# H1 TRAINING PRINCIPLES

## Key Notes

**Individuality**

Individuality refers to the fact that all athletes are not the same, and that heredity significantly influences the speed and degree to which a body adapts to a training regime. Therefore a training program should take account of individual needs.

**Specificity**

Training adaptations are specific to the type of activity undertaken. Training for swimming is ideally performed in water rather than dry land, whilst a cyclist is better suited to cycling as a mode of training rather than running.

**Progressive overload**

The concepts of progression and overload are the foundation for all training. Progression means that as the training continues there is a need to increase the resistance in resistance training or produce a faster time in sets of running, swimming or cycling, whereas overload is where the muscles need to be loaded beyond which they are normally loaded.

**Maintenance**

Once a specific level of adaptation has taken place, this level can be maintained by the same or a reduced volume of work.

**Reversibility**

If an individual ceases training, the muscles (or cardiovascular system) become weaker, less aerobic or less powerful with time.

**Warm-up and cool-down**

Although not essentially training principles *per se*, nonetheless warm-up and cool-down should play an integral part in any training program. Warm-up implies that as a result of appropriate activity the muscle temperature is elevated from that at rest. Cool-down occurs when appropriate activity following exercise is undertaken to gradually reduce muscle temperature and aid removal of waste products from muscle.

**Related topics**

Bioenergetics for movement (B)
Pulmonary adaptations to exercise (D)
Cardiovascular adaptations to exercise (E)

### Individuality

Heredity plays a significant role in determining how quickly and how much a body adapts to a training program. Other than identical twins, no two individuals have exactly the same genetic characteristics. Consequently, there can be large variations between individuals in cell growth and repair, metabolism, and regulation of processes by nerves and hormones. These individual variations may explain why some athletes can improve significantly on a certain training program whereas another may experience little or no change following the same training program. Appropriate training normally results in improvements in strength, flexibility, power, speed, aerobic power and so on, although the rates at which these changes occur vary between individuals.

Muscle fiber type is a genetically inherited characteristic, and so an athlete who has a relatively large proportion of slow oxidative (SO) fibers is unlikely to adapt to power and speed training as rapidly as an athlete who has a relatively large proportion of fast glycolytic (FG) fibers and vice versa for endurance training. Coaches and managers should be aware that lack of significant progress in a fitness parameter is not necessarily due to the athlete being lazy, but may be that the training is not wholly suitable for that person.

Another important influence in the rate of adaptation to a training program is the individual's level of fitness. In general, the greatest improvements in fitness are observed with those who are less fit at the beginning of the program. For example, $\dot{V}O_{2max}$ can be increased by as much as 50% when middle-aged sedentary males are placed on an endurance training program, yet a similar program only results in a 10–15% improvement in normal active adults. However, it should be recognized that for elite athletes a small increase in their level of fitness can make the difference between being a medallist or not even reaching the final.

It is for these reasons that individualized training programs should be employed, although for many practical considerations this is not always possible. For example athletes involved in team sports and some individual sports often train together, undertaking the same regimes. This can be seen not only in team sports such as soccer, rugby, hockey, basketball, and volleyball, but also in some individual sports such as swimming and athletics. Coaches can however target individuals to undertake extra sessions in order to redress any shortcomings.

**Specificity**

The concept of specificity refers not only to the mode of training and the muscle groups trained, but also to the energy systems needed to provide ATP for undertaking the activity. Training adaptations are specific to the type of activity as well as the volume and intensity of the exercise performed. A soccer player for example would not be expected to perform significant amounts of training in a swimming pool nor a swimmer train predominantly on a cycle ergometer. In these instances specificity refers to the mode of exercise.

In addition, specificity also refers to the muscle groups trained. Although most athletes would train both upper and lower body muscle groups for strength and symmetry, it is unreasonable to expect cyclists to spend a great deal of time undertaking upper body routines nor long-distance swimmers to spend too much training effort in developing their legs. The reasons are clear, in order to improve performance in their sport, athletes need not only train using a similar mode of training to their sport but also to train the muscle groups which are most likely to engender the movement. Even more specifically, athletes should be training the appropriate muscle groups in the same manner and speed likely to be used in the performance. A javelin thrower would be expected to employ training routines associated with the muscle groups and movement patterns involved in throwing the javelin.

As already mentioned, specificity also refers to the energy systems likely to be involved in generating the ATP for that sport. It seems pointless that a 100-meter sprinter would carry out 10 mile runs or a marathon runner perform many repeated sprints as a significant part of their program. The energy demands of the sport must be recognized so as to provide guidance for the types of training to be undertaken. *Table 1* highlights the energy sources for selected sports, from which appropriate training strategies can be produced.

*Table 1. Predominant energy sources for selected sports*

| Sport | % contribution from energy source | | |
|---|---|---|---|
| | ATP-PC | Glycolytic | Aerobic |
| Athletics | | | |
| 100 meters | 98 | 2 | 0 |
| 800 meters | 30 | 60 | 10 |
| 5 kilometers | 10 | 20 | 70 |
| marathon | 0 | 5 | 95 |
| Basketball | 55 | 30 | 15 |
| Hockey | 20 | 30 | 50 |
| Netball | 40 | 30 | 30 |
| Rowing | 20 | 40 | 40 |
| Rugby Union | 15 | 25 | 60 |
| Soccer | 10 | 20 | 70 |
| Swimming | | | |
| 50 meters | 45 | 50 | 5 |
| 100 meters | 40 | 40 | 20 |
| 400 meters | 20 | 30 | 50 |
| Tennis | 20 | 30 | 50 |
| Volleyball | 55 | 30 | 15 |

**Progressive overload**

Systems such as the cardiovascular system and muscles increase their capacity in response to a training overload. In order to achieve this the training program must stress the system above the level to which it is accustomed. As the body adapts to the training load there is a need to progress to a higher work level. For example, an individual who starts to leg press with 70 kg and can just about undertake three sets of eight repetitions, within a week or two should be capable of either performing three sets of 10–15 repetitions or to be using the original number of repetitions but with a resistance of 80 kg. Thus there is a progressive increase in the total amount of weight lifted (see *Fig. 1*). Likewise with sprint or aerobic training sessions, the intensity and duration of the program should increase. Progression can be achieved by increasing the distance or work

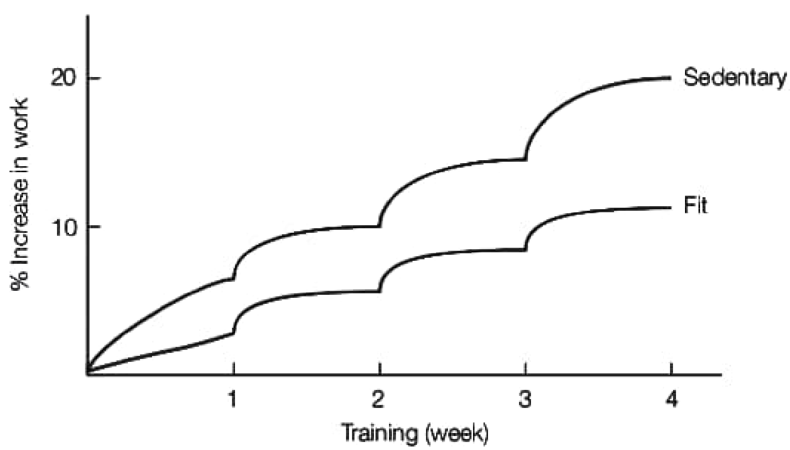


*Fig. 1. Schematic illustrating the effects of training on the % improvements in work with a sedentary individual and a relatively fit individual.*

load, increasing the number of repetitions, decreasing the length of the recovery period, or decreasing the time to cover a set distance. The key to success is an increase in intensity and total training volume.

Progressive overload should be gradual. The total work done in a session should not normally exceed 10% a week. For beginners this might be easily achievable, whereas for more experienced athletes the progression is likely to be small and may take more than a week before even a 1% increase can be reached.

### Maintenance

Once a set level of adaptation has resulted from a training program, this level can be maintained by the same or even a reduced volume of work. Training one day a week in order to maintain a set level of aerobic capacity is feasible as long as the intensity is maintained. However, the maintenance phase cannot last indefinitely. Training one day a week to maintain a set level of aerobic capacity is possible for a few weeks before detraining effects are observed. Therefore in the off-season, athletes are advised to undertake minimum amounts of training for maintenance. This is approximately one session a week for aerobic fitness, two sessions a week for strength, and three or four sessions a week for flexibility.

Maintenance is also an important consideration for athletes during the competitive season where it is unlikely that all the fitness parameters can be addressed during the week. In this instance coaches **periodize** training so that at particular times of a season the training emphasizes one or two fitness parameters rather than trying to improve all. Examples of this can be seen when coaches often emphasize improvements in aerobic capacity and strength through aerobic and strength training regimes in the winter months with maintenance in speed and power. Speed and power are then emphasized nearer competition when aerobic and strength training are maintained. In sports such as soccer, the pre-season training is often the time when emphasis is placed on improving aerobic capacity and strength, whilst nearer the start of the season the emphasis shifts to speed and power work. During the soccer season the emphasis is on match play and maintenance of the fitness parameters. However, if opportunities present themselves the coach may place emphasis on strength or aerobic capacity for a short periodized cycle of a week or 10 days.

### Reversibility

When an athlete stops or reduces training for a significant period of time, the improvements previously observed are reversed, i.e. **detraining** occurs. Any gains in fitness through training will be lost. This reversibility of adaptations to training occurs in the muscle within days or weeks after training ceases resulting in a reduction in both maximal and sub-maximal performance. However it is not only muscle that regresses with inactivity, so does the cardiovascular system.

Individuals who have undergone a relatively short period of training exhibit the fastest rates of reversibility whereas those who have trained for long periods appear to be capable of 'holding on' to their fitness for a longer period. Aerobic fitness is generally more easily reversed than speed, probably because the metabolic processes required for power and speed involve anaerobic metabolism which is increased to a lesser extent with training and therefore lost more slowly with detraining. A classical study reported in 1968 showed that when subjects were given 3 weeks of bed rest there was a 20% decrease in $\dot{V}O_{2max}$ and maximum cardiac output. Hence, aerobic capacity can be rapidly reversed with detraining.

**Warm-up and cool-down**

Although not strictly training principles, warm-up and cool-down are nevertheless important components of training. Training sessions should be organized based on a warm-up, the work out, and then a cool-down. The purpose of the warm-up is to increase blood flow to the muscles and thereby deliver oxygen and metabolic nutrients for the muscles to work, and also to increase the muscle temperature so that the enzymes responsible for generation of energy can function at their optimum. In addition, it is recommended that some stretching routines are incorporated into the warm-up. Warm-up should last between 5 and 20 minutes dependent on the type of training that ensues. A low level of aerobic training demands a short warm-up whereas a vigorous power and speed session necessitates a more lengthy warm-up. The gap between the warm-up and the training should not be longer than 15 minutes or else the effects of the warm-up are likely to be lost.

The warm-up should involve large muscle groups to promote cardiac output and increase blood flow to the muscles, thereby raising body and muscle temperature. The intensity of the warm-up should not result in fatigue, and so working at 50–60% of maximum heart rate (max HR) is generally suitable. For more elite performers some short periods in the latter stages of the warm-up with a heart rate approximately 70–80% max HR is deemed suitable. Specificity of actions should also be included in a warm-up, i.e. soccer players should incorporate running sideways and backwards at speed, changing directions, jumping to head a ball, and kicking a ball.

A cool-down is desirable after a strenuous session or game in order to remove lactic acid and any other metabolites or hormones that may have accumulated, and generally to enable blood that may have pooled in the muscles to be returned to the central circulation. The length of the cool-down need only be 10–20 minutes depending on the intensity and duration of the previous training session as well as the level of fitness of the athlete. The cool-down should be performed at an intensity of approximately 70% max HR since this intensity has been shown to result in the fastest rates of lactate removal, although activity as low as 50% max HR is also desirable if the previous session has not been too intense. A stretching routine should also be used. Results from selected studies that revealed a 20 minute cool-down resulted in less muscle soreness in the following 24 hours.