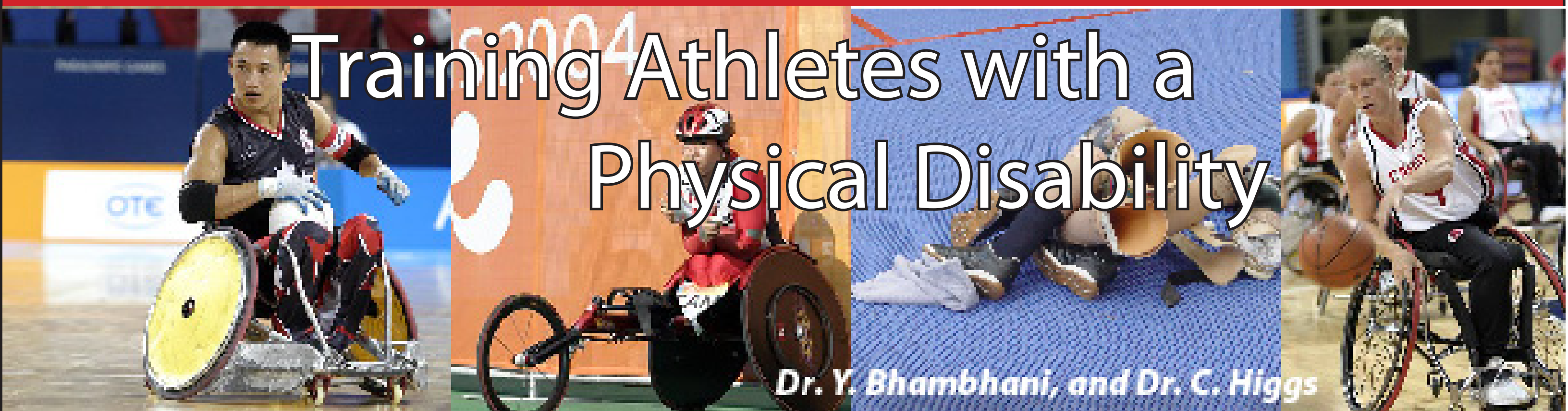
A supplement to:
Canadian Sport for Life



Training Athletes with a Physical Disability

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Athletes with a disability pass through the same stages of Long-Term Athlete Development (LTAD)[1] as their able bodied peers, and much of the training of their five Ss - Strength, Stamina, Suppleness, Speed and Skill is similar to that of other athletes.

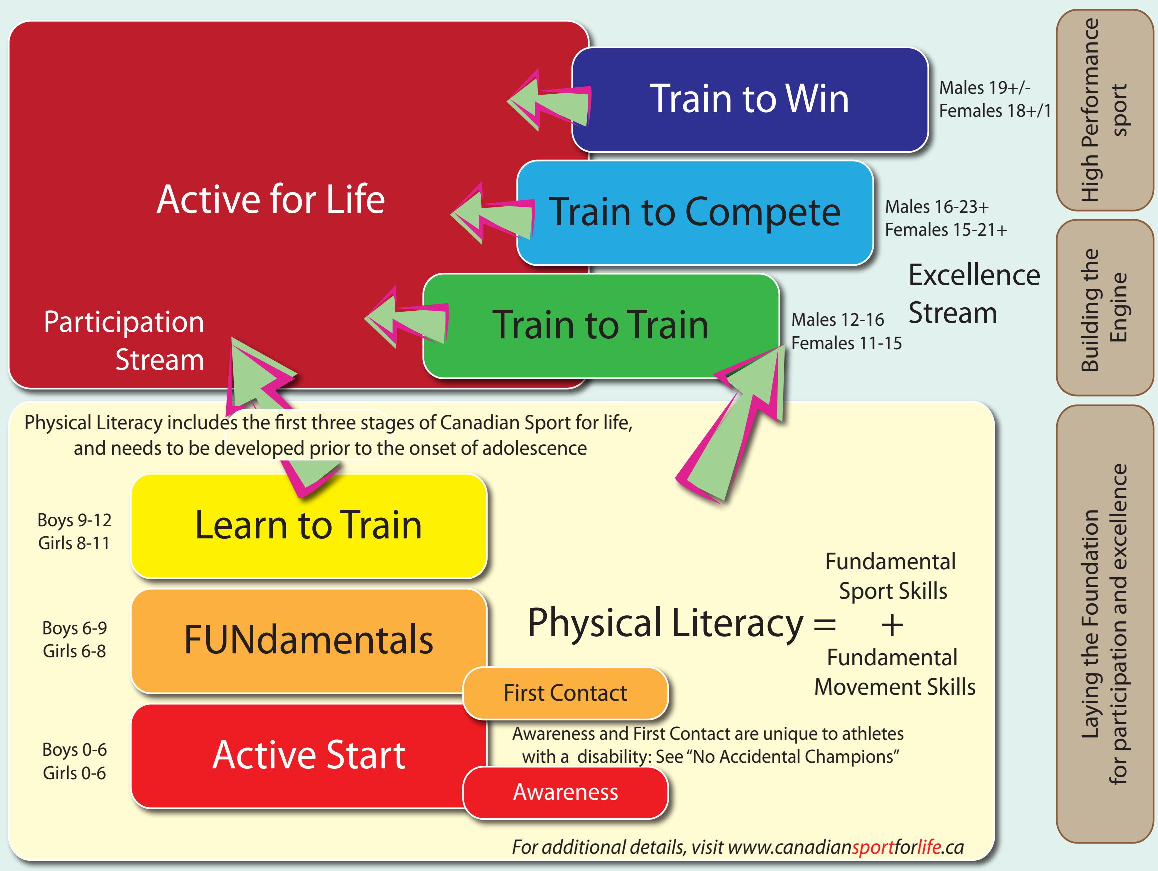
Despite this, there is considerable uncertainty among coaches about the best ways of physically training athletes with a disability. This uncertainty is coupled with a fear that intense training of these athletes might somehow increase their risk for injury.

This document is a summary of current scientific research about training of athletes with a disability. It is organized by major disability type and the LTAD stages of development.

For most sports and a majority of able-bodied athletes, there are seven stages of LTAD from Active Start through to Training to Win, plus Active for Life, as illustrated in Figure 1. The ages shown are appropriate for athletes with congenital disabilities, but do not apply to individuals with acquired disabilities. Those who acquire disabilities still need to make an Active Start and should learn (or re-learn) FUNdamental movement skills and basic sport skills - using techniques and equipment that maximize the potential of their remaining functional capacities.

For athletes with a disability there are two additional stages: Awareness and First Contact. For these stages an

Figure 1: Canadian Sport for Life: Canada's Long-term Athlete Development Model



understanding of physical preparation is not usually necessary, and therefore, they are not covered in this document.

Disability and optimal windows of trainability

Stamina, strength, speed, skill and suppleness (flexibility) are all trainable at any time, but there are times in a person's life when each can be trained more easily, and with better results, than at other times. There is no compelling evidence to suggest that the optimum windows are different in athletes with a disability, although some specific types of disability are known to have an impact on the age of onset of adolescence.

Some of these optimal windows of trainability occur before adolescence, and for these, chronological age is the only guide available to the coach. Some, however occur during or after the adolescent growth spurt, and for those it is important to track the athlete's passage through this phase.

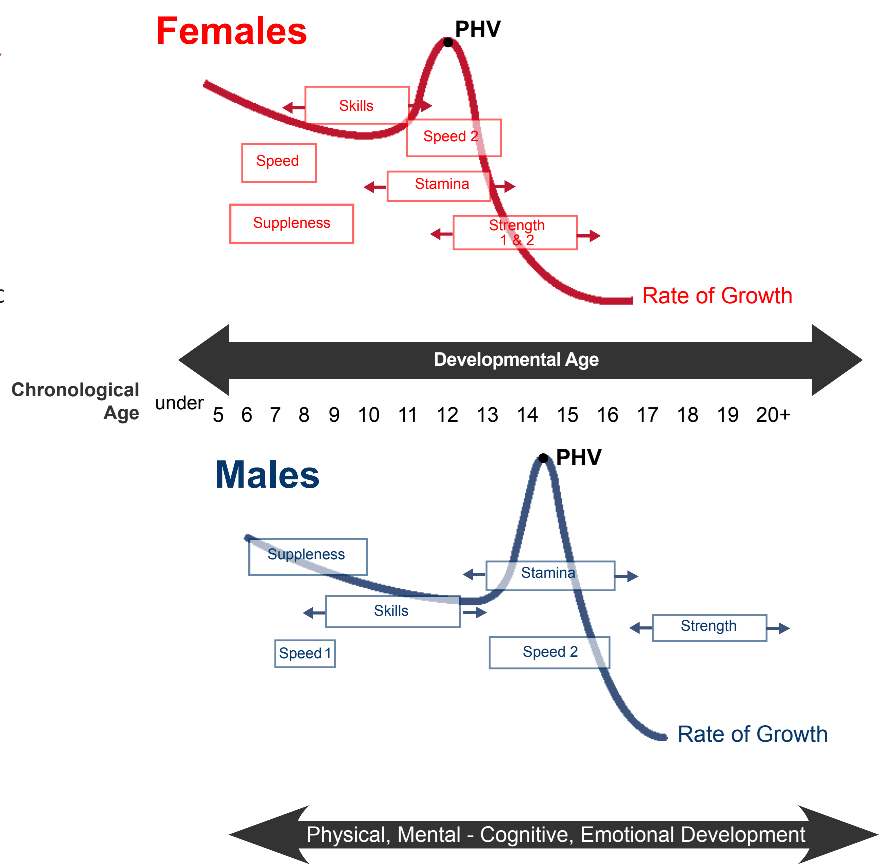
Training for athletes with Cerebral Palsy

Cerebral Palsy (CP) is a congenital disability which occurs in 2 to 3 per 1,000 children over the age of 3. While there are several types of CP, the most common characteristic that affects physical activity is poor muscular control of one or more limbs.

Active Start - FUNdamentals

There is little scientific evidence related to physical training of young people with CP in the Active Start and FUNdamentals stages of LTAD.

Figure 2: Windows of optimum trainability



Notes

1. There is no evidence that optimum windows of trainability are different between athletes with adisability and able-bodied athletes.

2. When measuring for PHV with wheelchair users, measure sitting height.

The onset of adolescence (and therefore peak height velocity - PHV) varies greatly from person-to-person, and may be related to specific disabilities.

Tracking standing (or for wheelchair users sitting) height is the best way to detect the onset of adolescence. Some other cues include kids rapidly outgrowing their shoes/skates, and visually starting to shoot-up.

The optimum windows of trainability are:

> ***Stamina (endurance): At the onset of PHV.***
>
> ***Strength: Immediately after PHV, or at onset of menarche for girls, and 12-18 months after PHV for boys***
>
> ***Speed: For boys ages 7-9 and again at an immediately after PHV. For girls ages 6-8 and during PHV.***
>
> ***Skill: For boys ages 9 -12, and girls ages 8-11.***
>
> ***Suppleness (flexibility): Boys and girls ages 6-10 and especially at PHV.***

Active Start

FUNdamentals

During these stages, children with CP and their parents are often pre-occupied with medical procedures, physiotherapy, occupational therapy, and dealing with important social and educational decisions that need to be made.

Like ALL children, those with CP need to be exposed to as wide a range of physical activities as possible during Active Start, and to the full range of fundamental movement skills during the FUNdamentals stage. For more detailed suggestions, see *Developing Physical Literacy: A Guide for parents of children 0-12* available at www.ltad.ca. While safety of children engaged in physical activity is always important, many fundamental movement skills are learned during the rough and tumble of childhood play. Care-givers should try not to be over-protective of young children with CP.

Learn to train

Overall: Children in this stage of development who are more physically fit show better gross motor performance. There is no compelling evidence to suggest that children with CP respond differently to training than children without disabilities.

Learn to Train

Strength (resistance) training performed 3 to 4 times per week, using progressive overload improves isometric, isotonic and isokinetic strength and endurance. This results in improved aerobic performance, increased bone mineral density, improved walking efficiency and tolerance, greater sense of wellbeing and improved quality of life.

NOTE: Resistance training does not induce any adverse effects such as increased spasticity or muscle damage. It is recommended in conjunction with standard therapeutic interventions for this age group only after the individual is familiarized with the training procedures by a qualified professional.

Circuit training: Generates significant improvement in functional strength for children with CP, along with improved aerobic fitness.

Aerobic training: Aerobic training modes such as brisk walking, running, swimming and wheeling will most likely produce significant gains in maximal aerobic fitness and improvements in the anaerobic threshold. Arm-crank training does not seem to be as effective as lower-limb exercise.

Respiratory muscle training: There are indications that breathing exercises designed to increase the strength of the respiratory muscles can improve vital capacity in children with CP. However, the impact of this training on sport performance has not been evaluated.

Aquatic therapy: Excellent at this age for developing motor skills and enhancing self-concept.

Flexibility: This is an important component of activity for persons with CP at all the stages of the LTAD model. The trainability of this fitness parameter has not been systematically investigated in this population. It is likely that individuals with CP will show similar improvements in flexibility as those without this condition.

Train to Train:

Train to Train

Overall: Youth who are more active have greater movement efficiency and this results in a faster walking speed. Regular involvement in dynamic coordination activities enhances movement skills. However these improvements do not seem to be retained when the training stops. This stresses the importance of regular long-term physical activity for this age group.

Strength (resistance) training: Gym based and home based strength programs can significantly enhance strength and endurance. These strength gains last for more than 3 months following the cessation of training. Gross motor efficiency improves with strength training, including walking and running economy. Resistance training can also improve psychological well being.

NOTE: Resistance training does not induce any adverse effects such as increased spasticity or muscle damage

Aerobic training: Standard aerobic training modes such as brisk walking, running, swimming and wheeling will most likely produce normal gains in overall aerobic fitness. This results in improved movement efficiency in movement with concomitant changes in self-esteem.

Gross motor skill training: Planned motor skill training generates a significant (measured and observed) improvement in movement performance. There is evidence that the skill level of participants decreases when training stops.

Flexibility: This is an important component of activity for persons with CP. It is likely that individuals with CP will show similar improvements in flexibility as those without this condition.

Train to Compete/Win

Train to Compete

Train to Win

Overall: There is no compelling evidence of any differences in response to training between able-bodied athletes and those with CP.

Strength (resistance) training: Well designed resistance training programs which follow the principles of progressive overload significantly improve arm and leg strength . The rates of improvement are consistent with improvements seen in able-bodied athletes. There is no evidence that resistance training is detrimental to the athlete.

Aerobic training: Aerobic training programs of sufficient intensity and duration performed for several weeks (months) induce significant improvement in cardiovascular fitness. This improvement is most likely due to adaptations in the heart, lungs and exercising muscles, as observed in able-bodied athletes.

Flexibility: This is an important component of activity for athletes with CP. It is likely that individuals with CP will show similar improvements in flexibility as those without this condition.

Active for Life

Active for Life

Overall: Physical activity for life is equally important for persons with CP as it is for the general population.

Strength (resistance) training: This method of training which incorporates principles of progressive overload increases (or maintains) strength in the same way as it does for able bodied participants. There is evidence that resistance training is beneficial for older participants and improves activities of daily living, including sit-to-stand times. There is no evidence that resistance training is detrimental to the health of older adults with CP.

Aerobic training: Regular aerobic exercise which utilizes the large muscle groups induces significant improvement in aerobic fitness in the same manner as observed in able-bodied individuals. Like their able-bodied counterparts, physically active participants with CP show lower levels of body fat than those who do not engage in aerobic activity.

Flexibility: This is an important fitness component to perform routine activities of daily living. Therefore, individuals with CP should continue to do flexibility training even though they are no longer competing in their sport.

Training for athletes with Spinal Cord Injury

Some background information

Individuals who have spinal cord injury (SCI) are at greater risk for coronary artery disease, diabetes, unhealthy body weight, and osteoporosis. Regular physical activity provides some protection against all of these conditions. People with SCI experience major changes in various physiological systems, many of which can adversely impact their physical and functional capacity. Usually, the higher the level of the SCI, the greater the physiological impact. There are several factors that are critical in determining the physical and functional capacity of individuals with SCI:

1. If the spinal cord injury is above the level of the first thoracic vertebrae (T1, quadriplegia), then there is a loss of stimulation to the heart from the sympathetic nervous system (SNS). If this signal cannot get through, the heart rate usually does not exceed 120 to 130 beats per minute during maximal exercise. In individuals with injuries below T1, the peak heart rate during exercise is usually higher. It is determined by the amount of functional muscle mass that the individual is able to utilize during exercise.

2. Individuals with high to mid level level spinal cord injuries also have inefficient breathing patterns. Typically, the overall breathing capacity during exercise is characterized by a low tidal volume (volume per breath) and a high breathing frequency. Because they have a limited capacity to use the diaphragm, the primary inspiratory muscle, they recruit accessory breathing muscles during exercise in order to get enough oxygen into the blood. This tends to increase the energy cost of breathing and can cause premature fatigue during exercise.

3. Because the neural signal cannot be transmitted to the muscle as a result of the SCI, all the muscles below the level of the injury are paralyzed. Therefore, the amount of muscle mass that can be recruited for physical activity is dependent upon the level of the SCI; the higher the lesion level, the lower the amount of muscle mass that can be recruited for physical activity.

4. Because of the muscle paralysis, the muscle pump (alternate contraction and relaxation of the muscles) is reduced in individuals with SCI. As a result, the volume of blood returning to the heart is reduced, and therefore, the stroke volume (amount of blood ejected during each heart beat) is also reduced. The overall effect is a significant reduction in the capacity of the heart to transport oxygen throughout the body. This will adversely affect aerobic types of activities which are dependent upon high levels of cardiac output and oxygen availability for enhanced performance.

Post trauma

Following a traumatic SCI there is a period of acute rehabilitation until the patient is stable. This is followed by the sub-acute and chronic rehabilitation periods, the latter being the remainder of the person's life.

There is little scientific evidence concerning the best time for an individual to start becoming active post-injury. It is likely that the earlier that it can be safely started, the less atrophy (loss of muscle mass) will occur. New habits of physical activity also need to be established at this time.

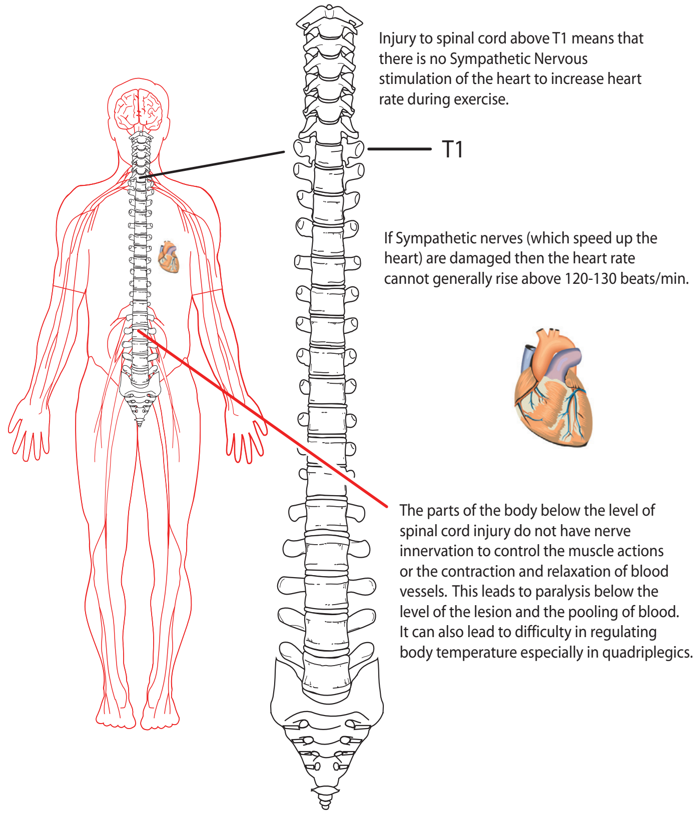
The majority of individuals with SCI will use a wheelchair for their activities of daily living. For sport participation, they need to develop a new set of fundamental movement skills related to wheelchair propulsion and object manipulation. They should start with relatively simple skills such as throwing and catching a ball and gradually progress to more complex skills such as propelling a wheelchair to strike a moving tennis ball. Their ability to complete these tasks is to a large extent determined by their existing functional capacity.

Cross sectional evidence shows that wheelchair athletes are stronger, fitter, and carry less body-fat then their non-athletic peers, and this results in better long term health.

New developments

Functional Electrical Stimulation (FES) of muscles is a relatively new training technique, in which computer-controlled electrical stimuli enable paralyzed large muscles of the lower limb to contract and relax in such a way so that they can operate exercise equipment such as a cycle or rowing

Figure 3: Heart rate in SCI athletes



ergometer. Using the larger muscles of the body puts more activity-induced load on the heart, and potentially contributes to improvements in aerobic fitness. This training modality also increases the capacity of the paralyzed muscles to utilize oxygen. It also slows down the rate of bone loss in the paralyzed limbs which occurs over time.

Active start/fundamentals

There are few children with a congenital SCI. Therefore for acquired spinal cord injuries, Active Start and FUNdamentals predominantly refers to the start of active engagement in physical activity post trauma, and learning/relearning fundamental movement skills post trauma.

There is little scientific evidence related to physical training of people with SCI in the Active Start and FUNdamentals stages of LTAD. Research is needed to determine the optimum time post-trauma for the introduction of strength and fitness training. The current "rule of thumb" is to start as soon as medical staff determines that it is safe to do so.

If young children have spinal cord injuries, then it as critical for them to be exposed to the largest possible range of physical activities that they enjoy, as it is for their non-disabled peers. One area in which wheelchair-using children often miss out, is activities in which they are upside down, or rotating in a front-to-back orientation, since wheelchair movements do not lend themselves easily to this type of motion.

For suggestions related to the Active Start and FUNdamentals stages of development for young people with SCI see Developing Physical Literacy: A Guide for parents of children 0-12 available at www.ltad.ca.

Learn to Train/Train to Train/Active for Life

Overall: Training regimes for SCI athletes should be based on the training demanded of able-bodied athletes at the same level of training and performance, with the following differences.

(1) Coaches should be aware of the symptoms of autonomic dysreflexia: (see Boosting: Autonomic dysreflexia on the next page) which are typically sweating, shivering, skin blotching, and headache. Since this condition can occur spontaneously and be dangerous to the athletes' health, the medical team should have a treatment plan in place should an emergency arise.

(2) Additional care should be taken in hot/humid weather to ensure that athletes do not experience hyperthermia; ie. an increase in core body temperature. This condition can result in cramping, nausea and dizziness, and in more severe cases can adversely affect brain function.

Strength (resistance) training: Well designed resistance training programs, when performed 3 to 4 times per week using progressive overload, significantly improves muscle strength and endurance in individuals with SCI Care should be taken to ensure that balanced strength increases are achieved in both flexion and extension around the shoulder and elbow joints in particular. For optimum performance, it is essential that the specific muscle groups be trained in movement patterns that simulate those required in competition.

Aerobic training: Aerobic training methods such as arm cranking and wheelchair exercise induce significant gains in peak aerobic fitness and the anaerobic threshold. Optimum training intensity appears to be 60% to 80% of peak heart rate, for a duration of 20-30 minutes of continuous activity, 3 to 4 times per week. However, there is emerging scientific evidence (well supported by leading coaches) that interval training is also highly effective in enhancing aerobic fitness in SCI athletes. The exercise:rest ratios for interval training should be similar to those used by able-bodied athletes. Typically, one minute exercise interspersed with one minute rest intervals (1:1) at maximal wheeling velocities can be used to enhance these aerobic fitness parameters.

Anaerobic training: This area had not been well researched in the SCI population. It is recommended that potential SCI athletes follow the same principles as those used by able-bodied athletes. Typically exercise:rest intervals of 1:1 to 1:3

with work durations between 10 secs to 30 secs will stress the anaerobic system and induce adaptations in this type of fitness.

Flexibility: In the SCI population, muscle spasticity can adversely impact flexibility and thereby influence performance. It is important , therefore, that flexibility training be incorporated into the normal training regimen of SCI athletes. Coaches and trainers should assist the athletes in completing the flexibility exercises of the pertinent muscle groups throughout the entire range of motion.

Train to Compete and Train to Win

Train to Compete

Train to Win

High performance SCI athletes in the Train to Compete and Train to Win stage should train at the same intensities, durations and frequencies as competitive able-bodied athletes. There is some evidence to suggest that using the percentage of maximum heart rate as a training-intensity monitoring device is not valid at intensities below 85% of peak oxygen uptake.

Aerobic training: The development of aerobic fitness in athletes with SCI is essentially the same as for able-bodied athletes. The general guidelines have been provided in the earlier section. In individuals with quadriplegia, there is evidence that much of the improvement in aerobic fitness is due to enhancement of the aerobic capacity of the peripheral muscles to extract oxygen rather than that of the capacity of the central circulation to transport oxygen. This is because at injury levels above T1, the sympathetic stimulation to the heart is disrupted and the athlete is unable to further increase the heart rate as a result of training. Therefore in these athletes, arm-muscle strength and endurance gains are critically important in order to improve performance.

Anaerobic training: Longitudinal training studies that have examined the changes in anaerobic fitness in SCI athletes have not been conducted. Therefore, the optimal method of training with respect to exercise:rest ratios, frequency and duration of training are not available for this population. It is generally recommended that SCI athletes utilize the same training principles as able-bodied athletes for enhancing this fitness parameter. It has been reported that females with SCI have a greater fatigue index (muscles fatigue more rapidly) than males. However, the implications of this for training have not been identified. Power output, measured during a 30 sec Wingate anaerobic test has been shown to be related to speed of wheeling in sprint events up to 400m.

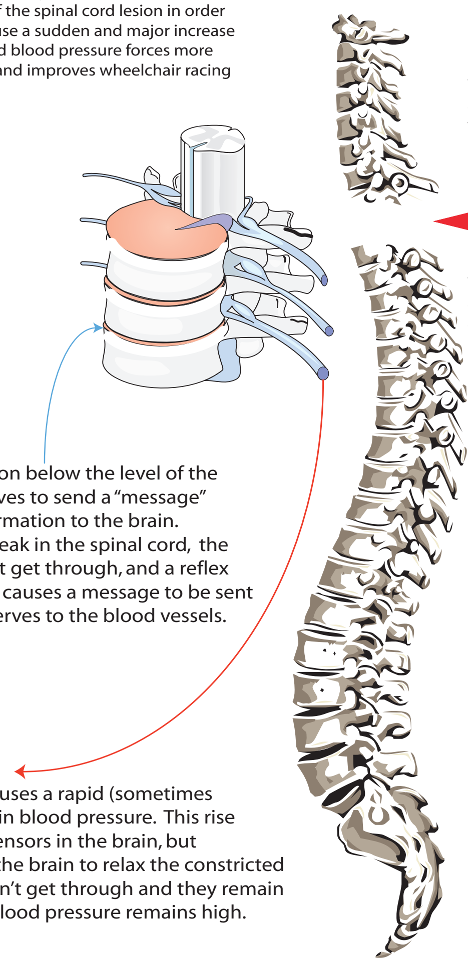
Resistance training: The importance of resistance training in SCI athletes cannot be overemphasized. The training program should be designed specifically for the individual athlete's sporting event and the progress should be monitored at regular intervals. Balanced strength development around the joints of the arm and shoulder remain critically important at this stage in order to minimize the risk of injury.

Respiratory Muscle training: Individuals with SCI, particularly quadriplegics, have compromised lung function. As a result, they have an inefficient breathing pattern during exercise; ie. a high rate of breathing with only small amounts of air exchanged on each breath. Respiratory muscle training

Figure 4: "Boosting"

"Boosting" or Autonomic Dysreflexia

Is a technique banned by the IPC and the World Anti-Doping Agency in which athletes deliberately cause serious irritation to their body below the level of the spinal cord lesion in order to set off the reflex that will cause a sudden and major increase in blood pressure. The increased blood pressure forces more blood to the working muscles and improves wheelchair racing performance by close to 10%.



is a relatively new training technique that is designed to improve the capacity of the breathing muscles. In this type of training, the athlete uses specialized breathing equipment that is designed to specifically exercise the breathing muscles. In order to improve the breathing endurance, the athlete breathes continuously in and out of a breathing bag at a specified frequency for several minutes while remaining seated. An alternate method of training to improve the strength of the breathing muscles is to breathe in and/or out against a resistance. Although these methods of training do induce significant improvements in breathing capacity, the influence on sport performance has not been documented. Theoretically, there are good reasons to believe that sport performance would indeed improve as a result of respiratory muscle training in the SCI population. This training, if undertaken, should only be done when the athlete has received adequate training from his or her medical staff or a qualified respiratory therapist.

Flexibility training: This component of training is extremely important in elite athletes who are competing at the highest level.

All Stages

Training for amputees

An amputation is usually an acquired disability. However, some children are born with limb deformities while others have early-life amputations and therefore are comparable to individuals with a congenital disability. In general, persons with an amputation have a normal physiological system and their functional responses are similar to that of the wider population. Although there are no scientific training studies on this population, it is likely that they will adapt in a manner that is similar to that of able-bodied athletes.

Like ALL children, those with a congenital limb disability or early amputation need to be exposed to as wide a range of physical activities as possible during Active Start, and to the full range of fundamental movement skills during the FUNdamentals stage. For more detailed information, see Developing Physical Literacy: A Guide for parents of children 0-12 available at www.ltad.ca.

While the safety of children engaged in physical activity is always important, many fundamental movement skills are learned during the rough and tumble of childhood play. Care-givers should try not to be over-protective of young children with an amputation.

An adult who acquires an amputation will need to go through a stage of Active Start - that might better be called Active Re-start - in which they need to get into, or back into, physical activity using their now modified body and (where appropriate) assistive devices. They may also need to relearn Fundamental movement skills that involve the prosthetic limb or mobility aid such as a wheelchair.

In individuals with an amputation, the level of physical activity is related to body image. The better the amputee feels about himself or herself, the more active they are likely to become and remain active. Creating a positive body image is therefore very important for the young child with a congenital amputation or the adult amputee who is making an active start or restart following an amputation.

For lower limb amputees, optimum shaping of the residuum (stump), gait training, and proper selection and fit of prosthesis helps in encouraging activity.

Since lower leg amputees use more energy to walk/run, they need good cardiovascular fitness to perform normal physical activity without undue fatigue.

Early post-amputation balance training is very important, particularly in adult lower limb amputees. This is because the centre of gravity is shifted with the loss of significant body mass and the individuals need to regain confidence in their overall ability to independently perform routine functional tasks.

Level of physical activity remains related to body image. The better the amputee feels about himself or herself, the more likely they are to become and remain active.

For lower limb amputees in particular, optimum shaping of residuum (stump), gait training, and proper selection and fit of prosthesis helps to maintain level of activity.

Since lower leg amputees use more energy to walk/run, they need very good to excellent cardiovascular fitness to compete at various levels in their respective sport. Increased leg strength through resistance training has a positive impact on how well athletes feel they are walking/running.

Balance training, particularly core balance activities, remain important especially following a change in prosthesis. Athletes should endeavor to make running and walking actions as symmetrical as possible. This will result in a more even load on the hip and spinal joints and will minimize the risk of developing deformities in the spinal curvature.

For amputee wheelchair racers: Long hours of wheelchair training and racing tend to create more powerful muscles on one side of the shoulder joint than the other. Over time, this asymmetric loading leads to over-use injuries and shoulder pain. It is therefore critically important to strengthen the shoulder girdle equally in all directions with a well designed training program.

All Stages

Training for athletes with visual impairment, or who are blind

Visual impairment can be either congenital or acquired, and if acquired can be gradual and fluctuating, or sudden onset. Because of this, the Active Start and FUNdamental stages can refer to either young children going through the normal growth and development process, or to older individuals becoming active and learning/re-learning skills following acquiring blindness/visual impairment.

The learning of physical skills is particularly difficult in the absence of visible action-role-models and visual cues. Research suggests that it takes up to 8 times as many trials for a child with a visual impairment to master a new skill.

The safety of children engaged in physical activity and sport is always important. Many fundamental movement skills are learned during the rough and tumble of childhood play. Care-givers should protect, but try not to over-protect, physically active young children with a visual impairment, and are encouraged to contact blind sport organizations (such as the Canadian Blind Sport Association) to learn about ways to stimulate physical activity related motor development.

Early orientation-and-mobility training for individuals with visual impairment is critically important, and while this training is related to "getting around" rather than to physical activity, it provides a sound starting point. The expertise and knowledge of organizations familiar with (and experienced in) working with visually impaired individuals/athletes should be sought out.

While athletes with blindness/visual impairment usually have unaltered physiology, the metabolic cost of physical activity is often much higher than that for sighted athletes. This appears to be due to increased residual muscle tension when a task is performed without visual feedback. Muscle tension can be reduced using biofeedback techniques and this should be an important part of the athletes' physical training regimen. Over time, this will most likely increase the self confidence of the athlete and result in improved efficiency of the different tasks that need to be performed.

The principles of physical training for individuals withblindness/visual impairment are similar to that of able-bodied individuals unless there is some accompanying cardiorespiratory, neuromuscular or metabolic disturbance.

Several factors need to be considered, however.

- ✓ Residual muscle tension is increased due to the absence of visual feedback. This results in a significantly higher than expected energy expenditure during complex functional tasks in the sporting environment.
- ✓ The additional muscle tension has the potential to cause early fatigue in individuals just getting into sport. This may pre-dispose visually impaired/blind athletes to a higher risk of tension-related muscle injury.
- ✓ Reducing the athletes' stress has both psychological and physical benefits. This can be achieved through a combination of increased confidence in his/her Guide, and through progressive relaxation techniques coupled with practiced visualization.
- ✓ The gait of many blind/visually impaired runners is asymmetric, with the stride on one side of the body being shorter than the stride on the other. The more ingrained this asymmetric running pattern becomes, the harder it is to reduce or eliminate. Therefore, early attention to symmetric running should be a high priority.
- ✓ Aerobic/anaerobic and Resistance training: There are no studies that have examined the effects of physical training on individuals with visual impairment. Therefore, these individuals and athletes should adhere to the same training principles that have been developed for their able bodied counterparts. It is likely that athletes with visual impairment will respond to training in a similar manner to those without visual impairment.

References and additional reading

The material in this document is heavily based on an extensive review of the current state of scientific knowledge concerning the physical training of athletes with a disability in the four major Paralympic disability groups: Spinal cord injured, Amputees, Cerebral Palsy, and Visual impairment.

Bhambhani, Y. (2007). Overview of physical training in athletes with disabilities: Focus on Long-term Athlete Development. A paper prepared for PacificSport Canadian Sport Centre, Vancouver, B.C.

The paper, along with other relevant material, is available for download at:

www.canadiansportforlife.ca

Other organizations that can provide important information about working with athletes with a disability are:

Canadian Wheelchair Sports Association

www.cwsa.ca

Canadian Cerebral Palsy Sports Association

www.ccpsa.ca

Canadian Blind Sports Association

www.canadianblindsports.ca

Canadian Paralympic Committee

www.paralympic.ca

International Paralympic Committee

www.paralympic.org