGURE 19-8.
Quad rugby is a fast, rigorous game played indoors with two teams consisting of four players each.

Players tend to use extreme wheelchair configurations, elastic binders, foams, and special tacky gloves to improve performance. Similar to basketball, players often become extremely proficient in adapting their equipment to promote balance and speed, so much so that they often appear to possess significantly more functional capacity then their neurological injury level would indicate. The styles of wheelchairs used in rugby are strictly regulated to ensure fairness, but the chairs vary considerably depending on each player's preference, functional level, and team role. Players with the most extreme upper body deficits tend to take on more defensive blocking and picking roles and use chairs that have additional length and hardware that enables them to grab other players' chairs.

Players with more functional ability usually take on the role of ball handler and use offensive chairs built more for scoring, which requires speed and quick maneuverability (Figure 19-9). In addition, many ball handlers' chairs are designed to deflect or slide off other chairs to minimize the likelihood of getting caught up or stopped in a tangle of chairs. Regardless of functional abilities and classification, all rugby chairs have extreme amounts of camber, 16 to 20 degrees, significant bucketing, and antitip bars. The camber provides lateral stability, hand protection, and ease in turning. The bucketing (i.e., knees are high relative to rear end) helps with trunk balance and protection of the ball.

FIGURE 19-9.
A rugby player maneuvers his fast, offensive-style chair especially built for scoring.

Sailing

Sailing consists of two classes: single-handed and crew boat (i.e., Sonar boats). The single-handed class consists of the sailor facing forward in the boat, with all controls accessible within an arm's reach. Sailors competing in crew are assigned a point classification based on their disability. Three individual sailors, with varying levels of disabilities,

comprise the Sonar crew. The team must be composed of individuals not exceeding a total set point value similar to that of rugby and basketball. Sailors with disabilities are able to add adaptive seating or assistive arrangements to the boat provided they are temporary fixtures and are approved before the event. Furthermore, the large cockpit and balanced inboard rudder add stability to the boat, making the sport ideal for individuals with a variety of disabilities.[51] Paralympic sailing is offered for athletes with physical disabilities and for those with vision loss. The International Paralympic Committee (IPC) follows the classification procedures developed by the International Foundation of Disabled Sailing, which are posted on the IPC website at www.paralympic.org. Classification tests for sailors with physical disabilities are designed to test the athlete's ability to compensate for the movement of the boat (stability), operate the control lines and tiller (hand function), move about in the boat (mobility), and see while racing (vision). Athletes who use prostheses or supportive devices while sailing must be classified under those conditions. During functional anatomical testing, performed in a room equipped with an examination table, athletes are judged on strength, movement, and coordination. During functional dock tests, performed on a Sonar boat at dockside, athletes are tested on tiller, sheeting, cleating, transferring, and hiking. The same tests also are performed during functional sailing tests in competition.[52]

There are seven classifications, with class 1 representing the least sailing ability and class 7, the most sailing ability. Sailors are assigned to different classes on the basis of their point scores in the classification tests. Each crew is allowed a maximum of 14 rating points. No sailing advantage is given to a crew with a total of less than 14 points. When sailors present themselves for classification, they are required to bring all their personal assistive devices, adaptations, prostheses, and orthotics that they intend to use during racing. Additional devices could include seating support, harnesses, and any other essential adaptations. Seats allow the sailors to position themselves so they can control the tiller and sheet without fear of falling. Seats can be as basic as a lawn chair modified to fit a cockpit or as complex as a translating seat, which allows a sailor to switch sides of the boat. Sailors often use transfer benches as well which allow them to switch sides when tacking or jibbing; these seats can be anything from a sturdy cooler in the middle of the cockpit (i.e., custom cockpit filler) to platforms that fill in the cockpit area. Boat modifications may not include any requiring drilling holes or installation of permanent fixtures. Any modifications to the sail may not raise more than 20 cm above the existing seat, increase the sailor's performance beyond that of an able-bodied person, be power assisted, or be judged unsafe. Boats must be equipped with radios for boat-to-boat and boat-to-shore communication. In addition, athletes must wear personal flotation devices. Support and rescue boats are required during all events and at least one boat must have a scuba (*s*elf-*c*ontained *u*nderwater *b*reathing *a*pparatus) diver available to assist with rescues. [52]

The Paralympics includes both the crew boat discipline with one skipper and two crew members and the single-handed discipline. The racing rules, including course specifications, are posted on the International Sailing Federation (ISAF) Web site at www.sailing.org. Boats used in the crew boat discipline include the American 210, Sonar, Squib, Surprise, or UFO. The boat used in the single-handed discipline is the International 2.4mR. Modifications to ISAF rules competition consists of a four-race series with points awarded for place finish in each race. Points are accumulated across races, with the low score winning the regatta.

SCUBA

Many individuals with a range of SCI levels participate in underwater activities. The Handicapped Scuba Association certifies individuals with disabilities and has established specific regulations indicating the level of support a disabled diver will need to dive. The extent of support a diver requires is largely a function of injury level and diving experience. Most individuals diving with disabilities, however, enjoy great freedom from the reduced effects of gravity when under water. Many disabled divers increase their abilities using equipment like webbed diving gloves for extra push and a special buoyancy compensator for a more comfortable dive.[53]

Shooting Sports

Shooting events are comprised of free and supported rifle and free pistol, both air and .22 caliber, shooting at distances from 10 to 50 m. Competition occurs in the form of individual men and women as well as mixed and team events; however, team competitions are not included in the Paralympic Games. Competitors are permitted to use assistive devices in an attempt to create equal competition among the athletes with different functional abilities. Depending on an individual's level of SCI, athletes may use various forms of approved assistance. Some of these supports include a specially prescribed stand used to support the weight of a rifle, a shooting table, or a person who assists the competitor to cock and load the gun and exchange shooting targets where necessary. Competitors with tetraplegia or paraplegia may not strap themselves to the chair to increase trunk stability for shooting. They may strap their knees together only if they have sought and received approval during their classification. The height of the wheelchair or chair back and push handles must be at least 30 mm below the armpits when the shoulders are in the resting position. The scapula, arms, or armpits cannot derive horizontal support from or rest on any part of the wheelchair. The use of wheelchair armrests or chair sides is not permitted during competition unless specifically authorized by the classification team. No part of the chair or competitor that touches the floor may be in front of the firing line.[54]

Skiing

Skiing is both a recreational and competitive sport. There are several options for snow skiers to choose from: alpine, downhill skiing, Nordic, cross-country, and sit-skiing with monoski or bi-ski configurations. Assistive devices such as adaptive seating, backrests, cushions, tethering ropes, roll bars, and outriggers allow skiers with disabilities to maintain a similar pace to that of unimpaired athletes. When an athlete is learning to ski, a guide can be used to assist new skiers down the slopes for direction and safety. Various types of sit-skis in combination with outriggers exist, offering a skier with a disability more or less support and stability when needed. Monoskis and bi-skis have become quite advanced and offer shock absorption systems, frames molded to body shape, and quick-release safety options. The outriggers that skiers use are an adapted version of a forearm crutch and a shortened ski. Outriggers provide extra balance and steering maneuverability not available from a typical ski pole.[55] In addition, many sit-skis, whether monoskis or bi-skis, have loading mechanisms, usually hydraulic, that enable an athlete to jack himself up into a high position for loading onto a ski lift. Many athletes can load onto lifts independently, whereas others may require assistance, depending on experience and level of SCI.

The monoski is typically the ski of choice for individuals wanting high-end performance, maneuverability, and speed. When using a monoski, the individual sits relatively high over the snow on one ski and can translate upper body, arm, and head movement into the ski more efficiently than with the bi-ski system. The monoski's sensitivity can make it more challenging to learn, particularly for individuals with less trunk control, upper thoracic and above injuries, and for novices hitting the slopes occasionally. Because of the dynamic nature and sensitivity of the monoski, there are some inherent risks. While athletes are moving at high speeds and balancing over the single ski, serious falls can occur. When falls happen, the mass of the equipment and body can translate through the shoulders, head, or neck, causing severe injury.[56]Experienced monoskiers can match the speeds and handle technical terrain with the same facility that experienced able-bodied downhill skiers demonstrate; however, sit-skiing biomechanics put different strains on the body. Research has found that the stress on the monoskiers' upper bodies occurring from normal skiing was three times that of stress occurring in the upper bodies of downhill skiers who stand.[56]Sit-skiing involves an elevated isometric muscle contraction component because the upper limbs must balance the entire body with outriggers.[56] Furthermore, other disabled skiing research has compared the incidence of injuries occurring in monoskiing with the incidences of injury occurring in other sports. Laskowski and Paul[57] compared the incidence of emergency department visits over a 4-year period and found that injury rates were not significantly different. Fractures and sprain incidence were nearly identical; the only category of injury found to be more frequent in sit-skiing was noticed in the bruise category, showing 18% of disabled compared with 11% of nondisabled skiers, respectively.[57] For skiing novices or individuals with less trunk stability seeking the freedom and excitement of skiing, bi-skis can serve as an appropriate alternative. Bi-skis are similar to monoskis but the user balances on two skis that can angulate

and shift to put the skis on edge. Bi-skis are much easier to control because they have a wider base of support and can be mastered more quickly with fewer falls.

Cross-country skiing, also called Nordic skiing, uses sit-ski technology as well. The Nordic sit-ski is composed of a seat balanced over a frame with two cross-country skis approximately 12 inches apart. Because cross-country skiing requires great strength and cardiovascular fitness, many wheelchair athletes find it to be a great cross-training application for sports such as racing and handcycling.

Sledge Hockey

Sledge hockey derives its name from the Norwegian word *sledge*, which means sled, and is referred to as sled hockey in some parts of Canada and the United States. Ice sled hockey was invented at a Stockholm, Sweden, rehabilitation center in the early 1960s by a group who, despite their physical impairments, wanted to continue playing hockey. [58] The ice surface, goal net, and pucks are all the same, and all U.S. hockey rules apply with some necessary adaptations resulting from the nature of the game and its participants.

The equipment used in the game consists of the sledge—a metal-framed oval sled with two blades and a small runner, a seat with a backrest, leg straps, and optional push handles The traditional hockey stick is shortened and modified with two picks attached to the end (i.e., metal pieces with a minimum of three teeth measuring a maximum of 4 mm).[59] The picks are used to provide traction while the player moves down the ice and also give leverage for the player to shoot the puck with the blade end of the stick. A player may secure his hands to the stick if his grip is not solid. Two-blade sledges that allow the puck to pass underneath replace skates, and the players use sticks with a spike-end and a blade-end. The chair backrest cannot protrude laterally beyond the armpits of the player when properly seated on the sledge, although it may be padded and should have rounded edges and corners with no hard or sharp obtrusions to the sides.

With a quick flip of the wrist, players are able to propel themselves using the spikes and then play the puck using the blade-end of the sticks. A player may use two sticks with blades to facilitate stick handling and ambidextrous shooting. Sticks are made of wood or other material approved by the International Ice Hockey Federation, such as aluminum or plastic. The stick must not have any projections and all edges must be beveled. The dimensions of the stick are as follows: maximum length 100 cm measured in a straight line from the toe to the pick end, maximum width 3 cm, maximum thickness 2.5 cm. The shaft must be straight and the blade's maximum length only 32 cm from the heel to the toe and have a width between 5 to 7.5 cm at the toe (i.e., front of the blade). A goalkeeper's stick may be equipped with a larger blade that must not exceed 35 cm in length and 9 cm in height.

Sledge hockey games consist of three 15-minute stop-time periods. Protective gear must be worn at all times and includes a helmet with cage or shield, shin guards, shoulder pads, gloves, elbow pads, neck guard, and hockey pants. In addition, straps are used to secure a player's feet, ankles, knees, and hips to the sledge. Repeated loss of straps or adjustments on ice causing delay of game is penalized accordingly. There are six players on the ice at a time for each team: one goalie, three forwards, and two defense players. Sledge hockey is unique because it does not have a classification system; its only requirement states that a player must have a disability that would prevent him from playing able-bodied hockey.

Snowmobiling

Snowmobiles can be accessible to wheelchair users with use of hand controls rather than foot pedals to operate the vehicle. A rider should have good upper body strength and dependable hand control. Equipment modifications can include seat adjustments, other equipment relevant to the person's disability, and the attachment of looped rubber tubing to the foot platform to maintain the lower limbs in correct positions. Warm, layered clothing for individuals

with poor or limited circulation in the lower limbs is advised. Snowmobiling is an easy way of being out in the outdoors and crisp winter air. The general features of snowmobiles are similar to wheelchairs: seat height, hand controls, no foot pedals or foot-activated controls. Selection of equipment is based on an individual's specific disability.

Softball

Wheelchair softball was designed to allow individuals with a physical disability to play a game similar to traditional softball and abides by the Amateur Softball Association of America's (ASAA) official rules for 16-inch slow pitch. Ten individuals play per team and, as in rugby and basketball, players are classified on the basis of functional abilities and only a specified quantity can legally be active on the playing field at one time. The playing field is a hard surface allowing for easier maneuverability of the wheelchairs to preserve the pace of the game. Individuals with tetraplegia can also be integrated into play because of the point classification system. Players with upper limb impairments are allowed more freedom for bat, grip, and glove alterations.

The official rules of the National Wheelchair Softball Association[59] do allow for some exceptions to the ASAA rules geared toward the wheelchair user. All participants must use manual wheelchairs with footplates, and the playing field must be a level smooth surface of blacktop or similar materials with 150 feet on the foul lines and 180 to 220 feet to straight center. The official diamond has 50 feet between all bases and 70 feet, 8.5 inches from home to second base (Figure 19-10). The base runner must be seated in his wheelchair and may tag or make contact with the base with either one or more wheels or his hand. If a runner is knocked out of his chair, he may proceed to the previous or next base by any means other than hopping, walking, or running and make contact with the base with any part of his body. A base runner may not place a lower limb on the ground or someone else's chair to stop his chair and if he does, the play is dead, resulting in a delay-dead ball situation.

FIGURE 19-10.
Wheelchair softball uses the official Amateur Softball Association of America's rules as its guide for indoor play with a diamond that has 50 feet between bases.

Figure options

All teams are required to have an individual with tetraplegia on their team in active play. Players with tetraplegia may alter the bat to improve the grip; however, alterations must be approved by the head umpire. If a team does not have someone with tetraplegia playing, the team is required to play with one less person on the field (i.e., nine rather than ten players). When a player is at bat there are rules set in place to prevent individuals with some lower limb movement from having unfair advantage. For example, a hitter cannot have a lower limb in contact with the ground when hitting. This action could help the batter unfairly stabilize himself. If this does occur, the batter is declared automatically out. A player's classification ranges from 1 to 3 points on the basis of his functional level. Someone with tetraplegia would receive a 1-point class and someone who has high functioning paraplegia (e.g., a low-level injury) would receive a 3-point class. A team of ten players may not exceed a total of 22 points.[59]

Swimming

The swimming events that take place at the Paralympic level include freestyle (50 to 1500 meter), backstroke (50 to 200 meter), breaststroke (50 to 200 meter), butterfly (50 to 200 meter), individual medley (150 and 400 meter), and relay events (4 × 50 meter free, 4 × 200 meter free, 4 × 50 meter medley, 4 × 100 meter medley). Athletes are classified and compete against others on the basis of how they move in the water with their hands, arms, trunk, and legs, which ultimately affects how starts and turns are performed. The level of an individual's SCI directly affects the types of strokes that he can perform. Stroke adaptations are permitted and specified within each stroke category and applied to swimmers' functional abilities, which are in turn indicated by swimmers' classifications. For example, in breast stroke competition swimmers may start in the water, off the side, or off the blocks. After the signal to start is given, one asymmetrical stroke is permitted to allow the swimmer to attain the breast position. Swimmers in specified classes may roll over on their backs to breathe but no attempts at forward propulsion are allowed. As an adaptation, swimmers who have completed their laps in relay races who are unable to immediately leave the water may stay in the water in an unused lane as long as they do not interfere with the other competitors or with timing equipment.[60]

Table Tennis

Table tennis can be played effectively with a power chair, a scooter, or a manual wheelchair. Standard four-wheel manual chairs are permitted; however, they are not as mobile as the three-wheeled chairs designed for tennis (i.e., with a minimum of two large wheels and one small wheel). In competition, men and woman can play individually and in teams. In addition, a wheelchair user is not permitted to strap any part of the body to the wheelchair unless medically necessary. For wheelchair play, the playing area may be reduced but should not be less than 8 meters long and 7 meters wide.

Disabled table tennis players are divided into 10 classes according to a functional classification system. Classes 1 to 5 compete in wheelchairs and classes 6 to 10 play standing. Activity mitts and Velcro straps can be used to secure the racket to the hand for participants with reduced hand function. When the ball is in play, the player may use the playing surface to restore his balance only after a shot has been played. In addition, when playing in a wheelchair, his feet are not permitted to touch the floor at any time during play. Players or teams score a point if the footrest or foot of an opponent touches the floor during play.[61] The game's objective is to use a hand-held paddle to pass the ball over a net onto the opponent's side of the table in a manner that prohibits the ball from being returned by the opponent. The game is played to 21 points, and a player must win by 2 points. A match is considered the best three of five games.

Tennis

Men and women who compete in singles and doubles tennis are required to use a wheelchair that is based on their having a diagnosis of a permanent mobility-related physical disability. Tennis is played on a court of the same size and net height as traditional tennis. Unlike traditional tennis, however, the ball is permitted two bounces on the court before it is returned. The same rules that apply to the athlete also apply equally to the wheelchair as a part of the body. Brakes are not permissible as stabilizers, and the athlete must keep one buttock in contact with the seat while hitting the ball (Figure 19-11).

FIGURE 19-11.
Wheelchair tennis is played on a court of the same size and net height as traditional tennis. Even though the ball is permitted two bounces, players must be agile and fast.
(Courtesy PVA Publications, Phoenix, Ariz.)

Tennis players typically use a three-wheeled chair with a large amount of camber to maximize mobility around the court. Players with high-level SCI can play tennis by using a power wheelchair and longer rackets to compensate for length taken up for strapping the racket to the hand. Because players must cover the entire court with speed and agility, the tennis wheelchair is designed to meet these needs. The rear wheels of a tennis wheelchair are typically large at 61- to 66-cm diameter; they use high-pressure tires (i.e., 120 to 200 psi) to lower the chair's rolling resistance on the court and to increase speed; a single front caster is 5 cm in diameter, which makes the chair light and more maneuverable. The rear wheels are cambered to increase lateral stability during lateral shots and to make the chair turn faster. Tennis players, like rugby players, use a steep seat angle or dump, which helps keep them against the seat backs and gives them greater control over the wheelchair while also providing greater balance. Their knees tend to be flexed, with the feet on the footrest behind the knees (Figure 19-12). With the body in a relatively compact position, the combined inertia of rider and wheelchair is reduced (e.g., figure skaters bringing their arms in to spin faster) and makes the chair more maneuverable.[34, and 62.]

FIGURE 19-12.
A tennis player keeps her knees flexed and her feet on the footrest, which is placed behind the knees. Her chair is considered a part of her body and the rules apply to it as well.
(Courtesy PVA Publications, Phoenix, Ariz.)

Many players use chairs that have handles incorporated into the front of the seat, which can assist the player while leaning for a shot. The handles can also help keep players' knees in place when quick directional changes are necessary. In addition, straps can be used around the waist, knees, and ankles, depending on the player's balance. Wheelchair skills important to success in tennis include hand speed, an explosive first push to get to top speed as quickly as possible, quick stopping, and overall wheelchair control to deal with difficult bounces. Some general workout strategies used to develop many of these wheelchair skills include pushing up hills, drills where a player tows another wheelchair user holding on to the back of their chair, court sprints, backward pushing, and traversing cones. For more detailed information regarding wheelchair tennis, the International Wheelchair Tennis Federation has an excellent Web site at www.itfwheelchairtennis.com that provided detailed information and resources on the topic.

Water Skiing

Water skiing is a popular water sport for individuals with SCI. Sit-ski design can incorporate a variety of adaptive features to suit a wide range of user levels. Ski modifications can compensate for trunk instability and hand weakness. Furthermore, some skis can be adjusted vertically, horizontally, and diagonally at the fin, allowing the user to fine-tune his equipment to meet individual skiing styles, user body weights, and varying boat velocities. At the competitive level skiing includes men and women's slalom, tricks, and jumping events.

ORGANIZATIONAL STRUCTURE OF SPORTS FOR PEOPLE WITH SPINAL CORD INJURY

Four major organizations coordinate sports competition for elite athletes active in the U.S. Paralympic movement. These groups are the IPC, the International Olympic Committee (IOC), the U.S. Olympic Committee (USOC), and United States Paralympics.

International Paralympic Committee

The IPC is an international nonprofit organization representing athletes of all sports and disabilities, run by individuals from nearly 160 national Paralympic committees worldwide. The IPC conducts the quadrennial summer and winter Paralympic Games and world and regional championships. The IPC sports committees create the rules of conduct applied to each sport, which include athlete classification rules and regulations, classifier coaching and officials training, and promotion of Paralympic sport worldwide.[63.] and [64.]

International Olympic Committee

A relationship between the IPC and the IOC is essential because the Paralympic games have occurred in the same city and have used the same sporting venues and facilities as the Olympics since 1988.[6.] and [64.] In addition, the sports rules for able-bodied sports established by the international sports federations often serve as the framework for guidelines applied to Paralympic sports. Furthermore, participation and competition for some Paralympic sports often require athletes to be members of particular sports federations.[63.] and [64.]

Role of the U.S. Olympic Committee

The USOC serves as the National Paralympic Committee in the United States and is responsible for a variety of functions. Some of these include coaching, administrator and classifiers training, doping control, athlete development programs, and delegation representation in Paralympic Games and other major international IPC-sanctioned competitions.[63.] and [64.]

Role of U.S. Paralympics

U.S. Paralympics, a division of the USOC, was created in May 2001 to focus efforts on enhancing programs, funding, and the opportunities for individuals with physical disabilities to participate in Paralympic sports.[65] U.S. Paralympics has developed comprehensive and sustainable programs for elite athletes that are integrated into Olympic National Governing Bodies and has functioned as a platform to promote excellence in the lives of people with disabilities. Some of the specific goals of U.S. Paralympics goals promote the enhancement, development, and funding of elite sports competitions for disabled competitors (Box 19-8).

BOX 19-8.
Goals of U.S. Paralympics
Data from the U.S. Paralympics Web site: www.usparalympics.org.

1. Identify Paralympic sports organizations for each of the Paralympic sports. Organizations to be considered for this status include the USOC-member national governing bodies and disability sport organizations and other organizations that can demonstrate the capability to direct a sports program for elite athletes with disabilities.
2. Develop a funding philosophy and secure financial support for Paralympic sports. Unlike the USOC, which is essentially restricted to seeking corporate support, private donations, and grant funding, U.S. Paralympics also has the flexibility to seek financial support from governmental agencies.
3. Facilitate the development of performance plans for each of the Paralympic sports. Performance plans typically include performance goals and plans for athlete identification and development, coach education, sports science support, and policy development.

Because it takes talent, time, and support for any athlete to attain elite level status, National Disabled Sports Organizations (DSOs), a part of the USOC, has been developed to help promote the development of athletes with disabilities. These DSOs offer grass-roots programs for athletes. In the United States six DSOs are involved in the Paralympic movement (Box 19-9). Although the existing DSOs differ in the services they provide to athletes, typical features of these sports programs include athlete development camps, competition, and organization of networks of local clubs offering opportunities for athlete and official education and services.[63]

BOX 19-9.
Disability Sports Organizations

- National Disability Sports Alliance (NDSA)
- U.S. Association of Blind Athletes (USABA)
- Special Olympics International (SOI)
- Wheelchair Sports USA (WSUSA)
- Disabled Sports USA (DSUSA)
- Dwarf Athletic Association of America (DAAA)

Paralympic Competition

Athletes who participate in the Paralympics have the privilege of representing their countries on a worldwide stage. Training for this level of competition takes years and countless hours of dedication. Participating athletes demonstrate athletic feats and a commitment of heart to the competition, which in turn inspires respect and admiration from their audiences and supporters. Sports have shown that SCI does not diminish the human spirit. The Paralympic movement has had a tremendously positive impact on the perceptions of society at large toward people with disabilities.

Athlete Classification Systems

Classification of athletes with disabilities helps to ensure fair competition among those with similar degrees of disability. The idea is to level the playing field for competitors and to allow individuals with similar physical attributes to compete against each other. Therefore it is important that the SCI classification system strives to achieve the following criteria:

- Be fair, with no individual having an edge solely on the basis of classification
- Enhance competition
- Enable individuals at different injury levels to compete on the same field
- Be easy to understand and apply

Because there is no ideal classification system that meets all the above criteria, there is consequently no uniformly accepted system. For example, athletes with SCI competing at the National Veterans Wheelchair Games are classified into seven classes on the basis of each individual's SCI level. Those with tetraplegia are classified into three classes: 1A (C4 to C6), 1B (C7), and 1C (C8); those with paraplegia are classified into four classes: II (T1 to T5), III (T6 to T10), and IV (T11 to L2), V (L3 to S5). The shortcomings of this system are related to their basis on a medical diagnosis confirmed or verified by the athlete's performance during a medical examination. The system fails to account for functional and performance capabilities of athletes with SCI in certain events using specialized sports equipment. In the Paralympics, the largest sports competition for individuals with a variety of disabilities, several different classification schemes govern competition. Classifications evolved from simply assigning an athlete on the basis of type of disability such as blindness, SCI, amputation, and other orthopedic conditions to increasingly complex

classification schemes resulting in a greater number of events that, unfortunately, decreased competition by reducing the number of competitors.[66]

The Paralympics have moved toward a functional classification system based on the athlete's ability to perform in a certain event. Wheelchair basketball is a leader in this movement because the wheelchair acts as an equalizer during the game, and skills in the wheelchair determine competition level.[67] Now classifiers observe a player's functions on the court during competitions and assign classifications on the basis of their observations. Observed trunk movement and stability during actual basketball participation, rather than the player's medical diagnosis or muscle function on an examining table, form the basis for his classification. On the basis of their classification, players are assigned a point value. With teams allowed only a predetermined maximum number on the court, the sum of the point value of all players cannot exceed this predetermined number.

Functional classification has made it harder for individuals with tetraplegia to compete, a situation that led, in part, to the development of wheelchair rugby. There are concerns that functional classification cannot work for all sports and many sports still use complex medical examinations to determine class. As seen in wheelchair basketball, many believe that the use of prosthetics or adaptive equipment may make it easier to combine individuals with different disabilities. Classification schemes currently used by the IPC are too complex for the purposes of this chapter. A full description is available on the IPC Web site: www.paralympic.org.

The Paralympic Games have become more inclusive and more successful over the years despite controversy over its classification system. They include exhibit events that are open and require no classification. Classification systems are anticipated to continue to evolve with time, approaching a more ideal solution.

RESEARCH RELATED TO WHEELCHAIR SPORTS

Research with physically impaired populations in relation to wheelchair sports is sparse. In general, a review of the literature relevant to wheelchair athletes with SCI reveals an emphasis on the biomechanics of wheelchair propulsion specific to wheelchair sports, exercise testing, training techniques, the physiological response to upper body activity, the thermoregulatory response to exercise, the occurrence of upper limb pain, and repetitive strain injury associated with wheelchair propulsion.[4., 29., 41., 68., 69., 70., 71., 72., 73., 74., 75. and 76.] Studies specific to wheelchair sports have included wheelchair racing, basketball, field throwing events, handcycling, upper arm ergometry, and sit-skiing.[12., 77., 78. and 79.] Research examining physiological variables tend to include measures of oxygen consumption, ventilation, heart rate, muscle contraction, electromyelography, and pain.[31., 68., 70., 80., 81., 82., 83., 84. and 85.]

Physiological Research

Some specific and notable physiological findings include the work of Janssen et al,[80] who examined the physical capacity of male handcycle users and demonstrated that peak power output, maximal rate of oxygen consumption, and gross mechanical efficiency were associated with 10K race performance. In addition, multiple researchers have studied the kinematics of racing wheelchair propulsion and its relationship to efficiency. Cooper and Bedi[83] reported that racing wheelchair propulsion has a gross mechanical efficiency over 30%, whereas Cooper[77] later reported that 10K wheelchair racers have a maximum gross efficiency of 35%. These findings indicate elite wheelchair racers are far more efficient than individuals propelling everyday chairs and able-bodied walkers, and above or comparable to runners and bicyclers.[83] Furthermore, research has shown that regular aerobic exercise in combination with strength training is important for all sports at the elite level.[4]

Several studies have measured cardiorespiratory function in wheelchair athletes as well. Van der Woude et al[71] investigated a wide range of athletes with SCI, testing them with a wheelchair ergometric sprint protocol, and reported

oxygen consumption levels and heart rate. Their findings have indicated that performance in propulsion is highly variable across wheelchair athletes and is influenced by level of injury and training hours. Other research has tested road racers and hand cyclists and reported that these activities require a high enough energy expenditure to maintain fitness and to potentially help to prevent cardiovascular diseases even at moderate intensity levels.[84]

In addition to these studies, which have been geared more toward sports-specific applications in elite wheelchair athletes, other findings in the physiological research arena point to the overall health benefits of active lifestyle. Studies have indicated that health benefits associated with exercise in wheelchair athletes does not necessarily put them at increased risk for injury.[85] In fact, a study by Fullerton et al[72] in 2003 found that the odds of having shoulder pain were twice as high among nonwheelchair athletes as they were among athletes. Curtis et al,[86] comparing two groups of individuals with SCI, found that wheelchair athletes had fewer physician visits and a trend toward fewer medical complications and fewer rehospitalizations compared with nonathletes. Sports participation did not lead to increased risk of medical complications and did not limit available time for vocational pursuits. These types of findings are of increased importance to individuals living with SCI because cardiovascular disease has been reported the number one cause of death in individuals surviving more than 30 years after SCI.[87] Research has also shown that sedentary individuals with SCI are far less fit than either their physically active counterparts or the sedentary unimpaired population.[11.] and [88.] Other resources available provide extensive detail on these subjects including work by Cooper et al,[88] who included chapters in their textbooks describing recreation technology and summarizing the benefits of exercise for people with disabilities. Frontera et al[89] have emphasized the importance of exercise physiology for successful rehabilitation, a healthy life after rehabilitation, and social reintegration.

Biomechanical Research

With the exception of wheelchair racing and wheelchair basketball, biomechanical studies related to wheelchair sports are not readily available. The research evaluated wheelchair propulsion during racing and primarily focused on improving physical performance and preventing secondary injury and extensively examined the biomechanics of this activity, especially such measures as segment angular and linear displacements, velocities, and accelerations.[90.] and [91.] More specifically, they studied the kinematics of the upper limbs during wheelchair propulsion to identify the most effective arm stroke pattern. O'Connor et al[92]showed that increased efficiency was related to minimizing head motion, a lower trunk angle, a larger push angle, and higher peak elbow height during recovery. Cooper et al[93] found that there was a maximal economy (i.e., steady-state oxygen consumption) for wheelchair athletes, which was associated with efficient biomechanics and level of fitness.

Generally speaking, literature has shown that the propulsion characteristics of experienced wheelchair athletes are different than those of inexperienced wheelchair users or control subjects. The differences are apparent and have been reported by many researchers. Experienced wheelchair users and athletes tend to push with significantly higher net mechanical efficiency. This efficiency has been quantified and reported by many researchers in a number of ways. Some of these optimal propulsion characteristics influencing efficiency are said to be a function of an individual having greater shoulder and elbow extension angles at initial hand-to-rim contact, maximal time spent in propulsion versus recovery, and lower peak forces reached later in the propulsion cycle maintained for longer periods of time at elevated velocities. Experienced wheelchair users adapt their propulsion technique not by changing their style but by increasing the amplitude of their movements.[93.], [94.], [95.], [96.] and [97.]

In addition to training and experience, the functional potential or the athlete's level of SCI may affect propulsion characteristics and may explain contrasting results in the literature. Stroke pattern changes may be the result of the interaction of many factors including joint injury, muscle imbalance, fatigue, seating and positioning, weight distribution, balancing of the trunk, level of SCI, and the training attained after injury.[98]For example, a study by Dallmeijer et al[99] found that the level of injury of the wheelchair user can affect the orientation of the push angle on the hand rim. Individuals with tetraplegia were found to position their hands more backward relative to top-dead-

center of the wheelchair push rim compared with individuals with paraplegia. Consequently, these elements need to be taken into consideration when biomechanical comparisons are made across heterogeneous groups of athletes with SCI.[94]

Clinical Case Study: Sports and Recreation for Individuals with a Spinal Cord Injury

Patient History

Charlie Tomlinson is a 22-year-old man with T10 paraplegia, ASIA A diagnosis from a diving accident at age 16 years. He currently is a junior in college and is active with wheelchair sports and recreational activities.
Charlie lives with his family in a wheelchair accessible home and has two younger brothers who are 12 and 10 years of age. His primary interest is basketball, which he played before his injury. He has begun training for wheelchair racing. He enjoys winter and summer recreational activities, including skiing, softball, and kayaking.

Patient's Self-Assessment

Charlie wants to live an active life anchored by a range of sport activities. He is open to new activities and continually pushing his physical limits.

Clinical Assessment

Patient Appearance

- Height 6 feet 0 inches, weight 175 pounds, body mass index 23.7

Cognitive Assessment

- Alert, oriented × 3

Cardiopulmonary Assessment

- Blood pressure 116/64 mm Hg, heart rate at rest 76 beats/min, respiratory rate 13 breaths/min, effective (>360 L/min), vital capacity is within normal limits

Musculoskeletal and Neuromuscular Assessment

- Motor assessment reveals T10 ASIA A motor to the T10 level
- Deep tendon reflexes 3+ below the level of lesion

Integumentary and Sensory Assessment

- Skin is intact throughout, sensory intact to T10

Range of Motion Assessment

- Passive and active motion is within normal limits in both upper limbs.
-

Straight leg raise is 105 degrees in both lower limbs and dorsiflexion is 8 degrees; all other motions in the lower limbs are within functional limits.

Mobility and ADL Assessment

- Independent with bed mobility
- Independent in transfers to all surfaces including wheelchair to floor
- Independent with pressure relief
- Independent in manual wheelchair maneuvering on all surfaces
- Independent in high-level wheelchair skills
- Independent in bowel and bladder care
- Independent in dressing
- Independent in driving

Evaluation of Clinical Assessment

Charlie Tomlinson is a 22-year-old man with T10 paraplegia, ASIA A diagnosis. He is active in wheelchair sports and is interested in pursuing wheelchair racing and other recreational activities.

Patient's Care Needs

1. Evaluation and prescription for an exercise arm crank test to assess the appropriate fitness levels
2. Strength testing for strength training prescription
3. Consultation for sports and recreation activities
4. Consultation for sports and recreation equipment
5. Education regarding fitness and wellness for safety and prevention of secondary complications after SCI

Diagnosis and Prognosis

Diagnosis is T10 paraplegia, ASIA A. Prognosis is excellent for improved strength training and exercise capacity for wheelchair sports and participation in recreational interests. In addition, prevention of secondary complications after SCI is good with adherence to the prescribed exercise program.

Preferred Practice Patterns

Impaired Muscle Performance (4C), Impairments Nonprogressive Spinal Cord Disorders (5H), Primary Prevention/Risk Reduction for Cardiovascular/Pulmonary Disorders (6A), Primary Prevention/Risk Reduction for Integumentary Disorders (7A)

Team Goals

1. Team to complete an exercise arm crank test
2. Team to design and evaluate a wellness exercise fitness program for wheelchair sports
3. Team to educate Charlie regarding fitness and wellness for safety and prevention of secondary complications after SCI
4. Team to conduct a strength testing for improved upper body strengthening for sports-related activities
5. Team to consult about sports and recreation activities and equipment

Patient Goals

"I want to be able to be active and participate in any recreational activities I want to."

Care Plan

Treatment Plan & Rationale

- Completion of an exercise arm crank test for designing a wellness exercise fitness program for Charlie to enable primary prevention of secondary complications after SCI and for the development of an effective training program for wheelchair sports
- Completion of a strength training prescription after testing for maximal strength in key upper limb muscle groups for sports
- Practice with a variety of sports chairs and protective equipment for wheelchair sports
- Educate Charlie in sporting activity teams and mentors near his living environment and provide game rules for sporting activities of interest

Interventions

- Perform exercise and strength testing and exercise prescription.
- Educate patient on injury prevention for wheelchair and other sports activities.
- Consultation with outpatient wellness and recreational therapy for wheelchair sports opportunities, appropriate equipment and protective gear

Documentation and Team Communication

- Team will document evaluation of strength and cardiorespiratory maximal tests.
- Team will meet to discuss options for wheelchairs that enable wheelchair sporting activities.

- Team will discuss patients' knowledge of potential for injury, sporting equipment, and game rules.
- Team will discuss potential opportunities for experienced athletes to serve as resources for Charlie to pursue to make contacts as a new disabled athlete.

Follow-Up Assessment

- Reassessment of the exercise prescription every 4 weeks for 4 months
- Reassessment of any injuries related to sports as needed
- Follow-up to ensure engagement with a team or mentor to begin sporting lifestyle

Critical Thinking Exercises

Consider factors related to Charlie's desire for an active lifestyle that will influence his ability to pursue a complete range of sport and recreational activities. Especially consider the concepts of classification, training, and Charlie's ability to perform activities with or without special equipment. On the basis of the preceding case study summarization and outlined care plan, answer the following questions:

1. How would Charlie be classified for wheelchair sports? Describe the shortcomings of the classification system. What sport has moved from the classification system and how are the athletes classified?
2. Describe how you would instruct Charlie regarding wheelchair propulsion as he begins training for wheelchair racing.
3. What training errors must be avoided? What training considerations would be appropriate for wheelchair basketball and racing?
4. Regarding recreational skiing, softball, and kayaking, what equipment would be required?

SUMMARY

There are numerous reasons for individuals with SCI to participate in sports, including maintaining fitness, social interaction, and improvement in self-esteem. When embarking on or expanding to a new sport, it is important to understanding appropriate training techniques necessary to prepare for the sporting event, including endurance, skill, and speed training along with the implementation of periodization. Strength training can incorporate free weights or machines, and the correct combination of sets and repetitions will focus the progression of the training regimen. There are numerous recreational and competitive sports in which individuals with SCI can participate. It is important for each athlete to understand the rules of classification, game rules, and the equipment needed for each sport. More competitive athletes may choose to engage in training for the Paralympics; representing their country requires extremely hard work, dedication, and continuous training but is extremely rewarding. Clinicians and researchers can support the athlete with knowledge of physiological and biomechanical training principles based on the evidence available. Physical or occupational therapists can help athletes apply research to their training regimens and often volunteer to classify athletes at athletic events. Encouraging patients to begin to explore athletic participation may provide them with an enjoyable form of life-long activity.

WHAT RESOURCES ARE AVAILABLE?

Adaptive Sports Association

P.O. Box 1884, Durango, CO 81302
Winter sports 970-385-2163
Summer sports 970-259-0374
Administration 970-259-0374
http://www.asadurango.com/site_map.html

Disabled Sports USA

451 Hungerford Dr., Suite 100 Rockville, MD 20850
Telephone: 301-217-0960
Fax: 301-217-0968
http://www.dsusa.org/

National Alliance for Accessible Golf

2805 E. 10th St., Bloomington, IN 47408
Telephone: 812-856-4422
TTY: 812-856-4421
Fax: 812-856-4480
http://www.accessgolf.org/

National Spinal Cord Injury Association

6701 Democracy Blvd., Suite 300-9, Bethesda, MD 20817
Telephone: 800-962-9629 or 301-214-4006
Fax: 301-881-9817
http://www.spinalcord.org/

National Veterans Wheelchair Games

http://www1.va.gov.erl.lib.byu.edu/vetevent/nvwg/2007/default.cfm

National Wheelchair Basketball Association

http://www.nwba.org/index.php

North American Riding for the Handicapped Association, Inc.

P.O. Box 33150, Denver, CO 80233
Telephone: 800-369-RIDE (7433)
Fax: 303- 252-4610
narha@narha.org

Paralyzed Veterans of America

801 18th St., NW, Washington, DC 20006
Telephone: 202- 872-1300 or 800-424-8200
http://www.pva.org

United States Handcycling Federation

P.O. Box 2245, Evergreen, CO 80437
Telephone: 303-679-2770
http://www.ushf.org/

United States Quad Rugby Association

5861 White Cypress Dr., Lake Worth, FL 33467-6230
Telephone: 561-964-1712
Fax: 561-642-4444
http://www.quadrugby.com/toc.htm

U.S. Paralympics

One Olympic Plaza, Colorado Springs, CO 80909
Telephone: 719-866-2030
Fax: 719-866-2029
http://www.usparalympics.com/

Wheelchair Sports, USA

10 Lake Circle Suite G19, Colorado Springs, CO 80906
Telephone: (719) 574-1150
http://www.wsusa.org/

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3522896/

WHAT EQUIPMENT IS USED?

The wheelchair is one of the most important therapeutic devices for individuals with spinal cord injury (SCI). Wheelchair mobility is central to independence for those who are unable to walk as their primary mode of locomotion. Provision of an appropriate wheelchair and wheelchair skills training are key aspects of rehabilitation after SCI. There are several choices for wheeled mobility for persons with SCI. These include manual wheelchairs, power wheelchairs, power-assisted manual wheelchairs, and scooters. An increasing number of options are available for various components and features. Some features are critical for safety, comfort, and maneuverability while other options might be based on personal preference.

WALKING GENERAL PRINCIPLES

Being able to walk again is a goal of the majority of people following spinal cord injury (SCI). However, it is not a feasible long-term ambulation option for many of those individuals. While walking does have several potential medical, psychological, and practical benefits, the high energy requirements and excessive demands on the upper extremities for weight bearing are primary factors that limit its utilization for long-term functional ambulation after SCI even with the use of orthoses and assistive devices. Wheelchair propulsion, on the other hand, has similar energy costs and speed as normal walking. Patient Selection for Trial of Walking The selection of patients for a trial of walking is an area of controversy. Ideally all people who have the potential to walk should be given the opportunity to try it should they wish to do so, in the absence of any medical or orthopedic contraindications (even with the knowledge that it will not be a viable long-term option for many). At the same time, however, unrealistic expectations can be counter-productive. Gait training should not supersede other aspects of rehabilitation that are crucial for improving function and independence such as transfers, mat activities, wheelchair skills, and activities of daily living. Factors Affecting Ability to Walk after SCI As discussed in Chapter 26 and Table 26.2, available motor function based on the level and completeness of SCI is the primary determinant of walking ability. Several other factors including muscle tone, range of motion, proprioception, endurance, age, and additional impairments or comorbidities are also important in determining the options available for walking after SCI (Table 30.1).

Therapeutic Strategies for Ambulation after SCI Approaches to facilitate ambulation after SCI can be broadly grouped into two main categories:

- Compensatory strategies, which include use of assistive devices and lower extremity orthoses, functional electrical stimulation (FES), or a combination of the two to compensate for the loss of muscle strength for walking.
- Locomotor training (LT), utilizing techniques towards a goal to facilitate restoration of walking by promoting plasticity in the central nervous system.

BENEFITS OF EXERCISE AND SPORTS PARTICIPATION AFTER SPINAL CORD INJURY:

Regular physical activity, exercise, and sports participation has many benefits. This is true of people with spinal cord injury (SCI) as well as the general population. The United States Department of Health and Human Services has published "Physical Activity Guidelines for Americans" that includes a section on physical activity guidelines for individuals with disabilities (Table 43.1). It concludes that "Overall, the evidence shows that regular physical activity provides important health benefits for people with disabilities. The benefits include improved cardiovascular and muscle fitness, improved mental health, and better ability to do tasks of daily life. Sufficient evidence now exists to recommend that adults with disabilities should get regular physical activity."

Research on benefits of exercise and sports participation after SCI is primarily based on small studies of variable quality and design and the evidence in many areas is still inconclusive, though promising. However, taken together, the literature consistently reports benefits of exercise and sports participation after SCI in enhancing physical fitness in measures of physical capacity (e.g., maximal oxygen consumption), body composition (increased lean mass), and functional performance (improved mobility and select activities of daily living), and in enhancing psychological well-being, community integration, and participation. There is also encouraging literature on the role of exercise in preventing chronic disease and ameliorating cardiovascular and metabolic disease risk factors (e.g., lipid profile, glucose metabolism) in people with SCI, although the optimal intensities, duration, and specific types of physical activities to reduce disease risk are not established. Barriers to Physical Activity and Exercise After SCI Significant physical, psychological, and access barriers to regular physical exercise after SCI exist.

PHYSICAL FACTORS:

Exercise capacity in SCI is limited by two primary physiological factors: muscle paralysis, and the blunted sympathetic response to exercise. In addition autonomic dysreflexia, orthostatic hypotension, impaired thermoregulation, insensate and fragile skin, and musculoskeletal overuse and injury can be significant SCI-related factors that can impact activity and exercise and need to be addressed (Table 43.2).

PSYCHOLOGICAL FACTORS:

Lack of motivation, lack of adherence, reduced energy, depression, concern about physical limitations, fear of embarrassment, lack of self-confidence, and worry about exercise being too difficult, can all be potential barriers to regular exercise.

ACCESS FACTORS:

Reduced access to exercise after SCI is a significant factor in multiple ways. Exercise facilities with wheelchair-accessible equipment and adequate transfer space may not be readily available. There may be difficulty operating exercise equipment independently. Environmental barriers to outdoor physical activity can include steep or uneven terrain, poorly maintained or absent sidewalks, lack of curb cuts, and inclement weather. Lack of readily available transportation to exercise facilities can be another barrier. Financial barriers may preclude access to specialized equipment or gym access. In addition, access can be hampered by lack of awareness of exercise and adapted sports programs, lack of SCI-specific knowledge amongst fitness professionals, and failure of clinicians to address options for regular physical activity. Sports and Exercise Options for People With SCI Adapted Exercise and Sports Equipment Advances in equipment innovation have led to development of increasing variety of equipment, which can facilitate participation in physical activity and exercise for people with different levels of motor function. Commercially available equipment is now increasingly available for individuals and facilities that can be accessed and adjusted for use by individuals with tetraplegia or paraplegia. This includes different forms of upper body aerobic exercise equipment, strength training equipment, and full body seated exercise equipment.

Functional electrical stimulation (FES) can be combined with residual voluntary movement for exercise, and has been incorporated into various exercise equipment including FES-assisted cycling, rowing, arm ergometry, and systems for standing and walking.

Specialized equipment is needed for several adapted sports. The typical daily-use wheelchair is not appropriate for sporting events. Sport-specific wheelchairs are available for racing, tennis, basketball, rugby, and hand-cycling.

SPORTS AND PHYSICAL ACTIVITY PARTICIPATION OPTIONS:

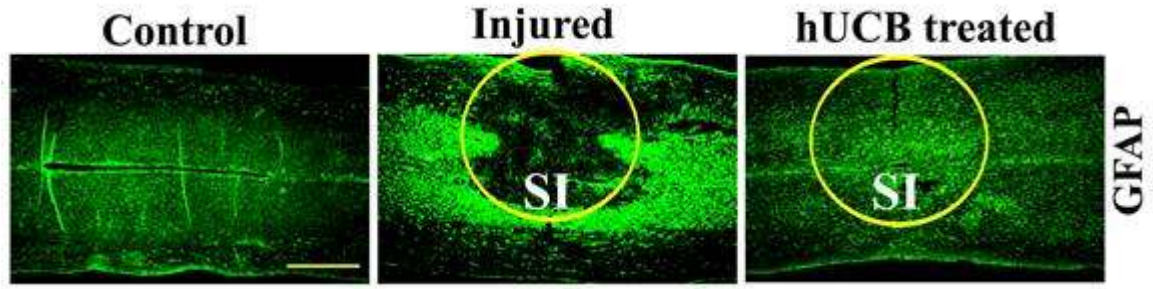
There is a plethora of options for recreational and/or competitive activities and adapted sports for people with SCI and other disabilities. These include archery, athletics, aviation, baseball, basketball, billiards, boating, bowling, curling, cycling, dancing, fencing, fishing, golf, hockey, horseback riding, kayaking, powerlifting, racing, rock climbing, rugby, sailing, scuba diving, shooting, skiing, sled hockey, snowmobiling, table tennis, tennis, and track and field events. Some are more organized than others, and most are supported and facilitated by various organizations. The National Veterans Wheelchair Games are among the largest wheelchair sporting events in the world. Several other competitive sporting venues are available at the local, regional, national, and international levels. http://web.b.ebscohost.com.erl.lib.byu.edu/ehost/ebookviewer/ebook/bmxlYmtfXzY3NzIxMF9fQU41?sid=cc33db98-d451-4e65-a34c-dbec8cf8426e@sessionmgr198&vid=0&format=EB&lpid=lp_1&rid=0

WHAT ARE THE TREATMENTS?

All knowing guide
http://site.ebrary.com.erl.lib.byu.edu/lib/byuprovo/reader.action?docID=10821768

STEM CELL RESEARCH

Methylprednisolone is the only FDA approved drug that is currently available to limit the extent of SCI in the acute settings but it does nothing for prevention or mitigation of subsequent neuropathic pain following SCI. Despite decades of extensive research in this area, no clinically effective therapies exist to modulate neuropathic pain and facilitate functional recovery after spinal cord injury. SCI results in a multitude of changes affecting several different cell types, leading to a complex pathological picture. Most research findings to date suggest that no single therapy will be sufficient to overcome the myriad of biological cascade initiated after SCI. Effective treatments of SCI require a multifaceted approach using a combination of different methodologies and therapeutic approaches over different time to address many of the devastating issues besides functional impairment such as chronic pain associated with SCI



Source: Figure 6A from Veeravalli et al., *Neurobiology of disease* 2009; 36: 200

Our current research utilizes two cutting edge approaches, stem cell transplantation and gene silencing. A variety of different stem cell types have been evaluated in animal models and humans with SCI. Previous studies have reported that human umbilical cord blood-derived mesenchymal stem cells (hUCB-MSCs) promotes neural repair after SCI, even when administered 5 days after injury. Transplanted hUCB-MSCs differentiate into various neural cells and induce motor function improvement in SCI rat models. In concert with these findings, we also have recently reported that hUCB-MSCs improved the locomotor recovery of spinal cord injured rats while regulating the expression of several genes related to apoptosis, axon outgrowth and myelin degradation. However, more detail experiments are needed to delineate the mechanism of how hUCB-MSCs modulate NP and functional improvement after SCI.

Collaborators
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http://peoria.medicine.uic.edu/cms/One.aspx?portalId=513437&pageId=14729105

MANAGEMENT COUNSELING

Individuals With SCI for Exercise and Sports Participation Clinicians play a key role in counseling people with SCI about the benefits of exercise and sports participation, and for enabling participation by initiating appropriate referrals and providing information and facilitating access to resources.

Based on available evidence, SCI clinicians should promote sports and exercise as means to improve physical fitness. It may be helpful to explain the importance of participating in strength and endurance activities for performing activities of daily living, maintaining independence, and mitigating some physical effects of SCI. Potential psychosocial outcomes of activity, such as reduced pain and stress, or enhanced mood and self-esteem, and improved quality of life may also be motivating factors.

EXERCISE PRESCRIPTION

Optimal intensity, duration, frequency, and mode of exercise for reducing disease risk in people with SCI are not established, but may be extrapolated from available guidelines for able-bodied individuals. The Federal guidelines included in Table 43.1 provide a framework for prescription, as do those developed by the American College of Sports Medicine. Prescription with specified and quantifiable goals can facilitate motivation and improve adherence to exercise programs. Endurance training can be provided by several modes including arm-crank ergometry, wheelchair ergometry, swimming, and hybrid FES systems. Strength training can be incorporated in task-specific functional activities and can be supplemented as appropriate by an adapted program using weights and/or elastic bands. Circuit training can provide both strength and endurance benefits. While training of weak muscles may follow the same principles as training muscles with normal strength, the training protocol may need to be modified. Resistive strength training should be individualized and progressive, and should include posterior shoulder and scapular stabilizing muscles. Flexibility exercises, including regular stretching of shoulder and pectoral muscles should be incorporated to minimize risk of overuse injury. Adequate warm-up and cool-down should be an integral part of the exercise prescription.

Preventing and Managing Medical Complications Related to Physical Activity
Although there may be some risks associated with physical activity participation, the benefits generally substantially outweigh the risks. Individualized counseling about risk prevention and prompt identification and management of SCI-specific medical complications that could be precipitated or exacerbated by physical and athletic activity, is important (Table 43.2).

KNOWLEDGE GAPS AND EMERGING CONCEPTS

Additional research is needed to more conclusively demonstrate the various benefits of exercise and sports participation in people with SCI. Demonstrating the value of these programs is especially important for advocating and securing the needed resources in an environment with increasing constraints to ensure value-based health care interventions. Research is also needed to establish optimal mode, duration, frequency, and intensity of exercise for cardiovascular and metabolic risk reduction in people with SCI.

Sabharwal, Sunil. Essentials of Spinal Cord Medicine. New York, NY, USA: Demos Medical Publishing, 2013. ProQuest ebrary. Web. 3 April 2015.