

Using specificity and resistance training to improve wheelchair athletes

A new study looks at the benefits of low-volume and strength training

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Traditionally, wheelchair athletes have placed a strong emphasis on habituating technique through high-volume training, the idea being that they could then compete in a range of events from 100m to the marathon. However, increased participation numbers and improved coaching mean that track events are becoming more competitive. For British athletes to remain successful in paralympic competition there may be a need for an increased emphasis on [specificity](#). This case-study focuses on the benefits of event-specific resistance and sprint training for two pre-elite wheelchair athletes.

In the past, wheelchair athletes when sprint training have used the same programmes as able-bodied sprinters. These sessions involved high volume training with a large number of repetitions performed during a session with little [recovery](#). More recent training programmes used by sprinters concentrate on [low-volume training and long recoveries](#) between repetitions with a major emphasis on quality work. This type of quality training was undertaken by the athletes involved in this training programme.

Originally thought to be detrimental, resistance and weight training has now been shown to improve functional ability and mobility for people with physical disabilities (Laskowski, 1994). However, wheelchair athletes in sprint and endurance events have placed little or no emphasis on [resistance training](#) as part of their programme. Reluctance has centred on the traditional myths surrounding weight training.

The athletes

The parents of a 17-year-old male and a 14-year-old female gave their written consent to participate in the study. The male subject was diagnosed with sacral agenesis, sometimes referred to as sacro-coccygeal agenesis or caudal regression syndrome. This is a congenital malformation syndrome of hypo- or aplasia of the caudal vertebra with developmental defects of the corresponding segment of the spinal cord. The male subject had malformed and atrophied legs, his knees were fused at the joint and he was paralysed from midway down the lower leg. The subject was able to perform limited hip flexion and very minor hip extension. His main means of ambulation were through the use of his wheelchair, although he frequented 'walked' using his arms.

The female subject was diagnosed with myelomeningocele spina bifida (lesion L3) which is characterised by the failure of the posterior aspect of the vertebrae column to form, resulting in the seepage of the meninges and spinal cord. The subject was paralysed from the knees downwards. She was capable of hip flexion and adduction, but was unable to perform hip extension or abduction. Her means of ambulation predominately involved the use of a wheelchair.

The tests

Resting measurements of height, weight and blood pressure were taken. Body composition

was estimated by taking skinfold measurements from four sites ([subscapular](#), [suprailiac](#), biceps and triceps). Anaerobic fitness was assessed using an adapted 30 s armcrank Wingate test using a load of 0.04 kp/ kg (Foster, Hector & McDonald, 1995). Mean power output, peak power output and fatigue index were recorded. A pre- and post-100m time trial was conducted (accurate to 0.01 s). Muscular endurance was assessed using three exercises (bench press, pull downs behind the neck and dips/ press ups). For the bench press and pull downs a 6 RM was used as this has been recommended for children rather than using a 1 RM (Kraemer & Fleck 1993). The dips (for the male subject) and press ups (for the female subject) were performed to voluntary exhaustion. Three-quarter press ups were used for the female subject as she was unable to perform dips.

Training programme

The subjects then participated in a nine-week training programme before being retested. This consisted of sprinting and resistance work. Exercise selection was based on analysis of wheelchair sprinting biomechanical needs, energy source utilisation, development of muscle balance and an analysis of sites which were common or susceptible to injury.

Sprint training

The track sessions typically started with a long warm up (1200-2400m) and ended with a long cool down (800-1600m.). These were used to help develop an aerobic base and to habituate movement patterns. During the second phase (strength phase) these distances were reduced. Maintenance stretches were performed after the warm up period and developmental stretches after the cool down period. Maintenance stretches lasted 12-15 seconds, whereas developmental stretches lasted over 30 seconds. Emphasis was placed on stretching the muscles around the shoulder joint, triceps, wrist flexors and extensors, chest and upper back. 'Striders' were then conducted over 100m. These are sub-maximal efforts which progressively get faster during each repetition. During this period emphasis is placed on developing pushing technique.

Typically 6-9 repetitions were performed during track training. Distances ranged from 30m.-400m. Although both subjects were tested over 100m., they both competed at 100m. and 200m. and therefore the track training was tailored to meet these needs. Various track training techniques were used and are summarised here:

1) Interval training: Subjects performed repetitions over various distances with either active or passive rest between repetitions. During high-quality speed training long passive rests (5 minutes) were given to promote full recovery. During a [lactate](#) tolerance session work relief was given, normally over set distances.

Example:

High-quality session: 60, 80, 100, 120, 140, 160 m. (five minutes recovery between repetitions).

Lactate tolerance session: 150 (220 work recovery {wr}), 180 (190 wr), 210 (160 wr), 240 (130 wr), 270 (100 wr), 300.

2) Tempo training: Repetitions are arranged into sets with each set comprising various distances. The aim of this type of training is help avoid over-pacing during longer runs, mixing speed work with over-distance work. Long recoveries are given between sets to promote full recovery.

Example:

Set 1 - 130, 120, 40 slow wheel back recoveries

Set 2 - 80, 30, 60 slow wheel back recoveries

Set 3 - 30, 50, 110 slow wheel back recoveries

3) Tyre pulling: Tyre pulling was performed over 20, 30 and occasionally 40m to help develop strength and power for the initial parts of the race. These sessions were used along with tempo training and mixed repetition with and without the tyres in the same set.

Example:

Set 1 - 150, 90, 60

Set 2 - 30 (with tire T), 30, 40T

Set 3 - 40, 30T, 60

4) Overspeed training: This type of training allows the athlete to work at very high intensities at speeds slightly above maximum with less maximum power output (Eriksson & Steadward 1992). This was achieved by performing repetitions with the wind at the athletes' back and starting repetitions off a rolling start.

5) Handicap racing: Finally, towards the end of phase one and during phase two handicap racing was used to motivate the subjects to perform maximally. Here subjects race over similar distances with one athlete given a head start. Cones were used to mark the head start. When a subject 'won' a race, their cone was moved back one space.

Resistance training

It has been suggested by the National Strength and Conditioning Association and the American Academy of Paediatrics that children can benefit from participating in a properly prescribed and supervised resistance training programme. The main benefits are increased muscular strength and endurance, prevention of injury and improved performance capacity in sport (Kraemer & Fleck, 1993).

Research into the effects of resistance training and athletic performance in wheelchair racing in children and young adults has been scarce. O'Connell, Barnhart and Parks (1992) reported that the distance pushed during a 12-minute test was significantly improved in six children with disabilities following an eight-week upper body circuit weight training programme. They also reported that after training there were significant correlation between eight upper body 6 RM scores and 50m sprint time and between seven upper body 6 RM scores and the distance pushed during the 12-minute test.

The training programme in the present case-study was devised into two distinct phases. The first six weeks consisted of a conditioning phase where typically 3 sets of 12 repetitions were performed. The final three weeks was a strength phase where typically 3 sets of 8-10 repetitions were performed. This seems quite a high number of repetitions for a strength phase; however, it was deemed appropriate for the subjects because of their age. Considering problems such as balance during some of the exercises, it seemed more appropriate in terms of safety and developing the subjects' confidence to use eight repetitions.

Exercise selection

The training programme was designed to improve performance in wheelchair sprinting and to develop muscle balance by strengthening the upper body musculature and posterior shoulder

groups. Disabled athletes tend to have [imbalances in muscle groups](#) (Horvat & Aufsesser, 1991). For example, individuals involved in wheelchair propulsion tend to have strong anterior shoulder muscles as a result of the action of pushing (Laskowski, 1994). This was clearly evident in the male subject, whose [incline shoulder press](#) (which primarily involves anterior deltoid) was as strong as his [bench press](#) (which primarily involves pectoris major). Therefore exercises involving trapezius, serratus anterior, levator scapulae, rhomboids, latissimus dorsi and the posterior aspect of the deltoids were included in the programme. Analysis of biomechanical needs of wheelchair racing identified pectoris major, anterior deltoids and triceps as the major gross musculature involved in wheelchair propulsion.

Injury prevention was partly achieved by developing muscle balance. The repetitive action of pushing with the arm and hand predisposes wheelchair athletes to repetitive strain syndromes such as inflammation of the shoulder external rotators and lateral and medial epicondylitis (Figoni, Morse & Hedrick, 1993). Therefore exercise selection included exercises for the shoulder rotator cuff, lateral and medial epicondyle, extensor carpi radialis brevis, extensor digitorum communis, carpi radialis longus and extensor carpi ulnaris. This conditioning intervention was particularly warranted as both subjects experienced mild lateral epicondylitis during the training programme.

Also considered during the process of exercise selection was the role that postural and stabilising muscles would perform. This was deemed particularly important for the male subject as the absence of his sacrum caused him problems with balance and producing maximal forces. Therefore exercises were included for the abdominals and spinal erector.

Finally, as the female subject had partial [control](#) of her hip flexors and leg adductors it was decided that these muscles should also be trained. The purpose here was to help develop stability, control of the chair and also to improve venous return through improved peripheral 'muscle pump'. Davis et al., (1990) have shown that stroke volume and cardiac output is increased when paraplegic subjects underwent functional neural muscular stimulation during arm-crank ergometry and this improvement was attributed to enhanced venous return.

Results

The results showed that both subjects had considerable improvement in all the measured indices. The male subject gained 1.3 kg in body weight, yet his skinfold measurements were lower following the training period. The female subject lost 1.0 kg. in body weight and her skinfold measurements were also lower following the training period. The male subject increased his peak power output from 142W to 157W, the female from 153 W to 190 W. The male subject had a lower peak power output than the female (157 W versus 190 W) yet his mean power output was higher (148 W versus 123 W). The male subject improved his mean power output by 29W, the female subject by 35 W. On the muscular endurance tests the male subject had considerable improvement on his 6 RM bench press (+12.5 kg), 6 RM pull downs (+4 kg) and dips RM (+19). The female also improved on the muscular endurance tests by +2.5 kg, +5kg and +13 respectively. The female subject was also able to perform 15 dips where as previously she had been unable to perform any. On the 100m. time trials both subjects had improvements. The male subject's time went down from 24.68 s to 20.24 s whereas the female subject's times went from 31.83 s to 27.19 s. Table one summaries the results.

Discussion

The training programme appears to have been beneficial for these two athletes in terms of

improving their 100m times, muscular endurance and body composition. The male subject has gained weight (+1.3 kg) and yet his skinfold measurements decreased. This suggests that he has gained fat-free mass and lost fat mass after the nine week period. The female subject also had lower skinfold measurements, but lost rather than gained weight. This suggests that she has lost fat mass. It was expected that, due to gender and age, the male subject would gain more fat-free mass.

The male and female subject improved their peak and mean power outputs following the nine-week training period. This was expected as the Wingate test is an anaerobic test and the training programme was predominately anaerobic. The male subject, although stronger and faster than the female subject, had a lower peak power output (157 W versus 190 W) but a greater mean power output (148 W versus 123 W). One explanation for this is that the male subject's disability means that he does not have a very stable sitting position. The Wingate test required him to stretch to reach the pedals and this stretch put him in an unstable position. As a result he was unable to reach a true peak power score. This is further supported with his rate of fatigue which was only -0.91 W/ s. The female subject, although in a more stable position, also had to stretch in order to reach the pedals. It is unlikely that she would have been able to produce a true estimate of her peak power output in such a position. Therefore the Wingate test may not be a suitable test for these subjects in determining their true peak power output.

In the muscular endurance tests both subjects showed considerable improvement. The male subject had a large increase in his bench press (+12.5 kg) whereas the female had only a small increase in her bench press (+2.5 kg). This was expected due to differences in age and gender. The pull down exercise did not produce a great increase in either subject. Again, for the male it was his stability that proved to be the limiting factor. The male subject had to be strapped to the machine so he could perform the exercise. Although efforts were made to make him as secure as possible, he still had trouble keeping his balance on the seat and also had trouble exerting maximum effort. As he was lifting greater than his body weight, he was being pulled off the seating during the *eccentric* phase of the exercise. On the dips and triceps exercises both subjects showed considerable improvement. Also of interest was that the female subject was able to perform 15 dips, whereas before the training period she was unable to perform any. The 100m time trials were also improved following the nine-week period. The male subject took 4.44 s off his time and the female subject took 4.64 s off her time.

Conclusions

Before the study the athletes had used a traditional high-volume training programme and had not done any *strength training*. The results indicate that the new training programme was beneficial in terms of improving their body composition, muscular endurance, anaerobic power and 100m sprint times. The training programme had to be tailored to each subject's functional ability. This is perhaps a key finding of the study. Not only do training programmes have to be specific to the metabolic and physiological requirements of the athlete, they have to be specific to the physical requirements of the individual athlete. In light of the male subject's stability needs, future study is needed to consider alternative ways of assessing muscular endurance and anaerobic power with young individuals with disabilities. Further research is necessary on the effects of strength training in wheelchair racers during a controlled study. This work is currently ongoing at the University of Wolverhampton.

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