The development of strength and power
by Wilf Paish

The author discusses two related elements of athletic performance, strength and power. In the first section he highlights the essential theories which underpin strength training. He describes a progression from the simple system of resistance training, designed to develop a base level of strength, to more sophisticated combination systems which can develop specific aspects of strength. The first section concludes with suggestions as to how weight training can be incorporated into the competition season. In the second section the author explains that the low status of British field event performance in the 1960s encouraged him to introduce innovative exercises for the training of power. After discussing the theories behind the development of power, and its relationship to strength, speed and stamina, he describes some of these exercises. He concludes the article with some suggestions for the phasing of power training in a single-periodized year, and for some event-specific combinations.

I The development of strength

The term strength is a very ambiguous one. In many dictionaries the word is defined as 'being strong'; subsequent reference to strong reveals the definition 'having strength'. However, the concise Oxford dictionary defines strength as 'having powers of resistance'. The first section of this article will be confined to the development of strength through working against a resistance in the form of free or stacked weights (Progressive Resistance Training or PRT); it is therefore this definition of strength which should be borne in mind.

In order to develop high levels of strength, coupled with the co-ordination necessary for the control of such levels, one must train with weighted discs using high intensity, low extent systems. Like any form of training, this type of strength development has its critics. Many point out the high risk of injury. Of course, some exercises are more suitable than others and there are indeed injury risks; however, if the athlete observes the proper lifting procedures the danger of injury is minimized. It is not the aim of this section of the article to list safety procedures and suitable exercises; these can be found in any text devoted to strength training. Instead, it will highlight some of the essential theories which underpin strength training techniques, together with the various systems that can be used to develop specific forms of strength, and it will direct the novice along the path leading from 'simple systems' to more advanced ones designed for athletes who desire a high degree of sophistication in their strength training.

Wilf Paish is an IAAF Lecturer and a former national coach for the British Athletic Federation. He also works as a fitness and nutrition consultant and a freelance writer and broadcaster.
1.2 The concept of strength – related training variables

In a magazine recently Liz McColgan, 1991 World Champion in the 10,000 metres, stated that she now feels stronger as a result of doing longer repetitions at a slower pace than previously on the track. Perhaps she is referring to strength endurance. The main problem in understanding the term strength is that, like fitness, it is specific. The strength required to run a fast 10,000 metres race is totally different from that which is required to throw the hammer or the javelin – all events in our own sport, yet all involving separate elements of the strength component. Figure A shows the related training variables placed in a pyramid configuration, in an attempt to identify the various aspects of strength.

A common misconception is that someone who has a relatively small physique must be correspondingly weaker. This can be true, but only in terms of gross strength, or the ability to exert a single, peak contraction. Moreover, because of the image of the weightlifter we tend to think that the only way to develop strength is to lift weights. Again, this is true only if one is searching for gross strength. For example, one can use bodyweight for resistance, as in circuit training, in order to improve local strength and strength endurance. By using elastic strands, resistance pulleys or weighted balls a specific strength for the throwing events can be developed. By running up a hill or using a harness a runner can develop specific strength endurance. However, having said this, I think that the only way significantly to improve an athlete’s ‘base level’ of strength is to do some form of progressive resistance training, using weighted discs or the stacked system.

1.3 Strength training – theories and research

Research indicates that:
- Systematized strength training will develop the capacity to exert a greater force, and therefore produce a greater impulse.
- Maximum strength-gain relies upon high-intensity work, close to 100% of the one-repetition maximum (1RM).
- Strength endurance is improved by using an extensive system of training with weights.

![Figure A: The place of power in the speed/strength/stamina triangle](image-url)
• The local circulation is improved.
• The ligaments and tendons are also strengthened.
• The increase in muscle size associated with training is certainly due to an increase in the cross-sectional area of each fibre, and to improved vasculization, rather than to an increase in the number of fibres. (It was in the early 1960s that research emanating from Kiev indicated that strength training offered a potential increase in the number of fibres. Other researchers have not been able to support this.)

There are other claims made about strength training, but they lack valid research evidence. However, they are listed below as there is a degree of empirical evidence in their support.

a) There is an improved energy release of ATP.
b) Dormant fibres can be reactivated (this could support the increased bulk associated with training).
c) There is an improved nerve response.
d) There is an improved muscle enzyme activity.
e) There is an improved response from the androgenic and anabolic hormones.

However, when an athlete trains systematically with weights there is a definite change in physique. He starts to look good; this is followed by a euphoric response; hence there is a massive psychological effect. The fact that an improvement can be almost immediately recognized is a great motivation for those who wish to become strong. On the other hand, there is a very real danger inherent in weight training in that many athletes forget what their original aim was. Training with weights will only ensure success in the weight lifting arena. It is a means to an end, and not an end in itself.

Systematized weight training relies upon the progressive overload principle. Adaptation takes place by the rule of overcompensation in response to a strong stressing agent. Once a person is past the age of puberty, strength gains can be rapid; however, should training cease, the muscles revert equally quickly to their pre-trained state. The rate of regression is steep, while the initial gains are in direct response to the quality of the training - presupposing that those associated with the sport would not use ergogenic aids which have a positive effect upon strength development but which are nevertheless banned. Women will never be able to make the same gains in strength as men, since strength development is considerably influenced by the androgenic hormones and especially testosterone, the male sex hormone.

My support of free weights training is influenced by the fact that during training one is searching for a harmonious development of the body. The antagonist as well as the agonist muscles must be stimulated. This happens when one has to work both with and against gravity. During the process of lifting, the body quite naturally limits any unwanted movements, hence the synergist and fixator muscles are stimulated at the same time. While one group of muscles can be seen to be working isotonically, there are others, with an equally important function in movement, that are working isometrically.

1.4 Strength training systems - simple and combination

The novice weight trainer should start off with what is known in coaching as the 'simple' system. For this I recommend that the athlete starts with a weight that can be lifted for three sets of eight repetitions. This is likely to be about 60-70% of the IRM. Only experience can fully support the starting weight. Once this resistance becomes easy to accommodate then the level of the resistance should be increased, still continuing with three sets of eight repetitions. Each exercise is completed with the stipulated three by eight repetitions before progressing to the next. There should be a short recovery between each set to permit a degree of energy replacement and the removal of waste products. The most suitable programme is to select an eight-item schedule with three exercises for the legs, three for the arms and two for the trunk.
In each case the selection should be influenced by both agonist and antagonist response. The exercises should be placed in order so that an arm exercise is followed by a trunk exercise which in turn is followed by a leg exercise. This will permit the individual muscle groups a greater period of recovery. This system is suitable for most athletes to maintain for the rest of their training career. There are of course other systems which the more ambitious can adopt, but the simple system is ideal for those who wish to become familiar with weightlifting techniques and systems for strength development.

Once the novice has had a period of at least one year of familiarization with the simple system, and if he wishes to develop strength endurance, I recommend that he progress to the combination system. This is identical to the simple system in that one adopts an eight-item schedule using three sets of eight repetitions. The difference is in the type of recovery between each set of exercises. In the combination system the eight exercises are paired together, with similar muscle groups kept separate. For example, one pair might be bench-press sit-ups. This is an arm and a trunk exercise linked together. Once one set of bench presses is complete the athlete immediately commences a set of sit-ups and continues this alternate system of exercise, without recovery, until all the repetitions are completed. There then follows a recovery before the next pair is started. This causes a degree of breathlessness with which the distance runner is both familiar and happy.

The next progression along the avenue of strength development is to adopt some form of 'blitzing' technique. When the muscle protein is completely broken down, as can be the case in extreme forms of exercise, the body compensates and makes the muscle stronger. The systems associated with blitzing are the super-sets and tri-sets. These are similar to the combination and simple systems, in that an eight- or nine-item schedule is adopted for three sets of eight repetitions. However, the recovery period is taken by exercising the same muscle group in a different way. The super-set is a pair of exercises, for example the biceps curl with the triceps curl. This exercises the same arm group but the agonist and antagonist in turn. There is no recovery until the three by eight repetitions have been completed for the pair. One could then progress to a trunk pair and then a leg pair.

In the tri-set system there are three exercises from the same basic group linked together. For example, one might select the bench press, the biceps curl and the triceps curl, exercising each in rotation without recovery until the repetitions are complete. A recovery should follow before attempting the next set of exercises. These two systems are ideal early training period systems for those who want to become very strong and who then progress onto high intensity, low repetition systems using something like a five by three repetition programme at 90%+ of the IRM.

1.5 Strength training and competition – combination systems for rapid recovery

The problem with lifting heavy weights is that the muscles take a long time to recover. Hence, weight training must be kept well-removed from the competition itself. This does not however mean that it should not be done at all during the competitive period. Quite the reverse – if the muscles are not sufficiently stimulated then they will atrophy. I also support the view that heavy weights should still be lifted throughout the season for those events in which a high level of gross strength is required.

When one trains with weights on successive days it is possible to permit a greater period of recovery by adopting a split routine. This is done by exercising the arm muscles one day and the leg muscles the next. A good diet and good sleeping habits can aid the recovery process.

There are of course many other systems that the advanced lifter might use to help pass quickly through the 'plateau' effects. These include such methods as the pyramid system and increasing-decreasing loads. Basically these systems introduce an element of competition to provide an added incentive to lift heavier weights, which in turn will trigger off the adaptive response.
The pyramid system calls for the lifter to start at the five-repetition maximum, then apply a determined additional resistance in the completion of a further four repetitions. The lifter works through to one repetition adding an extra resistance each time. Once the IRM is reached he continues with increased resistance for a single rep., until only an isometric contraction is experienced. Increasing-decreasing loads use the pyramid system but in this case the lifter reverses the process back down as well as up, carefully logging the four, three, two and one repetition maximum weights. Due to fatigue they are unlikely to remain the same as those lifted when climbing up the pyramid.

2 The development of power

As a national coach working in England in the early 1960s I was concerned about our lack of success in the field events. Even then, we could match the best in Europe on the track, but despite the success of our long jumpers in the Games of the XVIIIth Olympiad in 1964 the status of British performance in the field was unimpressive.

In 1966 I was made responsible for the throwing events. The scene then was that the throwers were more interested in the intensity of their bench press exercises than in how far they were throwing. It was obvious that conventional weightlifting for training purposes would not on its own produce athletic success. I therefore attempted to redress the balance by introducing innovative ideas for the development of power. This saw the initiation of the jumps decathlon, a form of throws decathlon, and a host of specific exercises using medicine balls, weighted balls and various forms of pulleys and elastic strands for resistance training. The second half of this article will discuss the theories behind the development of power, and its relationship to the concepts of speed, strength and stamina. It will then present some exercises for the development of power, finishing with some suggestions for the phasing of training for a single-periodized year and some event-specific combinations.

2.1 Specific power – strength applied at speed

In terms of pure physics power is the work done per unit of time. Power = Work/Time. This can be translated into P (power) = F (force) x D (distance)/T (time). Since D/T = V (velocity) we have an equation that represents force and speed. In simpler terms, power is strength applied at speed. Its place in the Speed, Strength, Stamina pyramid can be seen in Figure A on page 46.

The concepts of strength and speed are not necessarily compatible. The very strong are often very slow, and vice-versa. Conventional training, with any form of resistance, must of necessity slow down the immediate speed potential. Hence an improvement in speed is expected through the applied force component. It must therefore be accepted that the conventional methods used to develop both force and speed as isolated components will not affect in any significant way the development of power.

In our sport power is specific. The thrower is looking for a force applied over a great range of movement. Hence the lean-back in the Javelin Throw, the torque (wind-up) in the Discus Throw, Hammer Throw and Shot Put. In jumping events, especially in the Long Jump, a compromise must be reached. For example, if we compute the World Record for speed, together with the greatest height raised for the CG, we would get a jump in excess of 36 feet (over 11 metres). This makes even the performances at the last World Championships seem mediocre. However, with such a model the CG would pass over the take-off foot so quickly that it would not be possible to produce a sufficiently great vertical component to extend the parabolic flight path.

Therefore we are looking at methods for inspiring the development of the elastic component of the muscles by using some form of plyometric training, or by using a slight resistance that will not detract from the speed component while at the same time hoping to increase the specific strength component. There is a need to consider the specificity of the event so that training methods use a similar pattern of muscular movement to that which is performed during the event proper.
(as with pulleys, ropes, balls, etc.). The term plyometrics involves the muscles working both concentrically and eccentrically.

2.2 The practical development of power

2.2.1 Bounding

- General bounding (as in jumps decathlon) – suitable for general training: long jump; hop (H), step (S), jump (J); 2HSJ; 2H2SJ; 2H2S2J: 5 bounds.
- The rest of the bounding events are not suitable for general training. Both the extent and the intensity of loading can be varied by using a weighted jacket, by varying the number of repetitions or by adding the incentive of measured targets.
- Sequence bounding
  This is a series of hops and steps performed over a distance of about 30m: HSHS; HHSSH; HSSH; HSHSSHSS; HHH; SSS.
  With these the emphasis must be on speed; measuring the time taken can add incentive. The extent and intensity of loading can be changed by altering the number of repetitions, the application of a weighted jacket and the timed factor. The recovery period is also a variable.
- Endurance bounding
  This is a combination of hops and steps over a measured distance either around the track or indoors in a shuttle formation, for example around a 400m track and over 8 x 50m segments. It must be a continuous series of movements; hence the timed factor.
  H dominant leg: long striding; H weak leg: long striding; HSHS etc.; HHSSH etc.; HSSHSS etc.; HSHSS etc.
  The variables are as for interval training, i.e. speed, frequency, number of repetitions and period/type of recovery.

2.2.2 Depth jumping

- Rebound for height (see Figure 1)
- Rebound for distance (see Figure 2)
- Double rebound for distance (see Figure 3)

The extent and intensity of loading can be changed by varying the height of the platform and of the rebound height incentive, by incorporating a weighted jacket, or by providing a measured target incentive. These activities can be used with a single leg, but only for the well conditioned. They must not be used for prepubertal children.

- Multiple rebound jumps
  Over hurdles or other appropriate obstacles. The introduction of a timed incentive is good to vary the intensity of loading. The other variables are as for interval training.

2.2.3 Exercises using weighted balls

These use medicine balls of weight 500 gm to 5 kg. They can involve the use of a partner who acts as a server.

- Single leg kicks (see Figure 4)
- Double leg kicks (see Figure 5)
- Leg flexion (see Figure 6)
- Back hyperextension (see Figure 7)
- Trunk twists (see Figure 8)
- Overhead throws (see Figure 9)
- Overhead leg isolation (see Figure 10)
- Overhead hip-flex isolation (see Figure 11)
- Leg/trunk isolation (See Figure 12)

2.2.4 Skill-related drills

- Drop down from raised platform, into throw position for shot/discus/javelin. (See Figure 13)
- Rear leg isolation (see Figure 14)
- Front leg raised to increase lever value (see Figure 15)

2.2.5 Pulleys, elastics, etc.

- Conventional pulley plus weight (see Figure 16)
- With resistance pulley (see Figure 17)
- Elastic strands used both eccentrically and concentrically (see Figure 18)

With all the latter groups of activities the intensity and extent of loading can be varied in the normal way.
Figure 4

Figure 5

Figure 6

Figure 7

Figure 8

Figure 9

Overhead throw - medicine ball
2.3 The phasing of training for a single-periodized year

2.3.1 Phase 1 – October to December (emphasis on endurance)

- Jumps decathlon, 3 sets of 10 repetitions. Medicine ball work 3-4 kilos, 3 sets of 10 repetitions. Endurance bounding, 3 to 5 repetitions of 400m, 8 min. recovery.

2.3.2 Phase 2 – December to February (emphasis on strength)

- Jumps decathlon with weighted jacket, 5 sets of 3 repetitions. Medicine ball work, 4-5 kilos, 5 sets of 5 repetitions. Depth jumping with weighted jacket.

2.3.3 Phase 3 – March to April (speed, power, specific strength)

- Jumps decathlon x 3 measured. Medicine ball, 2-3 kilos, 3 sets of 10 repetitions timed. Sequence bounds x 3 timed. Pulleys, etc., 3 sets of 10 repetitions. Skill drills, 3 sets of 10 repetitions. Multiple rebounds timed.

2.3.4 Phase 4 – competition, hence retention of power

- Try to keep a weekly specific session to maintain stimulation of the respective muscle groups. The type of event included will depend upon the specific athletic event targeted.

Jumpers should include platform work for the Triple Jump, rope swings to kick the medicine ball for the Pole Vault, etc. See Figure 18. Throwers to include pulley work, elastics and skill isolation drills. Sprinters to utilize resistance pulleys, elastics, etc. Bounding will improve the power and co-ordination of distance runners.

All of this work must be complementary to the more conventional methods of developing speed, strength, stamina and flexibility.

3 Conclusion

In the two sections of this article I have tried to give simple interpretations of what are fast becoming well-informed scientific aspects of training. I am confident that our better understanding of strength and power and their development will continue to provide us with new horizons.