LEARN THE 15 LAWS OF TRAINING

by Tim Noakes, MD

Before the development in the early 1970s of modern sports science as a legitimate academic discipline, we knew very little about the real factors that determine running ability or about how the body adapts to training. As you may have noticed while reading chapters 1 through 4, most of the definitive work in this area was done in the last two decades. As a result, virtually all the ideas about training that accumulated over the first 150 years of the sport (since the mid-1800s) are based on the intuition and personal observations of many individual athletes and their coaches. Few of these ideas have been subjected to independent scientific evaluation; they owe their truth only to the perceived credibility of the person making the claims or to untested observation that, when applied to many athletes on many different occasions, these training methods seem to produce the desired result of improved athletic performance.

In writing this section, I read a wide selection of the more readily accessible writings on training and racing by most of the outstanding coaches and athletes of the past 150 years. When combined with what is now known about the physiology of human performance and how the body adapts to training, this information led me to propose that there are 15 basic laws of athletic training that apply to all runners. These will now be introduced. Chapter 6 includes some additional refinements that are probably more relevant to elite athletes wishing to perform optimally for extended periods (years to decades). These ideas may also be of value to other competitive athletes seeking to make the most of their running careers.

Arthur Newton's Contributions to Training

As I researched the writings of the pioneering runners and coaches of the late nineteenth and early twentieth centuries, it became increasingly clear that one, the Englishman Arthur Newton (whose athletic career is described in chapter 6), was the first to describe in the English language a set of training ideas that modern experience has shown to be essentially correct. Newton's ideas evolved between 1922 and 1935, the 13 years he ran competitively. It is not difficult to understand why Newton was the first to write of his experiences in such detail. He began his international running career at the advanced age of 38, so that he retired from running and perhaps from other professional responsibilities when in his early fifties. As a result, he was able to concentrate on this writing, which, besides his remarkable athletic achievements, became his legacy. It is clear that there were nine aspects of training about which he frequently wrote. I have used his own words to describe how he understood these nine laws (marked by * below). I have added another six laws about which Newton did not write, but which I consider complimentary to the laws he described. Together these constitute what I consider the 15 Laws of Training (presented in full in italics at the beginning of each of the following 15 sections):

1. Train frequently, all year-round*
2. Start gradually and train gently*
3. Train first for distance, only later for speed*
4. Don't set your daily training schedule in stone*

5. Alternate hard and easy training
6. At first, try to achieve as much as possible on a minimum of training
7. Don't race when in training or run at race pace for distances above 16 km*
8. Specialize*
9. Incorporate base training and peaking (sharpening)
10. Don't overtrain*
11. Train with a coach
12. Train the mind*
13. Rest before a big race*
14. Keep a detailed logbook
15. Understand the holism of training

Law 1: Train Frequently, All Year-Round

First practice your event as often as possible, paying less attention to other activities. If you want to be a good athlete, you must train all the year round, no matter what. What is really required is a little exercise constantly; this will benefit you permanently to a far greater degree than single heavy doses at long intervals.

This advice of Newton's no longer sounds particularly remarkable, yet for the amateur runners of his era it certainly was. When Newton started running in 1922, the great amateur distance runners of the day or of the immediate past were Walter George, Alf Shrubb, Hannes Kolehmainen, Paavo Nurmi, and Clarence de Mar (see chapter 6). None of these runners trained as much as Newton did, and only De Mar trained consistently all year round. Kolehmainen trained only 64 km per week and George no more than 3 km per day (Lovesey 1968; Krise and Squires 1982). Even Nurmi trained for only five months of the year (between April and September), and before 1924 he seldom ran more than 10 km per day.

The books about marathon training that Newton might have read were those by Walter Thorn (1813), Alfred Downer (1900), Walter George (1902; 1908), Alf Shrubb (1909; 1910) and his coach Harry Andrews (1903), James Sullivan (1909), J.H. Hardwick (1912), Sam Mussabini and C. Ransom (1913), and Alec Nelson (1924). None of these advised that training should be as frequent as Newton proposed or that it should be practiced all year round.

For example, Shrubb's advice was to train for marathons by walking: *Get out for a 16-mile walk three or four times a week, and walk at 4-miles-anhour pace [6.4 km]. On the other days, go 8 miles [12.8 km] only at about 5 miles [8 km] an hour, saving one day for a 16-mile [26 km] steady road run. (Shrubb 1910, p. 64)*

Shrubb suggested that this training program be followed for four to six weeks. For the last month before the race, he recommended that the long run be increased to 20 or even 25 miles [32 or 40 km] and that this should be done either twice per week or three times a fortnight. Andrew's advice was similar, although he emphasized the need to run more: *To train for long distances a great amount of walking must be done. It is necessary to negotiate many miles both of walking and running at a stretch, the distance to be regulated according to the number of miles a man is training for. . . . At first long road-walks, 15, 20, or 30 miles 24, 32 or 48 km] a day, alternate with runs of a like distance on the track, but at the easiest of speeds. (Andrews 1903, pp. 72-73.)*

In his book, Marathon Running (1909), James Sullivan wrote that "distance walking is one of the best forms of preparing for distance races; alternate daily running one day and walking the next." Athletes were advised to start walking about 4.8 km at first and to build this up as they felt comfortable. Similarly, it was recommended that athletes start running 8 or 9.6 km three times per week and build this up so that they could go 8 or 16 km without tiring. Sullivan advised athletes to compete in cross-country races and in the marathon only after this level of training had been achieved. However, running the full marathon distance was not recommended until runners had covered at least 40 km several times in training. They were also advised to use George's "100-up" exercises, in which athletes ran on the spot, lifting their knees up in sets of 100.

American John Hayes, who won the marathon in the 1908 Olympic Games in London, apparently only ran 4.8 km in the evenings. If he ran further than this, he would not do any training the next day but would walk on the second day after his run and would go back to running on the third day. However, before the 1908 Olympic Games in England, the American runners were stranded in England for a month, during which time they became bored and therefore trained harder-sometimes 19 to 48 km on their longer runs. In addition, during the last two weeks of their marathon training, the Americans ran the full marathon distance several times. Perhaps because of this sudden training spurt, Americans finished first, third, fourth, ninth, and fourteenth at the Olympics. (the second runner was C. Hefferson of South Africa.)

Before setting the American marathon record in 1908, Matt Maloney only ran three times per week---24 km on the first day, 6 km on the third day and 11 km on the fifth day. On two or three other days of the week, he would walk up to 16 km per day. He also advised runners to run up to 24 km on one of the three training days as they became fitter. On this training, Maloney set the then world record of 2:35:26.2. As there are few modern runners who could run so fast on so little training, his performances again indicate the value of genetic endowment for running ability. .

The advice of Alec Nelson (1924), who set the professional half-mile record in 1905 and who was coach to Cambridge University and the British Olympic Team, was very similar: "First of all, then, to build up the body and stamina, it is necessary to specialize in long strong walks." He suggested that the athlete should train twice per week-one of these training sessions should be a long walk, the other a run of gradually increasing distance. He added that "if the athlete feels that he is quite capable of turning out more frequently, additional runs of from 6 to 8 miles may be included." Nelson also provided a 16-week marathon training program that is reproduced in table 5.1.

Table 5.1 Alec Nelson's 16-week marathon training program

Week	Walking distance (km) (one session)	Running distance (km) (one session)	
1	24	8	Training speed 4:04 km^{-1} to 4:23 km^{-1}
2	24	8	
3	24	8	
4	16	16	
5	16	24	
6	16	16	
7	24	24	
8	16	41	
9	24	20	
10	16	48	
11	24	16	
12	16	16	
13	16	32*	Training speed 3:45 km^{-1}
14	24	16	
15	16	24	
16	24	16	

* Final trial
From Nelson (1924, pp. 75-76).

Only in the books by Thom (1813) and Downer (1900) is reference made to the more exacting training methods of the pedestrians-the professional walkers/runners of the late nineteenth century, who are discussed in detail in chapter 6 and whose approaches were more similar to Newton's. It seems likely that Newton borrowed heavily from the ideas of those professionals.

Newton's contact with Walter George (chapter 6), who was a friend of the great pedestrian, Charles Rowell, as well as with pedestrians Len Hurst and John Fowler Dixon, who set amateur world records at 40, 50, and 100 miles in the 1870s and 1880s, would have exposed him to the training methods of the pedestrians. For example, George informed Newton of experiments undertaken by Rowell and Harry Shaw, in which they perfected the running style that reduced knee bend to a mini. mum. This style involved running on the heels with hands and arms in front of the body, causing the rear leg to swing "from toe to heel without exertion" (Dillon and Milroy 1984, p. 48). It is likely that Newton ultimately revised his ideas on the basis of that additional information (Milroy 1987), particularly in respect of the very large volumes of training undertaken by the professional pedestrians competing in the six-day races. Milroy (1992b) makes the point that, during the Transcontinental race of 1928, Newton would also have met the Finns Willi Kolehmainen and Arne Souminen. He apparently stayed with the three Kolehmainen brothers among the large Finnish community in New York. Thus, Newton was also exposed to the training methods of the first great Finnish runners. This would also explain why a book describing the Finnish training methods was found among Newton's possessions after his death.

Newton would have learned that the pedestrians would train for up to 8 hours per day by walking and running up to 80 km (Milroy 1983). As they were training for six-day races in which they usually averaged about 9 km per hour, it is probable that they trained considerably slower than did those who, like Newton, were preparing for shorter distance races run at a faster pace.

Newton was really breaking new ground for amateur, but not professional, runners by stating that training must be continued all year round, as frequently as possible; that most of the training should involve running; and that runs of 32 km should become a daily, not a weekly, occurrence.

This first law is also known as the consistency ethic (Liquori and Parker 1980). When starting to run, the key is to train regularly. For the jogger interested only in improving health, 30 minutes of exercise three or four times per week is probably all that is required (ACSM 1978). For the competitive runner, training needs to be done at least six days per week. Although most elite runners probably aim to train for at least 11 months of the year, I now believe this to be wrong. Athletes who wish to have successful careers that last for more than a few brief summers need, I think, to rest completely from all training for at least two months each year and to train slowly and consistently for another three months every year. I learned this approach from Mark Allen, perhaps one of the most consistently successful endurance athletes of all time.

Law 2: Start Gradually and Train Gently

Nearly all of us dash into it hoping for and expecting results which are quite unwarranted. Nature is unable to make a really first-class job of anything if she is hustled. To enhance our best, we need only, and should only, enhance our average. That is the basis we ought to work on, for it succeeds every time when the other fails. So, in running, it is essential to take to it kindly.

Newton proposed that the most effective training method for beginners is to run longer distances at a comfortable pace that is much slower than race pace and not to race in training. This type of training was rediscovered in the 1960s and termed long slow distance (LSD) by the American runner Joe Henderson (1969; 1974; 1976; 1977).

The wisdom in Newton's ideas is borne out by the training methods of the modern distance exponents, who do most of their running at slower than race pace and who are seldom able to reproduce their racing performances over distances longer than about 21 km in practice.

How the body is able to produce competitive performances greatly in excess of what is achieved in daily training is not known, but it must relate to either the accumulated effects of training or to specific programming of the brain, according to the Integrated Neuromuscular Recruitment Model. Nevertheless, it is clear that this very real phenomenon must be appreciated if the athlete is ever to achieve lasting success. The novice runner who repeatedly attempts to reproduce racing performances in training simply becomes overtrained (see chapter 7). It is also clear that runners who train only at low exercise intensities will not perform to their potential in competition (see Law 3), at least at running distances up to 100 km.

We now appreciate that another reason why training should initially be gentle is because the bones, tendons, and muscles, even of young healthy humans, are simply not able to adapt overnight to the cumulative stress of regular training. For this reason, it is best to begin training with a period of walking and to start jogging slowly at first and for short periods of time only.

The beginner's training program in shown in table 5.8 incorporates an initial walking period like this. As training volumes increase, it is invaluable to include some walking in the training program.

It is only necessary and possible for average runners to train at race pace for 5% to 10% of their total training distance. Most of the world's best marathon runners do most of their training at a speed of between 30 and 50 seconds per km slower than their race pace. Two excellent examples are Alberto Salazar and Rob de Castella (see chapter 6), both of whom did most of their training at 3:45 per km yet raced standard marathons at close to 3:00 per km. Wally Hayward seldom trained faster than 5:00 per km yet set world records in ultramarathon races by averaging 4:05 per km for up to 90 km. In simple terms, this means that the novice runner who ultimately plans to run a standard marathon in 4:30:00 will need to run the marathon at 6:00 per km. Therefore, an appropriate training speed would be between 6:00 and 7:00 per km. Similarly, this rule applies to races at other distances.

The best way for a novice to achieve the correct intensity of training is to monitor how the body responds to the effort. While running, you should feel that the effort is comfortable. You should also be able to carryon a conversation with your running companions. This ability to speak intelligently without becoming short of breath while running is known as the "talk test." Should the effort of the run become noticeable and result in you being unable to talk, you are straining, not training, and should slow down.

Another important point is that runners should never be ashamed to walk during training runs if they become overtired. At the start, at least, beginners should always finish each run feeling only pleasantly tired, knowing that, if they had to, they could comfortably run the same distance again.

The first scientist to observe that athletes could accurately predict how hard they were exercising on the basis of how they felt was Gunnar Borg. Borg (1973; 1978) noticed that there was a close relationship between the exercising heart rate, which, as we saw in chapter 2, is directly related to the intensity of the exercise, and how athletes actually perceived the effort they were making. He produced his Borg Scale, which provides a scoring system ranging 6 to 20, based on how the athlete feels when running (see table 5.2a). The figures he chose relate quite closely to the heart rate (divided by 10) that the athlete would achieve while exercising at those different ratings.

Table 5.2A The original Borg Scale Rating Perception of Effort (RPE)

Rating	Perception of effort
6	
7	Very, very light
8	
9	Very light
10	
11	Fairly light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Very, very hard
20	

From Borg (1973, p. 92). © by Lippincott, Williams & Wilkins. Adapted by permission.

More recently, the original Borg Scale was modified to accommodate the observation that the perception of effort does not increase in a linear fashion with increasing exercise intensity. Rather, as the runner approaches the lactate turn-point, the perception of effort increases very steeply. The new Borg Scale (Noble et al. 1983; Borg 1998), listed in table 5.2b, takes this into account by reducing the range of ratings that describe mild to moderate exercise (0-3) and increasing the range of ratings for heavy exercise (4-10). Using the scale, the athlete is able to describe with far greater precision the exact intensity of any exercise, but particularly that of more vigorous exercise. One of the best uses to which the runner can put the new Borg Scale is to record it in a logbook and use that information to calculate both the strain and monotony of the training program, as described in chapter 7.

Table 5.2B The category-ratio scale of perceived exertion—the new Borg Scale

Rating	Perception of effort
0	Nothing at all
0.5	Very, very weak (just noticeable)
1	Very weak
2	Weak
3	Moderate
4	Somewhat strong
5	Strong (heavy)
6	
7	Very strong
8	
9	
10	Very, very strong (almost maximal)
>10 (any number)	

From B.J. Noble et al. (1983, p. 523). © by Lippincott, Williams & Wilkins. Adapted by permission.

Another method of determining effort during running is to monitor heart rate during exercise. It is traditionally taught that maximum heart rate falls with age, but this does not necessarily appear to be the case in those who remain vigorously active for life (S. Edwards 1997). A simple equation used to predict the maximum heart rate (in beats per minute) is 220 minus age in years. Therefore, the predicted maximum heart rate of a 40-year-old is (220-40) beats per minute, which equals 180 beats per minute. However, there appears to be little or no scientific basis for this calculation (S. Edwards 1997). Thus, it is recommended that should you wish to use your heart rate to determine your appropriate exercise intensity, you should first establish your maximum heart rate.

Two factors that influence the maximum heart rate are endurance training and heart disease. All younger, highly trained athletes and most patients with heart disease have maximum heart rates that are lower than expected for their ages. In contrast, highly trained athletes over 50 years of age have higher maximal heart rates than predicted by this equation. Unless you are young and untrained, in which case the 220 minus age equation may be reasonably accurate, it is more appropriate to establish your maximum heart rate more accurately.

This can be done in one of two ways. If necessary (see chapter 2), you can visit an exercise laboratory and have an exercise scientist perform a maximum exercise test, during which your maximum heart rate, VO_2max, and lactate turn-point are measured. Alternatively, you can use a heart rate monitor and perform your own maximal exercise test. Maximal heart rates are usually achieved at exhaustion during all-out exercise that terminates within 4 to 10 minutes. Thus, the highest heart rate you achieve when running as hard as you can for 4 to 10 minutes will be your maximum heart rate. However, this test should not be undertaken in an unsupervised setting by people whose heart conditions are not known.

The popular training dogma is that maximum benefit is achieved by training at between

60% and 90% of maximum heart rate. Ideally, heart rates should fall between these values for most of the training time. Values higher than these should only be achieved during short-duration speed training with lower values achieved only when you are jogging during the days of recovery from hard training or racing. Table 5.3 and figure 5.5 have been drawn up for those who wish to control their exercise intensities on the basis of their exercising heart rates. Note that these heart rate ranges are for people with normal hearts. Anyone with known heart disease should first seek specialist medical advice before embarking on a training program. Sally Edwards (1997) has compiled one of the most comprehensive books on the use of heart rate monitors during training. She contends that the 220 minus age calculation for predicting the maximum heart rate has no solid scientific basis and stresses therefore that individual runners must establish their own maximum heart rates if they wish to use this method for establishing the correct training intensity.

Table 5.3 Maximum heart rates and target range for different ages

Age	Maximum heart rate (beats·min^{-1})	Target heart rate (beats·min^{-1})	Target heart rate range (beats 15·sec^{-1})
20-29	200	120-180	20-30
30-39	190	114-168	19-28
40-49	180	108-162	18-27
50-59	170	102-150	17-25
60-69	160	96-144	16-24
70+	150	90-132	15-22

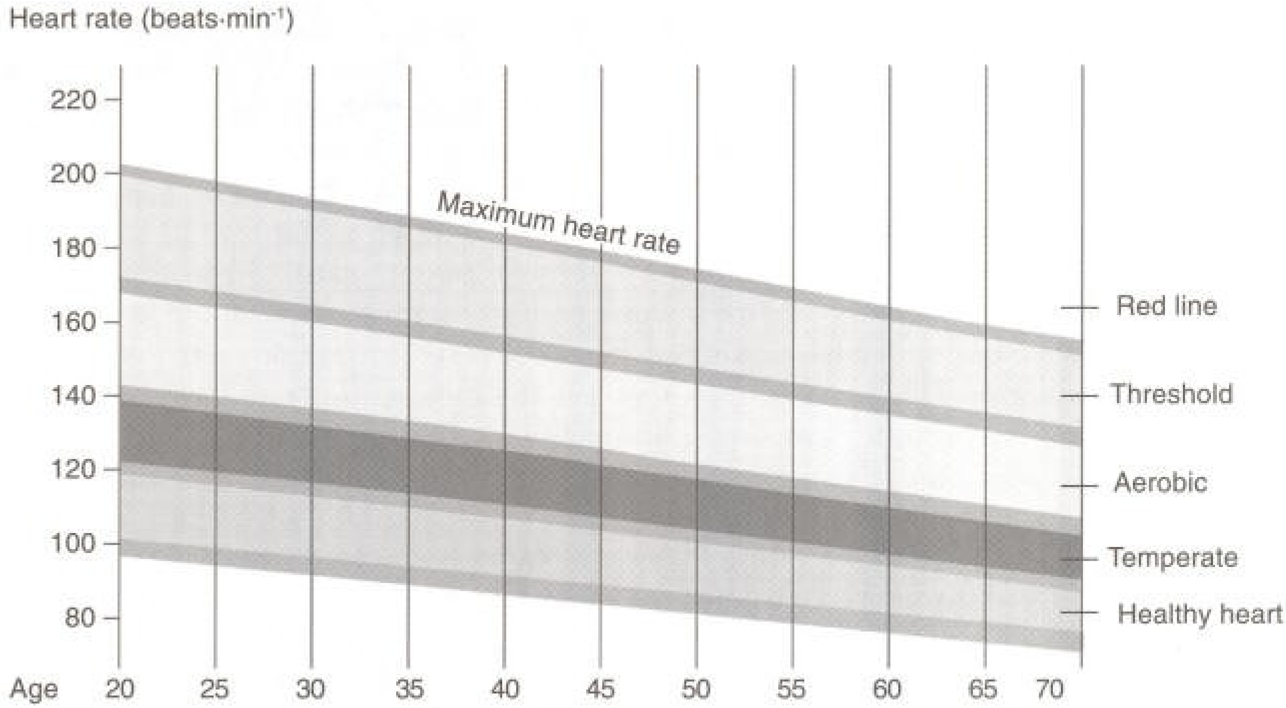

Figure 5.5 The five heart rate training zones of Edwards and Burke.

A recent study of Ironman triathletes indeed confirms the accuracy of Edwards's concern. That study (O'Toole et al. 1998) found that although the 220 minus age formula for calculating the maximum heart rate was more accurate than another popular formula of 210 (0.5 X age), individual variation in maximum heart rate was great. Thus, individual triathletes had maximum measured heart rates during cycling that could be either 35 beats per minute below or 16 beats per minute above those predicted by that equation. During running, the range was from 25 beats per minute below to 19 beats per minute above the predicted values. The authors also found that maximal cycling heart rates were substantially lower than maximum heart rates measured when running. Edwards also argues that the training guidelines of 60% to 85% of maximum heart rate are too broad to be of real value. Instead, she proposes five training heart rate zones. Table 5.4 identifies those zones and the frequency and duration of training in those zones, as well as the type of activity that will take you into those different zones.

Table 5.4 Exercise prescription according to five training heart rate zones: The methods of Sally Edwards and Edmund Burke

Zone	Frequency times/ week	Intensity (% of maximum heart rate)	Intensity (% $\dot{V}O_2max$)	Time (min)	Activity	Rating of perceived exertion (Borg Scale)	Descriptive rating, perceived exertion
Red line	0-2	90-100%	>85	2-4	Racing, intervals speed work	18-20	Very hard to very fast. Quite heavy breathing
Threshold	1-3	80-90%	75-84	15-55	Run, spinning, cross-country skiing	16-17	Hard to very hard. Heavier breathing
Aerobic	4-6	70-80%	63-74	20-120	Jog, swim, cycle step	13-15	Somewhat hard but still able to talk
Temperate	3-4	60-70%	50-62	15-30	Jog/walk, swim cycle	11-12	Fairly light. Brisk but comfortable. Breathing becomes slightly noticeable
Healthy heart	2-3	50-60%	40-49	10-60	Walk, low-impact aerobics	9-10	Very comfortable and light. Able to converse with ease

Adapted, by permission, from Iknoian (1998, p. 47).

Sally Edwards has competed in ultra-distance endurance events for the past 30 years, having completed, among others, the Hawaiian Ironman Triathlon on numerous occasions. In her book, Smart Heart (1997), she describes the following five training heart rate zones:

Zone 1: Healthy Heart-50% to 60% of the maximum heart rate. Training in this zone for sufficiently long (10 to 60 minutes, two to three times per week) produces the health benefits of exercise described in chapter 15.

Zone 2: Temperate-60% to 70% of the maximum heart rate. Exercising in this zone produces the same health benefits as those achieved in Zone 1 but, for the same time commitments, the benefits are greater. In addition, when the habitual training load is closer to 70% than to 60% of the maximum heart rate, the benefits begin to include adaptations that will improve running performance.

Zone 3: Aerobic70% to 80% of the maximum heart rate. The bottom rung of this zone (70% of maximum heart rate) is still more gentle exercise but the upper range (80% of maximum heart rate) corresponds to exercise that is "somewhat hard" or "hard" according to the Borg Scale (tables 5.2a and 5.2b). According to Edwards, training in this zone for sufficient durations produces major physiological adaptations (in the heart, in the exercised skeletal muscles, and in metabolism) that enhance endurance running performance.

Zone 4: Threshold Zone-80% to 90% of the maximum heart rate. This zone is strictly for those interested in high performance. It reflects the transition from the Aerobic Zone, a training zone that can be sustained for hours, to one that can be sustained by elite athletes for prolonged periods of at least 60 minutes, but only with some difficulty. When added to a sustained period of training in the Aerobic Zone, training in this zone produces rapid gains in performance and is most effectively used in the period immediately before competition. However, training too often and for too long in this zone, without adequate rest, will precipitate the overtraining syndrome (see chapter 7).

Zone 5: Red Une-90% to 100% of the maximum heart rate. Interval training at running distances up to 400 m provides entry into this training zone. This training produces the same results as those achieved by Zone 4 training.

Edwards made an important additional contribution by demonstrating how her training zone concept allows a more accurate quantification of the amount of training achieved with each training session. She suggests the following formula to make this calculation:

Workload (points) = duration x zone

Thus, exercising for 30 minutes in Zone 3 (with a heart rate of 70% to 80% of maximum) produces 90 points. When the training for each week is summed, a total weekly training load can be calculated. This information can then be used to calculate the exact amount of training that produces optimum racing results without the risk of overtraining.

Using Heart Rate Monitors in Training

The first heart rate monitors used by modern athletes can be traced to a meeting held in 1976 between Professor Seppo Saynajakangas of the Oulu University Electronics Laboratory in Oulu, Finland, and the coach of the university's crosscountry skiing team. The coach sought the professor's help because of his conviction that he would be a better coach if he knew what the heart rates of his athletes were during training and competition.

Appropriately challenged, Saynajakangas formed the family-controlled company, Polar Electro, in Kempele, Finland, in 1997, subsequently leaving the university to devote his time exclusively to his new company. In 1998, in excess of 2 million Polar heart rates monitors were sold worldwide, establishing Polar as the leading manufacturer in the field and proving that athletes around the world endorse this technology.

Modern heart rate monitors vary considerably in their levels of sophistication. The simplest heart rate monitors display heart rates in real time and are therefore useful in controlling the appropriate exercise intensity by heart rate (figure 5.5). The added advantage of some, like the Polar Smart Edge, is that they also calculate the number of calories expended during each exercise session. This calculation is based on the measured relationship between heart rate and oxygen consumption, adjusted for the subject's gender, body mass, and maximum exercise capacity predicted from the VO_2max.

These models are appropriate for novice athletes who do not wish to analyze their training in any great detail and do not foresee themselves becoming committed racers. Any runner who plans to become a serious racer with long-term performance goals, however modest, needs to consider the next advance in heart rate monitoring, which is the ability to store heart rate information from either a single exercise session (polar Coach) or multiple exercise sessions (polar Accurex Plus; Polar X Trainer Plus; Polar Vantage NY) and then to download that information via either a sound link or an interface unit. This allows all the heart rate information collected during each exercise session to be stored on a personal computer for analysis at a later stage. This information has additional value:

◙ As you become fitter, your heart rate at any running speed falls. Thus, improvements in fitness can be more easily gauged. For example, if you run a favorite route at a lower average heart rate but at the same or faster speed, then your body is adapting positively to your training.

◙ The rationale behind using frequent running tests to establish whether your body is adapting effectively to your specific training program is that, as you become fitter, your heart rate after exercise will return more quickly to its normal resting value.

◙ Once you are overreaching or overtraining (chapter 7), your heart rate will be increased at any running speed. When you observe this, you need to rest, not train.

◙ Should you notice that your heart rate is abnormally elevated during a training session, you should abort the session before greater damage is done.

◙ By quantifying the amount of time spent in each training zone, you are able to determine the exact training load you achieved in each session. When you subsequently evaluate your racing performances, you will be able to calculate the amount of training measured as the accumulated time you spent training in each heart rate zone. Conversely, if you perform poorly, then you will have an indication of where you went wrong-whether you did too much training at intensities that were too low or too high.

◙ By using a heart rate monitor, you will soon learn the heart rates you can sustain for different distances. This can help prevent you from starting out too fast in longer distance races.

The Polar Coach heart rate monitor enables you to download training information daily, by sound, into a computerized training logbook that stores the information for later analysis. You can then integrate this information into a series of different training programs developed by running experts, including Jeff Galloway, Arturo Barrios, and Ray Benson, among others. Novice runners who use this system can therefore follow more personalized training programs not covered to any great extent in this book.

The most recent advance on this technique comes from the novel idea of South African-schooled Crispian Hotson, who realized that the value of heart rate monitoring resides not in the technology but in the intelligent interpretation of the information stored in the heart rate monitor. The key then is to link the heart rate monitor to the exercise scientist who understands that information and who is able to interpret it most effectively for the exerciser. In this way, the exerciser can be coached at a distance using heart rate monitoring and access via the Internet to appropriately trained exercise scientists working in university research laboratories around the world.

Winning Wellness, the company that has developed Body iQ in collaboration with our research team at the University of Cape Town and the Sports Science Institute of South Africa, now provides training advice and distance coaching to those with access to the Internet who use either Polar Heart Rate monitors or the Body iQ Binky Heart Rate Monitoring system, the Body iQ Max product. The product includes a sophisticated logbook function and a unique electronic personal medical and training folder, accessible via the Internet.

Phillip Maffetone (1996) is another scientist/coach who has become well known for training ideas that incorporate heart rate monitoring. Coach to world class triathletes Mike Pigg and Mark Allen, Maffetone developed his "180 minus" formula for establishing the peak heart rate you should achieve during the first three months of training at the start of the new training year. The same formula is probably also appropriate for the beginner runner. To calculate your "180 minus" training heart rate, you subtract the following from the number ***180:***

your age (in years);

10, if you are recovering from a major illness or recent hospital visit, or if you are on any regular medication; and

5, if you have not exercised before, or if you have not recently been exercising normally because of injury, illness, or lack of interest; or

0, if you have recently been exercising regularly without interruption.

Finally, if you have been exercising for more than two years without interruption and your fitness has steadily improved, you should add 5 to your total. Thus, a 50-year-old runner with no known medical conditions who has never exercised before would exercise at a peak heart rate of 180 50 5 + 0, or 125, beats per minute. If the same runner had a known medical condition for which he was receiving treatment, his peak heart rate would be 10 beats per minute lower, or 115 beats per minute. If, on the other hand, he was completely healthy and had been training without incident for two years, his peak heart rate would be 135 beats per minute. While there is no firm scientific basis for these calculations, their great value is that they give a fixed and easily understandable guideline, they are extremely conservative, and they encourage you to train gently for a prolonged period (three months) with little risk of illness or injury.

Mark Allen has ascribed much of his success during an astonishing 14-year career to his adherence to the Maffetone principle for at least three months per year. Allen calls this period of training his "patience phase." Patience in training is indeed an excellent maxim for most runners.

----Note: Use the following formula to estimate the max heart rate of a very well conditioned athlete: 210 - 1/2 the athletes age. RKD

Law 3: Train First for Distance, Only Later for Speed.

If you are going to contest a 26-mile event, you must at least be used to 100 miles a week. . . . As it is always the speed, never the distance, that kills, so is it the distance, not the speed, that has to be acquired. In the early days of training, you must endeavor only to manage as great a distance on each practice outing as you can cover without becoming abnormally tired. . . . Your aim throughout, should be to avoid all maximum effort while you work with one purpose only and that is to achieve a definite and sustained rise in the average speed at which you practice, for that is the secret of ultimate achievement. . . . You must never, except for short temporary bursts, practice at racing speed.

The notion that you should never, except for short, temporary bursts, practice at racing speed is essentially a corollary to Newton's second law, in which he warned against the dangers of excessive speed training. In this law, Newton elaborated on his principal belief that the goal of training is to gradually increase the speed that can be maintained for prolonged distances. And this, he believed, could be achieved only by training that emphasized distance, not speed. Interestingly, AU Shrubb (1910, page 64) had drawn the same conclusions: "It is the distance and not the pace that is going to kill in the long-distance race."

Newton was the first, after the professional pedestrians, to describe two components that are central to the training beliefs of the New Zealand running coach, Arthur Lydiard: the 100-mile training week and the belief that the human body already has sufficient speed and lacks only endurance.

However, since Newton's era, training has evolved considerably, with more emphasis being placed on the need for regular weekly sessions of speed training or speed work. The first reference that I could find to an athlete who regularly performed speed training was AU Shrubb (1910). At least twice per week, Shrubb ran at close to race pace for distances from 4 to 16 km. Hannes Kolehmainen probably also used speed training and has been credited as one of the first runners to practice speed play (fartlek), in which the athlete surges with bursts of speed over varying distances, usually on the road or across country (Doherty 1964). Kolehmainen probably also influenced the next great Finnish runner, Paavo Nurmi, to include speed work in his training. As described in chapter 6, Nurmi considered his early years of training to be less than optimal because he had not included sufficient speed training. He believed this to be the reason why he remained a "slow trudger" until 1924, when he first included regular speed training sessions, having already developed the training base that Newton advocated.

With this evidence, I have altered this third law from Newton's to read: Train first for distance, only later for speed.

Thus, Nurmi's principal method of speed training was interval repeats, first of 80 to 120 m and later of 400 to 600 m. This type of training was subsequently refined independently by the German team of physiologist, Hans Reindell, and coach, Woldemar Gerschler (pirie 1961; Doherty 1964; Burfoot 1981a) and by Franz Stampfl, the British coach of Roger Bannister (Stampfl 1955; Lenton 1983a). Bannister used pure interval training to break the 4-minute mile barrier, whereas Zatopek was the first to use large numbers of intervals, run at varying paces, to accumulate both a volume and an intensity of training not previously matched. In the 1950s and 1960s, marathoners Jim Peters and Buddy Edelen then adapted these principles for marathon training, as did Alberto Salazar in the 1970s and Steve Jones in the 1980s (chapter 6). Also, it seems likely that the East, North, and South African distance runners, who began to dominate the marathon in the 1990s and into the new millennium will continue to do so.

The wide acceptance of speed work today suggests that it is both effective and essential for all runners who wish to improve and to be competitive. But this should not detract from Newton's observation that the greatest performance improvements occur, at least initially, after the athlete has developed a strong endurance base through long, slow, distance training. My own feeling is that speed work should be approached with extreme caution, preferably with the help of a knowledgeable coach, or after consulting the appropriate writings of the training experts listed earlier in this chapter.

Thus, Newton's advice that you should never undertake speed training clearly only applies to novice runners and to athletes who run for enjoyment and who are not concerned about improving their speed. There is no doubt that the standard of competitive running has progressed significantly since Newton's day, and it would be unthinkable for a modern elite distance athlete to try to succeed in competition without doing some speed training. As we shall see when we discuss the training methods of several athletes in chapter 6, it becomes clear that even ultra-distance runners need speed training. .

In summary, the key to successful training, at least for the first 12 months or so, is the amount of time you spend running each week, rather than the distance you cover or the speed at which you run. Therefore, you should initially aim to run for a certain time each session. You will run farther when you are fresh and rested than when you are tired. In this way, the effort will be controlled. Remember that the initial goal in distance training is to increase gradually the speed or effort that can be maintained for prolonged distances.

It has been found that after 12 or more months of training, athletes who only do distance training reach a definite plateau. To improve beyond this, the athlete must either further increase the distance run in training or else run the same distance but run some of that distance at a faster pace-that is, use speed training.

The evidence clearly indicates that increasing the distance run in training is frequently counterproductive, particularly when the weekly training distance goes beyond about 190 km per week. By judiciously using a limited amount of speed training at the correct time, it is possible to achieve quite dramatic improvements in performance (see Law 9 on pages 307-324).

If you wish to experiment with speed training, first read all you can about the different methods of speed training (Gardner and Purdy 1970; Henderson 1977; Daws 1977; Osler 1978; Lydiard and Gilmour 1978; Galloway 1984; Glover and Schuder 1983; S. Edwards 1997; Martin and Coe 1997; Daniels 1998). Then speak to the experts, the speed-trained athletes and their coaches, and find a group of experienced runners whose running performances are similar to yours but who do regular speed training as part of their peaking program. Or else consider using a computerized training program, such as the PC Coach Athletic Training software, which has programs for training purely by heart rate for distances of 800 m to 10 km (developed by Coach Ray Benson), 10 km (by Arturo Barrios), 21 to 42 km (by Jeff Galloway), and 42 km (by Uta Pippig). Or, if you have Internet access, consider the Body iQ option (www.BodyiQ.com) ***Note: "BodyiQ" is now "Virgin Life Care" http://www.virginlifecare.co.za/ RKD.***

The reasons for doing speed work relate to both physical and mental needs. Faster running trains the quadriceps muscles and the Type II muscle fibers in all the lower limb muscles. These are the muscle groups and the muscle fibers that are needed during longer distance races but remain untrained if you run slowly during training. Another benefit is learning to relax at speed. Furthermore, it is likely that the fast running adapts the ventilatory muscles for high work rates and may help prevent stitches.

Speed work also trains the central governor to allow for greater effort. A target is set, and a time is laid down. But the governor resists by testing the will, arguing that such effort is unnecessary. As a result, speed work becomes a test of that will. The choice is simply between doing and not doing the chosen task. There is no place for explanations, excuses, and rationalizations. Only when you have successfully faced that reality in the unforgiving solitude of the track are you ready for that best race.

Indeed, according to the Integrated Neuromuscular Recruitment Model, the real benefit of interval training may simply be to reset the central brain governor so that it allows a greater skeletal muscle recruitment during maximum exercise. This theory predicts that the very high-intensity training achieved during the intervals teaches the governor that such exercise can indeed be undertaken without risk of damage to the body. Thus, the governor learns to allow higher levels of skeletal muscle recruitment during subsequent bouts of high-intensity exercise.

But speed work is not without risk: the twin dangers are running the sessions too often and running them too fast, the natural trap for athletes who are overeager or for those who consider their inability to run faster a result of not training sufficiently hard (rather than a lack of genetic endowment-see chapter 2). My ideas about this type of training are described in greater detail at the end of this chapter. Those of some of the world's greatest runners are presented in chapter 6. All agree that high-intensity training is one of the two pillars on which successful racing is based.

Law 4: Don't Set Your Daily Training Schedule in Stone

Don't set yourself a daily schedule; it is far more sensible to run to a weekly one, because you can't tell what the temperature, the weather, or your own condition will be on any day.

Here Newton introduces the concept of listening to your body, an idea subsequently popularized by George Sheehan (1972; 1975). Using this technique, runners monitor how they feel before and during their runs and then adjust their training on any given day according to how they feel during each run.

Many runners choose to run each day according to a prearranged schedule. This approach is less than ideal because, as Newton pointed out, the weather may not always be appropriate. On that particular day, your body may not be up to undertaking the scheduled training. In particular, factors either within the body (minor illness or muscle soreness indicating lingering fatigue from the last workout) or external to it (work and family commitments, lack of sleep, and travel) may reduce the body's ability to perform on that day and, more important, its ability to benefit from that particular training session. Inappropriate training performed with sore and damaged muscles will not only be ineffectual, as the damaged muscles are unable to perform properly, but will also delay muscle recovery.

A daily schedule should act only as a guideline. You should be flexible about modifying the plan if conditions such as the weather or any other factor mitigate against adhering to it. The key to knowing how much to train on any given day comes from learning to listen to your body. This, of course, is much more difficult than religiously following a detailed training schedule because it demands insight and flexibility, attributes that not everyone possesses. Yet, in the end, the ability to know how much training to do on any particular day ultimately determines your running success. There is immense wisdom in Marti Liquori's statement: "What is pain or discomfort to a relatively inexperienced runner is merely information to the elite runner" (Liquori and Parker 1980, page 78).

Be attuned and monitor how your legs feel at the start of each run, as well as during the run. When you are training hard, it is usual for your legs to feel slightly tired and lethargic at the start of a run. However, this feeling should lift rapidly as the run progresses. Muscle stiffness and soreness that either persist or get worse during a training run indicate that your legs have not recovered. In this instance, you should abandon your run and rest for a period to allow muscle recovery before undertaking another hard or long training session. If your legs do not regain their feeling of strength after 24 to 48 hours of rest, then your body is telling you that you are well on the road to overtraining (see chapter 7).

Law 5: Alternate Hard and Easy Training

This is one of the laws that Newton did not practice. His training was relatively similar from day to day, a luxury he enjoyed first as a self-employed farmer in KwaZulu Natal and later as a professional runner. The danger of training monotonously in this way, by following a heavy but unvaried daily training schedule, is that it increases the probability of illness and overtraining.

Bill Bowermann and Bill Dellinger, the coaches behind the dynasty of great runners that has emerged from the University of Oregon at Eugene, were the first to teach that training should not always be of the same intensity and duration, day in and day out (Burfoot 1981b). They observed that their runners progressed best when they were allowed a suitable recovery period after each hard training session. For some, this period was only 24 hours; for others, it might have been as long as 48 hours. This is what is known as the hard day/easy day training program. Author and marathon Olympian Kenny Moore, who trained under Bowermann and Dellinger (K. Moore 1982) and who was one of the runners needing 48 hours' recovery, called his personal variation the "hard/easy/easier training method" (Galloway 1984).

Dellinger claims that the hard day/easy day description of the Oregon training approach is inaccurate: "Strictly speaking, it's misleading to say that we follow a hard-day/easy-day pattern. Our kids run two workouts that I consider fairly hard, on Tuesday and Saturday. On Thursday they might do a little quality work, but it's short and not very intense" (Burfoot 1981b, page 57).

Researchers have not established why the body is unable to train hard every day, but the phenomenon is probably due to muscle damage of the same type as that caused by marathon racing, although less severe. It is probable that this degree of muscle damage requires about 24 to 48 hours to recover fully, rather than the six to eight weeks needed after a 42-km marathon race.

Training is not simply a matter of stocking up with fuel and repeating what was done the previous day. To be a wise runner, you must learn that if the previous training session was hard, regardless of what your mind tells you or what you imagine your competitors might be doing in training, you must allow your body to recover so that it can restock its energy stores and repair the micro-damage caused by the previous day's heavy training. Hard training when the body is not fully recovered simply compounds damage already done.

All athletes must establish for themselves how frequently they can train hard. Their success will, to a large extent, depend on whether or not they achieve this balance. Paula Newby-Fraser, eight-time winner of the women's division of the 226km Hawaiian Ironman Triathlon, has also written that she built her training around three key workouts per week:

These sessions are the foundations of my training, and they rarely change in structure. They are my "bread-and-butter" work. During these workouts, I focus all my energy-mentally, physically, emotionally-in every possible way. Key workouts are the best measure of my peak fitness and are the acid tests for speed, endurance, and strength. After a key workout, I can accurately judge where I am on my performance scale. Key workouts are a much better measure of fitness than total mileage because, even though you're racking up the miles, weaknesses such as lack of speed, endurance, or strength may be camouflaged. (Newby-Fraser and Mora 1995, p. 161)

Law 6: Achieve As Much As Possible on a Minimum of Training

This law, which was not ever formulated by Newton, would seem to be the opposite of the first law, which emphasizes the importance of training frequently all year round. The point, perhaps, is that it was only after Newton's example in the 1920s that amateur runners around the world began to train as hard as their bodies would allow. Before that, only the professional pedestrians had pushed their bodies to their physical limits in both training and racing.

But since the first running boom of the 1970s, an increasing number of runners have begun to believe that the more they train, the more successful they will be. In fact, there is a limit to the amount of training the body can benefit from. Training beyond that limit produces progressively poorer performances, leading ultimately to overtraining.

Thus, for some reason, part of the macho image of running is built on the myth that the top runners and Ironman triathletes achieve greatness by enduring training programs quite beyond the level of the rest of us. The best runners, the world would have us believe, are those who train the hardest. Nowhere do you ever read about the many great athletic performances that have been achieved on very little training nor, as described in chapter 6, about how well these top runners perform even when they train very little. In part, this results from a prevailing international ethic that holds that the environment contributes far more to who we are and what we become than do factors that are beyond our control and that may have an hereditary (genetic) component.

But it is clear that genetic ability has more to do with why the great athletes beat us than their harder training, and there is no earthly way in which training can reverse the physiological realities and thus reduce the chasm that divides us from them. Unfortunately, too many runners believe that they must train hard to run well and end up doing too much to try to compensate for their genetic deficits. But, by starting with a modest training program and then gradually increasing and modifying the balance between increasing training distance and training speed (see Bruce Fordyce, chapter 6), the crossover point where increased training leads to compromised, not better, performance and increased injury risk can be clearly identified. In sum, this was how both Mark Plaatjes became world champion.

For example, who ever records that exceptional runners like Walter George and AU Shrubb achieved quite remarkable performances on very low mileage? George ran a mile in 4:10.6 and a 16-km run in 49:29 on little more than 3 km of training per day. Even Paavo Nurmi, the most medaled Olympic runner of all times, trained pathetically little but performed exceptionally, even by today's standards. The outstanding performances of the black African runners, from Kip Keino to Matthews Temane, have also been achieved on relatively little training in which high quality but relatively low volume has been emphasized.

My own experience has backed this up. If I had my running career over again, I would seldom run more than 120 km per week, the maximum training distance suggested by the University of Oregon's Bowermann and Dellinger. I would see what I could achieve by maintaining that training load for a few years. If I still wished to improve, I would then increase my amount of speed training and perfect the peaking technique. Only when these methods failed to improve my running would I consider further increasing my training distances.

So I would suggest that, when starting a running career, you should decide on the amount of time you can commit to your training. Provided this is less than 6 to 8 hours per week, there is little possibility that, on this volume of training, you will be able to overtrain to the point that your running performances will be impaired by training too much. Thus, any amount of training that can be completed in less than 8 to 10 hours per week can be undertaken quite safely.

The danger starts when you wish to train for more than 10 hours per week, equivalent to a training volume of 120 to 160 km per week for average and elite runners respectively. This is the point beyond which the law of diminishing returns begins that is, more training produces progressively less benefit with the increasing possibility that you will start to perform worse than if you had trained less (figure 5.6).

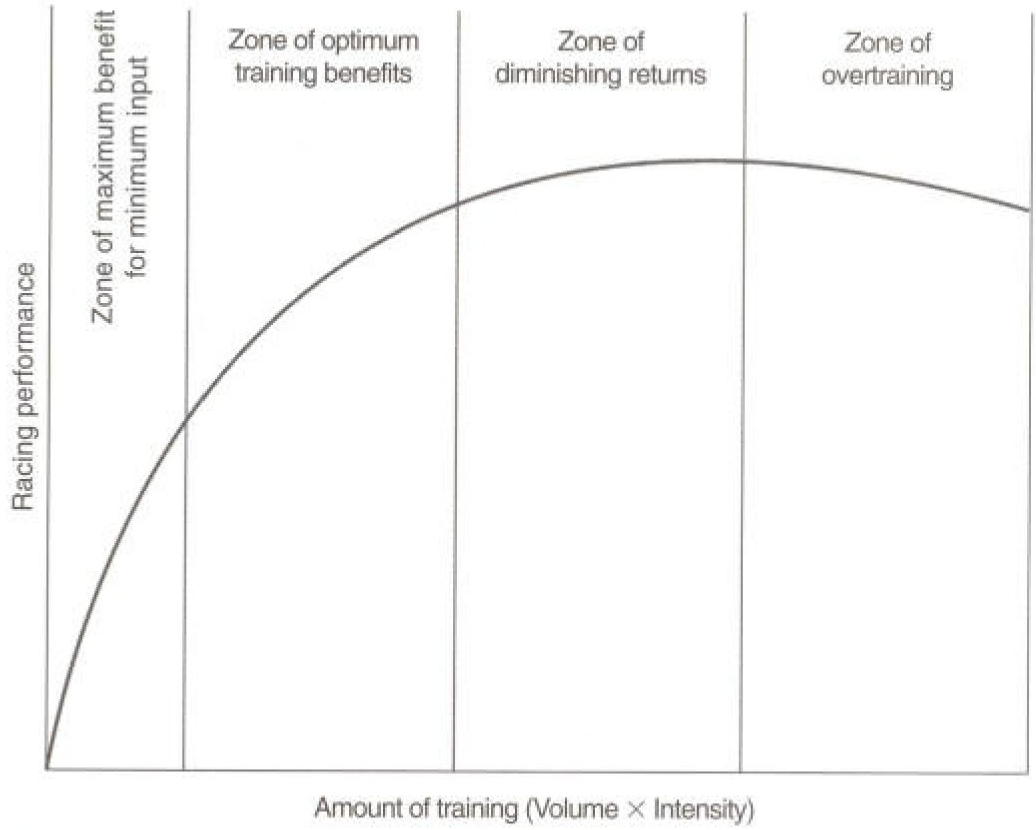

Figure 5.6 Theoretical diagrams showing how to determine your optimal training load. Adapted from C. Foster, Daines, et al. (1996).

How, then, do you determine the individual training threshold at which your training volume produces maximum benefits (figure 5.6, zone of optimum training benefits)? I would suggest that your first priority is patience-you have many years to answer this question, so a measured approach is essential. Take the long-term view that running is something worth doing for at least 5 to 15 years and that, during that time, your goal should be a progressive but gradual improvement. This is to be achieved first by finding the training volume that produces the best results and then by gradually increasing the intensity of some (perhaps 15% to 30%) of that training to optimize training.

Thus, your weekly training volume during the more intensive training period of the year can be gradually increased until the point of optimum training is identified. This training threshold can really only be identified if you train both less and, finally, more than this optimum amount. Accordingly, your training volume needs to be increased gradually and progressively until the training volume at your individual failure threshold is identified. This corresponds to the training volume that produces a deteriorating, not an improved, racing performance. The identification of this training threshold is a crucial exercise in ultimately helping you determine how you achieve success. Runners such as Bruce Fordyce and triathlete Mark Allen, who consistently achieve levels of excellence, largely owe their success to their ability to identify their individual failure thresholds that they never again exceeded in their training. (Interestingly, Mark Allen originally failed to win the 226-km Hawaiian Ironman Triathlon because he trained less than he needed to (see chapter 6)an uncommon failing in runners but perhaps more likely in triathletes, who spend most of their training time in non-weight-bearing activities.

In contrast, athletes whose success is intermittent and who are never certain of how they will perform, such as Ron Hill, have never identified their individual training thresholds. Usually they train beyond their thresholds, perform poorly, and conclude that their failure proves exactly how lazy they are. Thus, they train even harder, and their performance deteriorates as they enter the zone of overtraining.

Only when these runners stop trying, lose interest, and train less do they again start performing to their potential. Only then, when it is too late, do they begin to understand the training threshold concept, and only then do they learn that too much training was more detrimental to their performance than too little training.

Quantifying Your Training Load

To identify your optimum training load, you must be able to quantify exactly how hard you are training. Most runners measure the number of kilometers they run each week and assume that mileage alone accurately measures their training loads. Yet, that measurement does not quantify the quality of that training. Furthermore, the quality of the training is probably a better predictor of both future performance and the risk of overtraining (chapter 7). Hence, a measure of both the quantity and quality of training is required. Carl Foster of the Milwaukee Heart Institute is one scientist who has pondered this challenge.

Foster and his colleagues (Foster et al. 1996) evaluated the performances of 56 competitive athletes as they increased their training. They calculated the training load as the duration of the session multiplied by the average rating of perceived exertion (RPE; tables 5.2a and 5.2b) during the session. However, to facilitate ease of use, they developed slightly different phrases to describe the different ratings on the Borg Scale (table 5.5). Then, to work out the mean weekly duration of high-intensity training, they calculated the minutes of training during the week that elicited an RPE greater than 5. Figure 5.7 illustrates some of their findings.

Table 5.5 The modified Borg Scale for RPE used to calculate training load according to the method of Foster et al. (1996).

Rating	Verbal description
0	Rest
1	Really easy
2	Easy
3	Moderate
4	Sort of hard
5	Hard
6	
7	Really hard
8	
9	Really, really hard
10	Just like my hardest race

Subjects were asked to describe the overall perception of effort during the session as if they were responding to their mothers' question: *How was your workout, honey?* Permission granted by C. Foster.

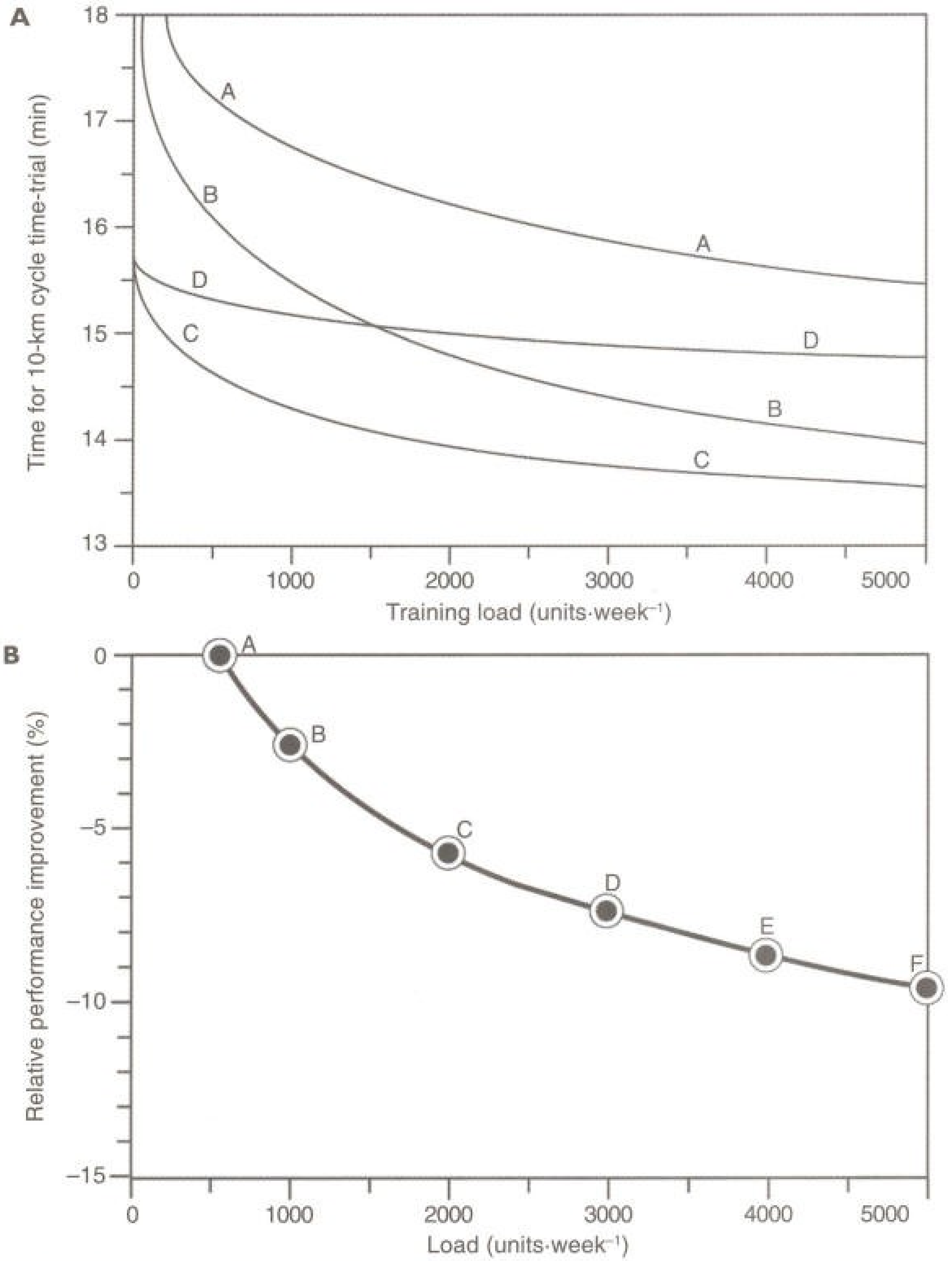

Figure 5.7 Carl Foster's models of the effects of different training loads on racing performance. Adapted from C. Foster, Daines, et al. (1996).

Figure 5.7A shows the improvement in 10-km times achieved by four different speed skaters as they increased their training loads. Observe that the rates of improvement with increasing training load (the slopes of the four curves) are quite different for the different skaters.

Whereas skater B shows the steepest improvement in performance with increasing training load, skater D improves very little with increased training. Skaters A and C show improvements that lie within these two extremes. Hence, the response to training is highly individualized, as frequently stated.

Figure 5.7 B represents the average percentage improvement that an athlete in that study could expect with increases in training load. Point A represents the baseline performance that an athlete with a weekly training load of 500 units (100 minutes of exercise at an RPE of 5, table 5.5) could expect. If the athlete doubled her training to point B on that figure, she could expect her performance to improve by 3%. Further training increases of 1000 units per week (points C, D, E, and F) would produce progressively smaller improvements in performance of 2.5%, 1 %, and 0.5% respectively. Thus, because of this logarithmic relationship between training load and performance, a 9% increase in performance requires a 10-fold increase in training load (figure 5.7B). Perhaps this too is expected as it confirms the law of diminishing returns. However, the importance is that the method of Foster et al. (1996) allows you to evaluate your training load (chapter 7). Plotting your training load against your own performance will enable you to determine your own optimum training load, as suggested in figure 5.6.

Law 7: Don't Race When in Training or Run at Race Pace for Distances Above 16 Kilometers

I decry such things as time-trials. . . . I am convinced that they are nothing more than a senseless waste of time and energy. They can't tell you any more than the race itself could. . . . Racing, then, should be the only time-trials, and should only be run every two, or preferably three, weeks apart. . . . six weeks between events would be more suitable for a marathon runner, but once every two months is probably better.

It is clear that Newton was strongly opposed to time trials and races other than the major event for which he was training. We have to presume he meant time trials over marathon distances, rather than over distances of 8 to 12 km, which would seem to be essential for elite 10-km, marathon, and ultramarathon runners and probably for any experienced athletes wanting to improve their performances (Law 3). However, I believe that all novice runners should avoid time trials initially and should rather follow Newton's ideas about building endurance and not speed.

The accuracy of Newton's observation that a period of six to eight weeks must be allowed between longer-distance races has only really been reinforced in recent years. We now know that races longer than about 25 km produce marked muscle damage that takes a considerable time to repair (Biomechanical Model of Exercise Physiology), probably longer than Newton estimated. The essential points to remember are that fast running exhausts not only the body but, equally important, the mind. Thus, the amount of fast training and racing that you do must be carefully controlled. As Bruce Fordyce (1996) has so frequently stated: "When I am preparing for a major effort in an ultra-distance race, I have one rule about entering other long-distance races-don't. If I could have my way I would force my running friends not to race a single race of 42 km or longer in the six months preceding the [90 km] Comrades" (p. 32).

A rule of thumb is that the shorter the race, the more frequently it can be run, but approach runs beyond 25 km with caution as it appears that racing-induced muscle damage starts to occur in races longer than 25 km (Strachan et al. 1984). Generally, only race two to three races longer than 32 km each year. By racing, I mean running to total exhaustion. An athlete can certainly enter shorter races more frequently but again, exercise restraint (see chapter 9 for more information on racing distances shorter than the marathon).

On the issue of time trials, those who have studied Lydiard's training methods (Lydiard and Gilmour 1978) are aware that he advocates regular time-trials during the peaking phase. Yet, it is clear that he shares Newton's concerns about the dangers of racing in training, for he states, *The word "time-trial" is often misleading. Basically, a time-trial is used to develop coordination in running races over certain distances, and to find* *weaknesses and use the appropriate training to strengthen them. Time-trials should not be run at full effort, but with strong, even efforts, leaving you with some reserves. (p. 76)*

Lydiard also advised strongly against racing in training and placing too much reliance on the stopwatch. Too much concern with time can result in athletes' losing confidence, particularly as they may be tired from heavy training. In his own words: "Remember that when you are doing time-trials, you are still training hard, so good times cannot always be expected. You cannot train hard and perform well simultaneously."

An error that many runners make in running regular time-trials is to think that each trial must be faster than the last. This is neither desirable nor possible. The surest indication that you are improving is if you are able to run the same or better times in successive time-trials but at a lower heart rate, with less effort, and with a more rapid recovery.

Law 8: Specialize

Specialization nowadays is a necessity. Modern exponents have raised the standards to such a height that nothing but intensive specialization can put a fellow anywhere near the top. Before the 1914 to 1918 war, the marathon was considered an event for only the favored few who had unusual toughness and stamina.

It takes anything from 18 months to three years to turn a novice into a first class athlete. You will have to drop the bulk of your present recreations and spend the time in training; anything from 2 to 3 hours a day will have to be set aside. Athletics must be your major engagement for at least two years on end, your business or means of making a livelihood being at all times of secondary importance.

In this rule, then, Newton was suggesting nothing less than making running a profession, a choice he made when he entered the 1928 Transcontinental Race across North America. Until the early 1980s, Newton's ideas were quite contrary to prevailing thought, perhaps best epitomized by Sir Roger Bannister (1955), the world's first sub-4-minute miler (chapter 8). Bannister has always seen sport as a diversion, rather than a profession:

I believe. . . that running has proved to be a truly amateur activity after all, one on which it is neither necessary nor desirable to spend unlimited time and energy. Fitting running into the rest of life until one S work becomes too demanding-this is the burden and joy of the true amateur. (p.221)

In my view, Sir Roger's ideas are not wrong. But times have changed, and what Newton foresaw more than half a century ago has now materialized.

For those of us who will never break into the professional ranks, I like to think that this rule stresses the importance of specific training. For we now appreciate that training is absolutely specific and that we are fit only for the sport for which we train.

Most runners will already have experienced this. They will know that while they can run effortlessly for hours, they are quite unable to swim comfortably even for a few minutes. The reason for this is that running and swimming train different muscle groups. When a runner exercises the untrained upper body in swimming, for example, the body responds as if it were essentially untrained.

Whereas running principally exercises the legs, leaving the upper body musculature relatively untrained, canoeing and swimming mainly train the upper body, leaving the legs untrained. Swimming and canoeing training do not improve running ability, or vice versa. This distinction may be even more subtle. Novice runners frequently find hill running difficult. This is because uphill running stresses the quadriceps (the upper thigh muscle)-a muscle that is much less important during running on the fiat and is therefore under-trained in people who run exclusively on fiat terrain. Similarly, running is the only form of training that adapts the legs for prolonged periods of weight bearing. According to the Biomechanical Model, weight-bearing exercise causes a specific form of exhaustion not encountered in a non-weight-bearing activity, like cycling. Hence, running is the sole method of training that will adapt the body to this type of exhaustion.

Training specifically also includes speed training, hot weather training, and altitude acclimatization. As discussed in chapter 1, the speed or intensity of training determines which muscle fibers will be active in the particular muscle groups being exercised. Thus, if you train slowly and then race at a faster pace, you may utilize muscle fibers that are relatively untrained. Similarly, to race effectively in the heat or at altitude, it follows that you need to train under these conditions as well to allow the body to adapt to them (chapters 4 and 9).

The result is that the more closely you tailor your training to the specific demands of the sport for which you are training and to the environment in which you will be expected to compete, the better you will perform.

Despite what I have written here, there is one observation that is at variance with the concept of the absolute training specificity. Some of the very best triathletes in the world have achieved prodigious endurance running performances, despite relatively modest running training. Some, like Mark Allen (chapter 6), have concluded that this is because of all the cycling training that they do. For example, in each of the four weeks of intensive training leading up to the Hawaiian Ironman Triathlon, Allen cycles up to 800 km per week while running about 128 km (Allen 1996b). This would equal about 20 hours of cycling and 8 hours of running per week. It seems possible that Allen's ability as a runner at the end of the Ironman may, in part, result from his cycling training.

Thus, one possibility is that cycling may provide the same metabolic stress as running without the same loading stresses on the muscles and the skeleton (see chapter 3). Cycling may produce training benefits for runners without the risk of muscle damage. Indeed, part of that training adaptation may be to preprogram the brain to accept that the brain was originally prepared to allow it. It is noteworthy that Allen observed that he became a winner of the Hawaiian Ironman Triathlon only after he included training sessions that lasted as long as his winning time in that race. This begs the question: does walking also have a similar programming effect on the brain?

Historically, it is interesting that walking was a central component in training all runners, including Paavo Nurmi. Newton also commented on the role of walking and cycling as additional training methods for long-distance running. Walking was very much in vogue in the 1920s, and there were many popular walking races, including the London-to-Brighton Stock Exchange race, the predecessor of the London-to-Brighton running race. As described in chapter 6, all runners of that era believed that walking should be the major component in long-distance training and that running should be performed only a few times per week. Even Newton's attitude was clear: "Walking is a waste of time. Long walks, even quick walks, do not help a man to run." (Newton 1949, p. 56)

Given this attitude, it is difficult to understand why Newton also walked more than 47,000 km during his running career. His explanation was that "There was a definite purpose in this walking, viz., to make me used to being on my feet nearly all the time. . . though at a much later date I decided it might have been better to run, for running was my job, not walking" (Newton 1947a, p. 64). Ultimately, he concluded that "the average young man would be better off if he left long walks until later on in life when strenuous exercise won't have so great an appeal" (Newton 1949, page 56). What is interesting is that walking is again earning respect as a training method, at least for older runners, especially those who have run many miles and countless marathons in their youth. The training circle continues to turn.

As one such runner, my observations are that very few runners are able to continue training hard and racing longer distances, especially marathons, indefinitely. Sooner or later, reality strikes and we discover that an unexplained X factor, present when we were younger, has gone missing. Of course, the most popular explanation is that we simply lack the desire to train and race as hard as we had in our youth. While this is certainly a possibility, my belief is that the loss of desire to train and race hard comes after we first notice changes in our bodies, partly due to aging and partly due to the accumulated effects of many years of heavy training and racing. My bias is dependent on observation made on myself and from following the careers of some great runners who are approximately my age, as well as the experiences of other runners described at the end of chapter 2.

First, I ran my best Comrades 90-km ultramarathon on my first attempt. Despite training as well, and perhaps better, for later races, I noticed that I ran differently in those races and consequently, I suggest, slower. I seemed to have lost some bounce in my stride in later years.

Second, close observation of Bruce Fordyce's running over the years during which he won nine Comrades Marathons suggested to me that he was not as fast or as consistent in his later years, when his running stride clearly changed. Previously light and bouncy, he seemed to become progressively more earthbound. The changes that were observed were similar to those sudden changes detected when runners hit the wall in the marathon and their running mechanics change as a result of the stretch-shortening cycle fatigue.

Third, it has become clear that the best young marathon runners of any generation are only the best for about the first 20 years of their careers. Thereafter, another group of their chronological peers, who began competitive running perhaps 15 years later, begin to dominate.

This explains why the world-class runners described in chapter 6 dominated world running before the age of 40 but no later. Any analysis shows that beyond age 40 it is a different group of runners who dominate, especially marathons. Then again, another different group of runners will dominate marathon races for 60-year-olds when that same group of chronological peers reaches that age. This tends to suggest that the best 80-year-old marathon runners will be those who take to the sport only after they turn 70. This factor alone explains why it has never been possible for one runner to dominate the sport at each group from, say, 20 to 60. An interesting recent example is Bill Rodgers (figure 5.8), who, with Frank Shorter, was the dominant marathon runner of the 1970s.

In 1999, at age 51, Rodgers set out to better the world marathon record for athletes over 50 years. In training, he completed one 16-km race in 52:15, a remarkable achievement for a 51-year-old athlete. Yet, he dropped out of the Boston Marathon at 30 km. In my analysis, this occurred because he hit the wall at that distance because his aging legs, altered by decades of heavy training and many marathon races, were no longer capable of coping with the eccentric loading necessary to complete the marathon without hitting the wall. What this means is that Rodgers is able to race almost as well as ever over the shorter distances, at which his muscles are still able to absorb the eccentric loading without failing.

But there is a racing distance that becomes shorter with increasing age and miles of races run at which this failure occurs, inducing the so-called wall phenomenon at increasingly shorter distances with age. It may also be that the running speed you can sustain after hitting the wall slows progressively as the result of this continued muscle aging and eccentric muscle damage.

In his book (Rodgers 1998), Rodgers provides insight into what I think has happened:

There have been other changes as I've aged. Starting in my late 30s and early 40s, I noticed a pretty much perpetual soreness in my legs that wasn't there before. I would definitely get sore 20 years ago, but when I did, it was an acute soreness, limited to one spot on my legs, and I could usually figure out why I had it. For example, if I wore spikes on the track, I could usually count on my calves being sore the next day, and I could count on that soreness disappearing within a few days. What I experience now is different, it's more low grade but it is almost always there. (p. 156)

I interpret the increased stiffness described by Rodgers as evidence of a fixed alteration in his muscle structure and function, causing a progressively reduced capacity to absorb shock and return elastic energy. This results in the earlier onset of fatigue and hitting the wall, especially during marathon races.

Thus, for older athletes, the value of walking (or cycling) may be that a measure of fitness can be achieved without risking further damage to the shock-absorbing and energy return systems in the legs. There may be a brain preprogramming component, as well.

Finally, in keeping with his ability to foresee trends in physical activity 50 years later, Newton also expressed some ideas about training for the triathlon or, at least, about the effects of cycling and swimming on running performance. He commented that walking, cycling, and swimming made no difference to his running abilities but did serve the purpose of keeping him "thoroughly fit."

Law 9: Incorporate Base Training and Sharpening

This rule implies that peak racing performance only occurs when a period of high-intensity, low-volume training (peaking or sharpening) follows a prolonged buildup period consisting of low-intensity, high-volume training (base training).

Franz Stampfl, the coach who had more to do with the first sub-4-minute mile than is generally acknowledged, was one of the first coaches to introduce the idea of background and peaking training (Stampfl 1955). But unquestionably, the coaches who refined this concept and first described it in detail were the Australian swimming coach, Forbes Carlile (1963), and the New Zealand running coach, Arthur Lydiard (Lydiard and Gilmour 1978).

In his book, Carlile (1963) provided the first detailed description of peaking that I could find. Figure 5.9 summarizes his ideas. Carlile divides the year into four quarters (periods I to IV) and into either a one-peak or two-peak year. For a one-peak year, period I comprises a complete rest from hard training, with emphasis on forms of exercise other than swimming. During period II, swimming training is increased, with the emphasis on technique, while period III is reserved for very heavy swimming training. This leads to period IV, the competitive period, during which the athlete tapers while competing regularly. In a two-peak year, all four periods are shortened, and less heavy training is done during period III.

Time	Southern hemisphere	Northern hemisphere	Relative amounts of training	
			One-peak year	Two-peak year
PERIOD I Recuperation	April to June	November to January		
PERIOD II Gentle training	July to September	February to April		
PERIOD III Hard training	October to December	May to July		
PERIOD IV Hard competition	January to March	August to October		

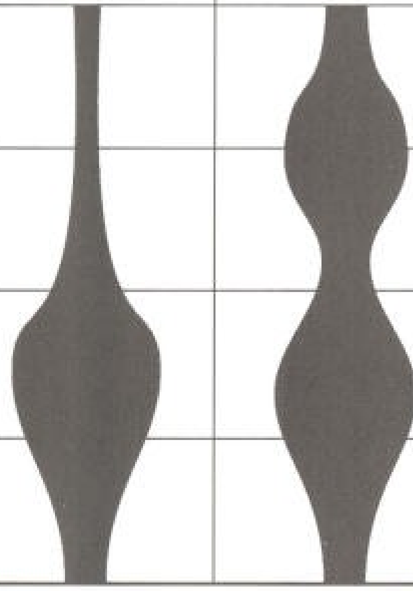

Figure 5.9 The Forbes Carlile yearly training plan.
Adapted from Carlile (1963, p.17). © 1963 by Forbes Carlile.

Two runners of that era who achieved their greatest success using this Carlile/Lydiard method of peaking were New Zealander Peter Snell and the "Flying Finn," Lasse Viren. Their stories illustrate the value of peaking. More recently, the great Kenyan runners have developed their own unique method of peaking.

Snell, the 1960 800-m Olympic gold medalist, had been written off by the press four weeks before the 1964 Olympic Games because he was unable to run the mile in less than 4 minutes. However, at the finals, Snell was unbeatable. While his competitors had already peaked by the time they arrived at the Olympics, Snell used the heats as the speed work he needed to bring him to his peak.

In January 1962, Snell completed what J. Kenneth Doherty (1964) considers the greatest middle-distance running the world has ever seen. In early December, Snell completed a standard marathon as part of Lydiard's base training program and began sharpening training in mid-December. With only two and a half weeks of speed training, he ran a mile in 4:01.3. During the following five weeks, he ran 880 yards in 1:48.3 and 1:47.3 and ran 800 m in 1:46.2; three days after the latter event, he ran a mile in the world record time of 3:54.4, followed one week later by a world record 800 m in 1:44.3 and 880 yards in 1:45.1. Snell fulfilled Lydiard's belief that his system would bring runners (you) "to your peak slower than many runners [ensuring that] you will be running last when they are running first. But when it is really important to run first, you will be passing them" (Lydiard and Gilmour 1978, p.33).

Similarly, Lasse Viren---a winner of very little besides four gold medals, two each at the 5000 m and 10,000 m in the 1972 and 1976 Olympic Games-appeared to be an "ordinary" athlete in non-Olympic years but beat the world by following Lydiard's ideas and choosing to peak only once every four years. I vividly recall watching a replay of the 1976 Olympic Games 1O,000-m final. With Viren leading the British hopeful Brendan Foster by half a lap, English broadcaster Ron Pickering remarked in dismay, "But Brendan Foster has beaten Lasse Viren four times this year." Viren spent four years of background training preparing for a single peak at the Olympic Games. And when he peaked, no one was near him. Of this ability Viren commented: "Some do well in other races, some run fast times, but they cannot do well in the ultimate, the Olympics. . . . The question is not why I run this way, but why so many cannot" (Daws 1978).

One of the less well appreciated facts about the rise of the great dynasty of Kenyan runners since 1985 was that Kenyan running began to sink into the (relative) doldrums in the early 1980s, in part because Kenya boycotted both the 1976 and the 1980 Olympic Games. As a result, a generation of runners was denied the incentive for excellence offered by the Olympic Games. However, former Kenyan international runner Michael Kosgei, who was appointed as the new national Kenyan coach in 1984, came up with a radical solution. He proposed that, in the future, teams chosen to represent Kenya in major international events (in particular the World Cross Country Championships) would be selected only from the best runners present at a three-week training camp held at altitude immediately before those international competitions. The effect was that Kenya's best runners at those camps would know that, to represent their country, they would have to race each other daily in training for those 21 days. The result is that Kenyan teams competing in international meets now represent the survivors of the hardest peaking training program ever undertaken by human athletes. For those who survive this ultimate peaking program, international competition must feel like a day off. Since adopting this model, the Kenyans have absolutely dominated the World Cross Country Championships and have achieved unequalled success in the Olympic Games (see chapter 6).

Somewhat easier and more conventional peaking methods have been described by Carlile (1963), Osler (1967 and 1978), Daws (1977), Lydiard and Gilmour (1978), and Daniels (1998), where more detailed explanations of the ideas and programs followed by these runners can be found. I personally found the books of Daws and Osler the most readable and easiest to follow. Their ideas are outlined in the section that follows.

Base Training

Base training consists mainly of long, slow distance (LSD) running. The aim is to run as high a mileage as possible without overtraining and to increase gradually the average speed and distance of the training sessions.

Tom Osler (1978; figure 5.10) suggests that base training should continue for at least six months and preferably one year before beginning any sharpening training. He also writes that the guiding principle during base training is that, after any training session, the runner should feel able to turn around and complete the same workout again if demanded.

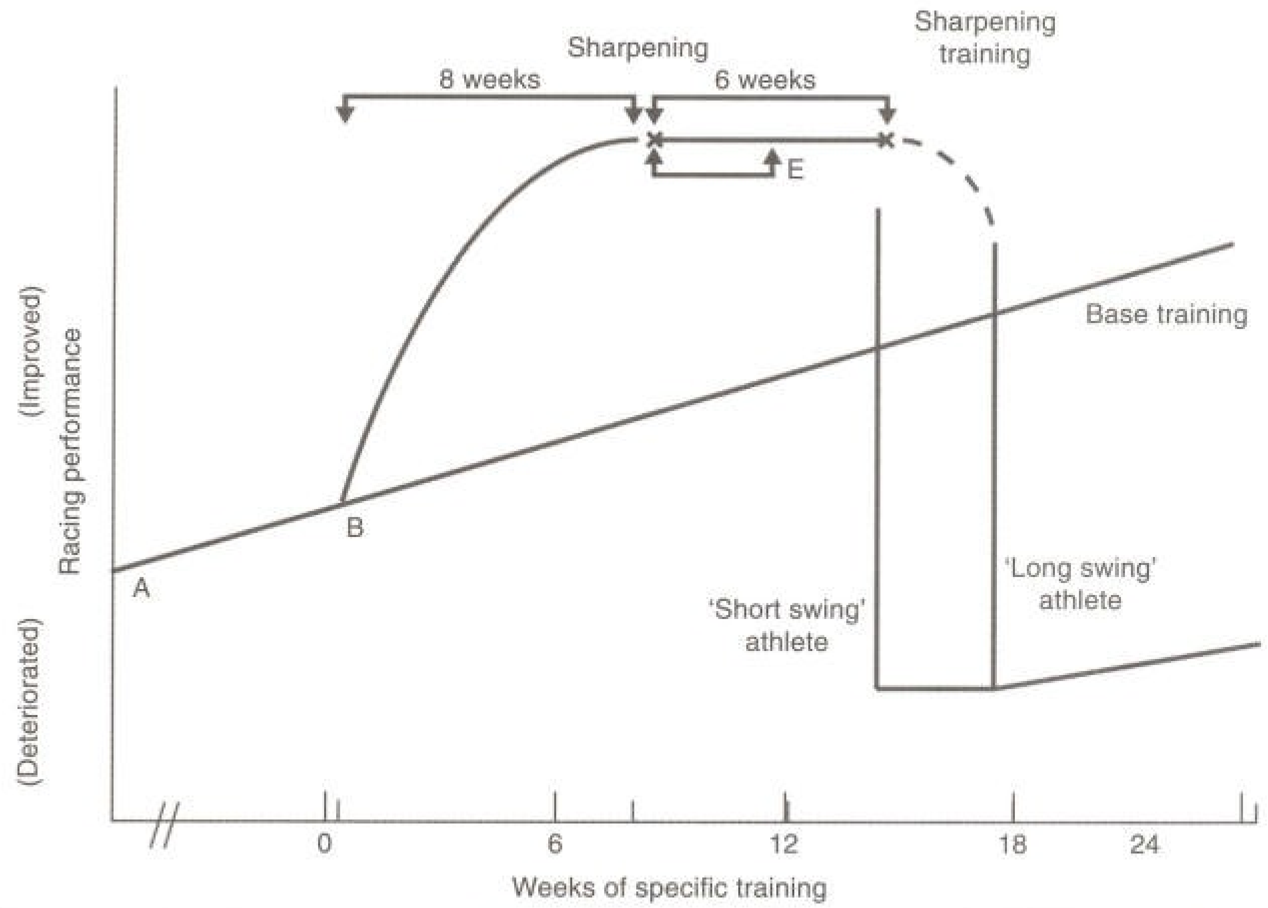

Figure 5.10 The theory behind peaking. Note that the performance of short-swing athletes begins to fall after about 11 weeks of sharpening training whereas that of long-swing athletes may continue to improve for up to 14 weeks of sharpening training.

According to Osler (1967 and 1978), base training provides the following benefits:

- It develops robust health.
- It conditions the cardiovascular system.
- Its slow pace helps keep injuries to a minimum.
- It fosters a continual, slow improvement. (Osler calls this an improvement in the runner's "base performance level.")
- It has a de-sharpening effect and conserves what Osler calls "adaptation energy."

No one knows precisely what adaptation energy is. Osler also refers to this energy form as "competitive juices." He suggests that we all have limited reserves of these juices, which must be expended with care. This concept is similar to that proposed by Hans Selye in his General Adaptation Theory and is also alluded to by Lord Moran (1945) in his discussion of the battle-weary troops in the trenches at the battle of the Somme during World War I. Moran wrote, *In war, men wear out like clothes. All around me are the faces of men who do not seem to have slept for a week. Some who were tired before, look ill; the very gait of the men has lost its spring. The sap has gone out of them. They are dried up. (Moran 1945, p. 70)*

Later, Moran described similar observations in the Royal Air Force Bomber Command in World War II: *When a pilot's behavior on the ground changes, when a lad that had been the life and soul of the mess becomes silent and morose, when he loses interest and zest, and becomes critical and bad-tempered, then it is too late to save him. Moods were the (silent) language in which they spoke to us of their distress. (Moran 1945, p. 43)*

Osler contends that stressful conditions of training hard and racing, like fighting a war, use up these competitive juices and that, when they are exhausted, the athlete is no longer able to perform to potential. Osler's theories have since been confirmed by our studies (Barron et al. 1985) showing that overtrained runners are unable to respond normally to stress by releasing the appropriate stress hormones or juices.

Osler warns that although base training is a very safe training method, its main disadvantage is that it fails to prepare either body or mind for the stresses of racing. In particular, it fails to develop the coordination and the relaxation at speed that are necessary for peak performance. Also, it fails to produce those biochemical adaptations specific to speed training (see chapter 3).

Thus, the athlete who only does pure base training may be able to run forever at a slow pace and will recover very quickly from even the most demanding performance but will never run to full potential. All the authors cited here agree that to achieve this, each athlete must undergo a period of sharpening.

Sharpening

Sharpening consists of any of a number of different training methods, the common feature of which is that they are all performed at race pace or faster, for varying lengths of time. The most common sharpening techniques are interval running and speed play (fartlek), hill work, and short races or time-trials of up to 8 to 10 km (Doherty 1964; Daws 1977; Galloway 1984; Lydiard and Gilmour 1978; Osler 1967; 1978; Glover and Schuder 1983; Martin and Coe 1997; Daniels 1998; see also chapter 6). These sessions become the focal point of training and may be performed one to three times per week, depending on the experience and physical strength of the athlete.

The Science of Sharpening Training

Surprisingly few studies of the effects of different training regimes on athletic performance have been quantified in scientifically designed trials (Hawley, Myburgh, et al. 1997). In part, this is because few exercise scientists have considered this to be important, choosing rather to study how the body adapts to training at the cellular and molecular level (Mujika 1998). Perhaps they believe that neither the Nobel Prize in Physiology or Medicine nor its sporting equivalent, the International Olympic Committee Science Prize, will be won by the exercise scientist who first discovers the most ideal athletic training program.

Another reason is that many of these studies have used surrogate physiological measures, such as a change in VO_2max (chapter 2) or in the "anaerobic threshold" (chapter 3), as predictors of an expected change in athletic performance according to the Cardiovascular/Anaerobic Model. Yet, changes in athletic performance frequently occur without any change in these physiological variables and vice versa (Madsen et al. 1993; McConell et al. 1993). Hence, studies based on that premise are not likely to establish the real effectiveness of different training programs.

A series of studies in our unit at the University of Cape Town and the Sports Science Institute of South Africa have attempted to evaluate the effects of specific additional "sharpening" training on the performance of athletes who have generally chosen to train exclusively with endurance-type training with little exposure to a systematic program that includes regular sessions of high-intensity training. .

Our first study (Lindsay et al. 1996) showed that replacing 15% (about 50 km) of a group of cyclists' usual 300-km-per-week training with six twice-weekly sessions of 6 to 8 five-minute rides at 80% of the athletes' VO_2max or 90% of their maximum heart rates improved their times in a 40-km cycling time-trial in the laboratory by 2 minutes (3.6%). Doubling the total number of training sessions by lengthening the high-intensity training program from three to six weeks did not produce any additional benefit (Westgarth-Taylor et al. 1997).

In the next study (Stepto et al. 1999), different groups of subjects performed high-intensity training of different durations (0:30 to 8:00) at different intensities (80% to 175% VO_2max). Interestingly, only race pace (4:00 at 85% VO_2max) or very high-intensity (0:30 at 175% VO_2max) training improved cycling performance during a 40-km time-trial.

Hence, the surprising finding from those studies was the rapidity with which quite large changes in cycling endurance can be achieved with relatively little training. This provides documentary proof needed to verify the anecdotal observations reported by Osler.

This conclusion that measurable changes in performance can be produced rapidly by sharpening training is extended by the study of TP. Smith et al. (1999) from Tasmania. Smith and colleagues measured the effects of sharpening training with two interval sessions per week for four weeks. Subjects trained at the maximal treadmill speed achieved during the VO_2max test (vVO_2max or V max; chapter 2). The duration of each interval was set at between 60% and 75% of the duration that each person could sustain when running at the V max. This duration was called T max. Each training session involved the repetition of either five or six of these intervals.

The authors made two interesting practical observations. First, when the exercise duration was 60% to 75% of T max, subjects maintained heart rates of approximately 90% to 95% maximum during all the intervals. However, when the exercise duration was 70% to 75% of T max, the heart rate would rise to 100% of maximum after the second or third repetition, suggesting that the intervals were too long and too stressful. Second, if the heart rate did not drop below 125 beats per minute between intervals, the next interval would always elicit a maximum heart rate.

But their main finding, in agreement with ours, was that this period of high-intensity training significantly increased V max, T max, and 3000-m time-trial performance, the latter by 2.8% (0: 17). They also suggested that using V max as the exercise intensity and 60% and 70% of the T max as the exercise duration might be particularly useful in exercise prescription for athletes, a suggestion I find appealing for a number of reasons.

The first is because the variables are easily measurable and do not require any sophisticated equipment, other than a treadmill to measure V max and T max. The second is because the method does not require the measurement of blood lactate concentrations and the prescription of exercise according to biological phenomena like the anaerobic threshold, the physiological basis of which is in doubt (see chapter 3). Third, the incorporation of heart rate monitoring provides another tool to determine when the interval duration has been too long or the number of intervals too many.

Hence, the conclusion from this group of studies is that large improvements in performance can be achieved quite dramatically by the addition of six to eight sessions of high-intensity interval training over a period of three to four weeks, confirming the accuracy of the ninth law.

An intriguing question is: What is the physiological basis for these changes? According to the Cardiovascular/Anaerobic Model, high-intensity training would be expected to improve oxygen delivery to the trained muscles, thereby rendering them less anaerobic. Alternatively, sharpening training might improve the ability of the exercising muscles to contract under anaerobic conditions, perhaps by increasing their capacity to contract when muscle pH is low.

My bias is to suggest that such physiological changes are unlikely to occur either as rapidly or to the same extent as do the large changes in performance produced by sharpening training. I tend to believe that these rapid changes occur in the nervous system, so that sharpening training increases the mass of skeletal muscle that can be recruited during exercise before the central governor is maximally activated, terminating exercise. According to this theory, sharpening training reprograms the subconscious brain to accept a higher exercise intensity as safe than the governor was prepared to allow before sharpening training took place.

According to Osler, an important advantage of sharpening is that it teaches you to run relaxed even at race pace. More important, it produces specific, physiological adaptations that yield quite dramatic improvements in racing performances, as shown by the experience of Peter Snell. Osler reports that after eight weeks of sharpening, he runs 10 to 20 sec per mile faster than previously and expects an II-minute improvement in his marathon time.

But even more than base training, sharpening training has serious disadvantages. In particular, it is very taxing and uses up adaptation energy; it increases the risk of injury and reduces resistance to infection. When sharpening, the athlete is on the knife's edge that divides a peak performance from a disastrous race. For this reason, sharpening can only be maintained for relatively short periods of time, with a probable maximum of between 8 and 12 weeks. I believe that this rule crosses all human activities, mental or physical. How, then, to achieve a peak?

Figure 5.10, which owes nothing to science and everything to the anecdotal experiences of great runners such as Lasse Viren and Peter Snell and great runner-thinkers such as Tom Osler and Bruce Fordyce (chapter 6), was first formulated by Osler (1967; 1978). The diagram compares the performance improvements that would be experienced by a runner following two different training methods of 32 weeks each. A hypothetical runner who chooses to do only base training in the 32-week period can expect to improve her racing performance along the line A-I. Osler calls this the improvement in the runner's base performance level.

If, however, our hypothetical runner chooses to start sharpening at the twelve-week point on the graph (point B) and, instead of only doing long, slow distance running, she now includes speed training, her racing performance will improve quite dramatically along the portion B-C-D of the graph. Eight weeks after starting sharpening training, her potential racing performance will probably start to plateau (point D). Please note that the time intervals shown on the graph are somewhat arbitrary and have been arrived at by empirical observation of rather small numbers of runners rather than by careful scientific study. Some runners will take either longer or shorter periods to arrive at the various points on the diagram.

To my knowledge, the first author to identify that people differ in the rapidity with which they adapt during peaking was Ludwig Prokop (1963-64), who noted that there are two types of athletes, the "short-swing" and the "long-swing" types. Short-swing athletes are able to improve their condition very quickly but can maintain their performances for only short periods of time before they must return to base training. These athletes are able to peak several times during the season. Long-swing types, on the other hand, need considerably more training to reach their peak, which they can also sustain for much longer.

Prokop reported that his athletes usually required seven to eight weeks' sharpening training to reach a peak that would last for between three and six weeks before their performances would start to fall. Two great athletes who observed this in themselves were Derek Clayton (1980) and Ron Hill (1981; 1982), who found that their running improved steadily for approximately 10 weeks. Beyond this period, they were easily tired, slept badly, were often injured, and raced poorly.

Once this hypothetical runner reaches her peaking plateau (line D-E in the diagram), she is ready for her best race, and all she need do is maintain her sharpening training. As coach Jumbo Elliott said: "After you start hard racing, hard training will get you nowhere" (Liquori and Parker 1980, page 150).

A frequent problem is that once a runner realizes he is on to a peak, he will seldom be happy with just one good race, unless that race happens to be in the Olympics. Inevitably, the now-greedy runner tries to pack in too many races, the last of which he runs when his performance level is already on the precipitous downward slide of the performance curve. The result is that he ends up injured, ill, and thoroughly overtrained-depicted as points F1 and F2 on the diagram and described in detail in chapter 7. An important feature of the line E-F2 is its steepness. I suspect that it takes only three weeks to go from a best-ever performance to the point at which you are physically incapacitated.

Two final points shown on the graph are the slow rate of recovery from overtraining and the way in which a sharpening runner can perform either much better or much worse than a runner who has performed only base training.

It is possible to monitor the success of peaking. Just as runners who do too much develop specific warning symptoms (chapter 7), so runners' bodies tell them when they are sharpening correctly. Once again, Osler (1967; 1978) first recorded these symptoms:

- During the speed-training sessions, the body no longer needs to be forced through the session. Rather the body "surges forward at its own will" and "thirsts to accelerate."

- In the hour following training, the runner feels supreme vigor, quite unlike the normal post-exercise feelings of mild fatigue.

- Everyday physical activities, such as climbing stairs, become easier.

- The runner becomes increasingly sensitive to everyday situations and is mildly irritable as the body is "prepared for action and is ready for the fight."

- As the body becomes flooded with previously latent energy, a heightened sexual awareness is often evident.

With regard to speed training during this peaking phase, I have observed that proper speed work training probably requires the presence of a coach (Law 12). Speed work requires more finesse and understanding than does long, slow, distance running (LSD), as it is more likely to cause injury or physical breakdown. For these reasons, it is essential to train with someone else who can analyze objectively whether the speed work is having the desired effect. Something coach Arthur Lydiard has written may at first seem to contradict this advice: *There is no coach in the world who can say exactly what athletes should do as far as the number of repetitions, distances and intervals are concerned. Not even physiologists can tell an athlete that. The important point is that the athlete knows what he is trying to achieve and goes out and works at it until he does. (Lydiard and Gilmour 1978, p. 12)*

The point I believe Lydiard is making is that interval coaching is as empirical as are all forms of coaching, and that is all the more reason to have two heads-an athlete's and a coach's-working on the problem rather than one.

Fast running is best done when the body and mind demand it. Fast running should be an enjoyable change from the occasional monotony of long training runs. When it is not, it indicates that the body is too tired and that the session must be postponed until the speed session again becomes pleasurable. (Refer to the different approaches of John Walker and Derek Clayton in chapter 6.) If Walker struggled in an interval training session, he packed up and went home; when Clayton struggled, he carried on until he had completed what his mind said that his body should do. Such obsessiveness is inevitably destructive and probably explains why Clayton was injured so frequently.

But Walker's experience teaches another lesson. Attempting to become the first athlete aged over 40 to run a sub-4-minute mile, Walker was forced to retire from the sport as a result of crippling Achilles tendinosis. American miler Steve Scott experienced the same end to his career, as did the indoor mile record holder of the 1970s, Irishman Eamonn Coghlan.

My impression is that speed work becomes increasingly dangerous with age, especially in those who, like these three great milers, have trained heavily for decades.

Somewhat predictably, the first athlete over 40 to break the sub-4-minute mile barrier was a relatively unknown runner who had trained little since leaving school. Possibly only those who have not exposed their legs to decades of heavy training, especially speed work, are still able to survive the quantity and quality of speed work necessary to run a sub-4-minute mile after 40. This point has already been discussed in chapter 2.

You cannot do speed training indefinitely within a season. Carlile and Lydiard have taught us that six to eight weeks' intensive training, when added to a solid period of base training, is all that is needed for a peak performance, and this is something on which everyone seems to agree (Osler 1967; 1978; Daws 1977; Galloway 1984; Glover and Schuder 1983; Dellinger and Freeman 1984). Derek Clayton (1980) wrote that he could sustain heavy training for only 10 weeks before his performances began to deteriorate.

Significantly, Ron Hill came to precisely the same conclusion (Hill 1982, page 160), for he wrote, "my ideal build-up to a peak occupies a period of ten weeks." When two of the world's best marathoners, as well as Mark Allen, arguably the greatest male triathlete of all time, come to the same conclusion independently, then there is likely to be some truth in it.

All too often I have seen not only runners but also other endurance athletes who, in attempting to maintain heavy training for longer than this period, have performed poorly in their target races. This is always a tragedy: they invest so much effort that, for the want of just a little knowledge and moderation, is wasted.

The most beneficial forms of speed training for marathon and ultramarathon runners seem to be hill running and fast, long intervals on the track. For those interested, the principles of hill training have been best described by Ron Daws (1977) and Bruce Fordyce (1996). Although Lydiard includes the use of short intervals (100 and 200 m) in his marathon training methods, I think that longer intervals (800 m to 1.6 km) are probably better for 10-km and marathon training.

One of the joys of speed training is the rapid improvement you feel. Very little effort produces remarkable rewards. I found that when I started my interval training sessions, I was able to run only two, or possibly three, l-km repetitions, each of which was very tiring. But after four or five such sessions, I was able to do twice as many repetitions, much faster and without the distress I experienced in the first session.

As long as I was running as fast as or faster than before with the same or less effort, I knew that the speed training was beneficial. However, if the sessions became increasingly difficult and the interval times started to slow, then I knew that I was in trouble and that my body was telling me that it had done too much and required a period of rest with no training, not more and harder training.

Where many runners make a critical error is that they believe that the fall in performance during these sessions indicates they are not sufficiently motivated and are being lazy. Instead of resting, they try harder and compound the error and the risk of overtraining. There is a danger that by training under these conditions, athletes not only damage themselves physically but also use up the motivation they should be conserving for their one all-out racing effort.

Short races of 5 to 16 km are an excellent form of speed training. Run these as hard efforts controlled by perceived effort or by heart rate, rather than by the stopwatch (Law 7). These races should serve as the equivalent of a hard interval session. By starting the race at a comfortable pace that you increase gradually with each kilometer, you will end the race having run 4 to 8 km at a hard pace (equivalent to an interval session of three to five 1.6-km repetitions). But because you started slowly without concern for your total time and did not race the entire distance, the overall stress of the race is reduced and you will recover more quickly.

Another reason for running these short races this way is that short-distance races usually fall on weekends when a long training run is also required. Galloway (1984) and Glover and Schuder (1983) emphasize not combining speed work or a race and a long training run on the same weekend: "Never put two stress days together under any circumstances" (Galloway 1984, page 134). Indeed, Galloway suggests that even after a race of only 10 km you should take about one week's easy running before tackling speed work or another long run. He also stresses that two easy days should follow each hard session or long training run (Law 5).

By racing half or less of the total race distance in these races, you can run them more frequently. I ran only 7 to 10 speed sessions during the entire peaking phase. This conforms closely to Galloway's suggestion of running only one speed session per week when training for a 10-km race and one every second week before the marathon. Galloway (1984) also proposes that you should never complete an interval session feeling totally fatigued and that you should rest for as long as desired between each interval repeat.

The keys to high-intensity training are the following:

- The volume of high-intensity training completed each week must not exceed a certain proportion of the total weekly training volume.
- The intensity (running speed) of each high-intensity training session must be tailored appropriately for each athlete's individual running ability.
- The duration (weeks) of the high-intensity training program must be carefully controlled.
- There needs to be some variety in the types of high-intensity training that the athlete performs during the period of high-intensity (peaking) training.

The man who has best described his philosophy in concise, easily understandable terms is the running guru, coach, and exercise physiologist, Jack Daniels, former coach to the Nike Athletics West Club in Eugene, Oregon, who is considered by some North Americans to be "the world's best coach."

Jack Daniels' Training Philosophy

In Daniels' Running Formula (1998), Daniels describes the wisdom he has acquired in the course of 36 years of coaching many of North America's most successful athletes. His success has been aided by his training in exercise physiology, including his doctoral thesis, in which he evaluated the effects of altitude training on the sea level performance of a group of elite distance runners, including Jim Ryun (Daniels and Oldridge 1970). He is also coauthor of the crucially relevant Oxygen Power, from which the data in table 2.4 were extracted.

As a result of his training in classical exercise physiology, Daniels uses specific physiological terms to describe both the nature of his different training sessions and the physiological adaptations that will result from those training sessions. The strength of this approach is that it fixes in athletes' minds the exact reason why they are doing a particular workout.

However, the terminology used by Daniels and by Pete Pfzinger (who appears to have been a disciple of Daniels and whose ideals are described subsequently) indicates that they are dedicated proponents of the Cardiovascular/Anaerobic Model. Hence, they both define the exercise intensities for their different sessions in terms of the different (anaerobic) thresholds that are at the core of that model. Furthermore, they explain the adaptations that are likely to occur, purely in terms of altering capacities of oxygen delivery to and use by the muscles, with resulting changes in skeletal muscle lactate production.

While these objections may be valid, they do not detract from the clear evidence that Daniels has achieved great practical success with this training method. That he uses an unproven and perhaps dated model to explain the physiological reasons for his success is of no consequence. In time, science will catch up with Daniels and will provide a more correct physiological explanation as to why his methods, field tested for more than three decades, produce the superior results his athletes have achieved.

Thus, Daniels proposes that there are six physiological processes, each of which needs to be adapted optimally if the athlete is to achieve optimum competitive performance:

1. Improving the body's ability to transport blood and oxygen
2. Increasing the ability of the running muscles to use the available oxygen effectively
3. Raising the lactate threshold to a faster running speed
4. Increasing aerobic capacity, VO_2max
5. Improving running speed
6. Lowering the energy demand of running (improving running economy)

Daniels further concludes that there are unique exercise intensities that will specifically adapt each of those different physiological processes.

However, to my knowledge, there are no published studies that prove that training at a particular exercise intensity uniquely adapts only one of the six physiological processes listed by Daniels. Perhaps this lack of evidence is simply because scientists have not yet researched this possibility in sufficient depth. Alternatively, as seems more likely to me, it may be that the body adapts all these different physiological processes during all training, regardless of its intensity, but that certain adaptations are emphasized at specific running intensities. For example, long, slow distance training may well enhance the mitochondrial capacity to oxidize fats, but it is also likely to adapt the connective tissue in the lower limbs, enabling it to cope better with repeated eccentric loading. Similarly, any training at intensities greater than the incorrectly labeled "anaerobic threshold" is likely to alter whole body lactate mechanics (Macrae et al. 1992), whether that training is at 80% or 100% of VO_2max.

Remember, then, that the physiological goals listed by Daniels are specific for the Cardiovascular/Anaerobic Model and do not take into account the other models of exercise that may equally determine running performance at different distances. Thus, this training ethos does not acknowledge that adapting the muscles to absorb the shock of running may be another important adaptation for marathon running specifically, as described in chapter 2. Furthermore, consideration is not given to the possibility that training adaptations may also occur in the brain and that these changes could possibly explain how training improves running performance.

With those points of scientific clarification, it is then appropriate to explain in detail how Daniels advises you to structure a high-intensity training program and what he believes are the specific physiological benefits of each of the different training methods that he advocates.

The first form of high-intensity training proposed by Daniels is the so-called VDOT training. This is training performed at the running speed at which the VO_2max is achieved.

We have already used the ideas of Daniels and others to explain the concept that a particular VDOT or VO_2max value predicts the likely running performances at other distances. Thus, the athlete who wishes to determine a VDOT value on the basis of the best running performance according to the Daniels method should refer to table 2.4.

In table 5.6, Daniels (1998) lists the six training intensities (as a percentage of VDOT) that he considers most effective in enhancing running performance.

Table 5.6 Training paces (min:sec) based on the current VDOT ($\dot{V}O_2max$) method of J. Daniels (1998)

1	2	3	4	5	6	7	8	9	10	11	12	13	14
VDOT	E/L Pace		MP	T Pace			I Pace				R Pace		
	km	mile	mile	400	1000	mile	400	1000	1200	mile	200	400	800
30	7:13	12:16	11:02	2:33	6:24	10:18	2:22	–	–	–	67	2:16	–
32	7:16	11:41	10:29	2:26	6:05	9:47	2:14	–	–	–	63	2:08	–
34	6:56	11:09	10:00	2:19	5:48	9:20	2:08	–	–	–	60	2:02	–
36	3:38	10:40	9:33	2:13	5:33	8:55	2:02	5:07	–	–	57	1:55	–
38	6:22	10:14	9:08	2:07	5:19	8:33	1:56	4:54	–	–	54	1:50	–
40	6:07	9:50	8:46	2:02	5:06	8:12	1:52	4:42	–	–	52	1:46	–
42	5:53	9:28	8:25	1:57	4:54	7:52	1:48	4:31	–	–	50	1:42	–
44	5:40	9:07	8:06	1:53	4:43	7:33	1:44	4:21	–	–	48	98	–
45	5:34	8:58	7:57	1:51	4:38	7:25	1:42	4:16	–	–	47	96	–
46	5:28	8:48	7:48	1:49	4:33	7:17	1:40	4:12	5:00	–	46	94	–
47	5:23	8:39	7:40	1:47	4:29	7:10	98	4:07	4:54	–	45	92	–
48	5:17	8:31	7:32	1:45	4:24	7:02	96	4:49	4:49	–	44	90	–
49	5:12	8:22	7:24	1:43	4:20	6:55	95	3:59	4:45	–	44	89	–
50	5:07	8:14	7:17	1:42	4:15	6:51	93	3:55	4:41	–	43	87	–
51	5:02	8:07	7:09	1:40	4:11	6:44	92	3:51	4:36	–	42	86	–
52	4:58	7:59	7:02	98	4:07	6:38	91	3:48	4:33	–	42	85	–
53	4:53	7:52	6:56	97	4:04	6:32	90	3:44	4:29	–	41	84	–
54	4:49	7:45	6:49	95	4:00	6:26	88	3:41	4:25	–	40	82	–
55	4:45	7:38	6:43	94	3:56	6:20	87	3:37	4:21	–	40	81	–
56	4:40	7:31	6:37	93	3:53	6:15	86	3:34	4:18	–	39	80	–
57	4:36	7:25	6:31	91	3:50	6:09	85	3:31	4:15	–	39	79	–
58	4:33	7:19	6:25	90	3:45	6:04	83	3:28	4:10	–	38	77	–
59	4:29	7:13	6:19	89	3:43	5:59	82	3:25	4:07	–	37	76	–
60	4:25	7:07	6:14	88	3:40	5:54	81	3:23	4:03	–	37	75	2:30
61	4:22	7:01	6:09	86	337	5:50	80	3:20	4:00	–	36	74	2:28
62	4:18	6:56	6:04	85	334	5:45	79	3:17	3:57	–	36	73	2:26
63	4:15	6:50	5:59	84	3:32	5:41	78	3:15	3:54	–	35	72	2:24
64	4:12	6:45	5:54	83	3:29	5:36	77	3:12	3:51	–	35	71	2:22
65	4:09	6:40	5:49	82	3:26	5:32	76	3:10	3:48	–	34	70	2:20
66	4:05	6:53	5:45	81	3:24	5:28	75	3:08	3:45	5:00	34	69	2:18
67	4:02	6:30	5:40	80	3:21	5:24	74	3:05	3:42	4:57	33	68	2:16
68	4:00	6:26	5:36	79	3:19	5:20	73	3:03	3:39	4:53	33	67	2:14
69	3:57	6:21	5:32	78	3:16	5:16	72	3:01	3:36	4:50	32	66	2:12
70	3:54	6:17	5:28	77	3:14	5:13	71	2:59	3:34	4:46	32	65	2:10
71	3:51	6:12	5:24	76	3:12	5:09	70	2:57	3:31	4:43	31	64	2:08
72	3:49	6:08	5:20	76	3:10	5:05	69	2:55	3:29	4:40	31	63	2:06
73	3:46	6:04	5:16	75	3:08	5:02	69	2:53	3:27	4:37	31	62	2:05
74	3:44	6:00	5:12	74	3:06	4:59	68	2:51	3:25	4:34	30	62	2:04
75	3:41	5:56	5:09	74	3:04	4:56	67	2:49	3:22	4:31	30	61	2:03
76	3:39	5:52	5:05	73	3:02	4:52	66	2:48	3:20	4:28	29	60	2:02
77	3:36	5:48	5:01	72	3:00	4:49	65	2:46	3:18	4:25	29	59	2:00
78	3:34	5:45	4:58	71	2:58	4:46	65	2:44	3:16	4:23	29	59	1:59
79	3:32	5:41	4:55	70	2:56	4:43	64	2:42	3:14	4:20	28	58	1:58
80	3:30	5:38	4:52	70	2:54	4:41	64	2:41	3:12	4:17	28	58	1:56
81	3:28	5:34	4:49	69	2:53	4:38	63	2:39	3:10	4:15	28	57	1:55
82	3:26	5:31	4:46	68	2:51	4:35	62	2:38	3:08	4:12	27	56	1:54
83	3:24	5:28	4:43	68	2:49	4:32	62	2:36	3:07	4:10	27	56	1:53
84	3:22	5:25	4:40	67	2:48	4:30	61	2:35	3:05	4:08	27	55	1:52
85	3:20	5:21	4:37	66	2:46	4:27	61	2:33	3:03	4:05	27	55	1:51

The six different intensities are:

Easy/Long (E/L) Pace. This intensity refers to the pace the athlete should maintain for easy and long runs. These are run at about 70% of VO_2max and, according to Daniels, enable the body to cope with fluid loss and glycogen depletion and to burn more fat during prolonged exercise. Such training probably also helps adapt the muscles, enabling them to cope with the loading requirements of prolonged exercise. Columns 2 and 3 in table 5.6 list the E/L pace that should be achieved by athletes with different VDOT values.

Marathon Pace (Mp). This is the pace that the athlete may hope to maintain during a marathon race. The appropriate pace in minutes per mile is listed as column 4 in table 5.6.

Threshold (T) Pace. These runs are considered to occur at the anaerobic threshold, which is at about 88% of VDOT (VO_2max) or at 90% of either the maximum heart rate or the running speed at the VO_2max (VO_2max). Daniels describes such training as comfortably hard running at about 25 to 30 seconds per mile (16 to 19 seconds per km) slower than current 5-km race pace. Daniels stresses that it is important to run at this pace and not any faster, which is hard for many overenthusiastic runners to do. He argues that running at a higher intensity does not enhance the physiological adaptations to this type of training. Columns 5, 6, and 7 in table 5.6 list the T pace that should be achieved by athletes with different VDOT values. Daniels also defines tempo runs as 20minute runs at the threshold pace. Similarly, cruise intervals are repeated runs of between 3 and 15 minutes at threshold pace, broken up by short recovery periods of usually 1 minute or less. The total amount of quality running for a cruise interval workout must never exceed 10% of the weekly mileage with a minimum of 6000 m or 13,000 m per week.

Interval (I) Pace. Daniels defines this running intensity as the speed that can be maintained for 10 to 15 minutes in a race situation that, for an elite athlete, is about the 5000-m race pace. The interval pace is described as demanding or hard running but does not involve all-out running. Daniels again warns that completing intervals at too fast a pace is of no value as the results will be no better than if you had run at the designated pace. In addition, the excessive pace will probably prevent full recovery before your next quality training session. Columns 8, 9, 10, and 11 give the interval pace for interval training according to the different VDOT values. Daniels also stipulates that interval training should never include more than 5 minutes of intense running. The total amount of quality running in an interval session should be less than 8% of the weekly mileage with a 10-km maximum. As these intervals are without doubt the most demanding training you can do, you must never do too many. Hence Daniels's six criteria for interval training are the following:

1. Run intervals of between 0:30 and 5:00 duration.

2. Stick to the I pace for all aspects of quality running.

3. Run easily during recoveries.

4. Keep recovery periods equal to or shorter than the work bouts they follow.

5. Let the quality portion of an interval session total up to 8% of your current weekly mileage with a nonnegotiable upper limit of 10 km.

6. Allow sufficient time to recover so that you feel you can perform the next interval as well as you did the previous one.

Repetition (R) Pace. Running at this pace, which is faster than VO_2max pace, aims to develop your speed, economy, and relaxation when running at the fastest speeds of which you are capable. Daniels suggests that this training does not influence either the VO_2max or the lactate threshold. The final three columns in table 5.6 list the repetition paces for athletes with different VDOT values.

Rest. The unsolved paradox of training is that while training allows you to run faster both in training and in racing, it also causes a progressive, accumulated fatigue without which you would run even faster. Frequent rest allows partial recovery from that accumulating fatigue, hence better training. Proper tapering before competition allows a more complete recovery, without which a peak performance is not possible.

Daniels advises runners to remain at the same training intensity for at least three or four weeks and at the same overall training volume for at least three weeks before increasing the mileage. Daniels's specific training programs, in which he combines all the different training sessions into comprehensive and coherent training programs for 10 to 21and 42-km races, are presented in chapters 9 and 10. A final insight by Daniels is his classification of four different types of runners:

Type 1. Those with high ability and motivation. It is from this group that the champions come.

Type 2. Those with high ability but little motivation. These are the athletes who will forever frustrate the coach.

Type 3. Those with little ability, but high motivation. These are the athletes who frustrate themselves and are the potential over-trainers.

Type 4. Those with little ability and little motivation. These people should not do any sports that require discipline. They are in the wrong activity.

Pete Pfitzinger's Training Advice

Pete Pfitzinger is a two-time member of the U.S. men's Olympic Marathon Team. In 1984, he was voted America's best distance runner and was named Runner of the Year by the Road Runners' Club of America. He is also a two-time winner of the San Francisco Marathon and finished third in the 1987 New York City Marathon. He has coached for 18 years and holds an MSc degree in exercise science from the University of Massachusetts. His book, coauthored by runner/writer Scott Douglas (Pfitzinger and Douglas 1999), provides another approach to the training of serious distance runners.

Pfitzinger describes five components of training:

1. Short, fast speed work to improve "leg turnover and running form"
2. Longer repetitions of 2 to 6 minutes at 3 to 5-km race pace to improve the VO_2max
3. Tempo runs of 20 to 40 minutes at 10-mile (16-km) race pace to increase the lactate threshold
4. Long runs to build endurance

5. Easy recovery runs to allow a maximum effort on the hard training days

Pfitzinger's ideas match those of Jack Daniels, as do his methods of achieving the different physiological adaptations. Note also that the Cardiovascular/Anaerobic Model is again used to explain the physiological adaptations that result from training. Pfitzinger proposes that the optimum training to improve VO_2max is to run 4 to 8 km of intervals per workout. He proposes running one workout like this each week, and he suggests that the most appropriate form of training is to do repetitions of 2:00 to 6:00 duration (600 to 1600 m per interval). These intervals should be run at your 3 to 5-km race pace to ensure that you are running at between 95 % to 100% of your VO_2max. The duration of recovery should be sufficiently long so that your heart rate drops to 65% of maximum between intervals. Pfitzinger also believes that the classic workout to improve your lactate threshold is the tempo-a continuous run of 20 to 40 minutes at your lactate threshold pace, which is your 15 to 21-km race pace. He also proposes the use of Daniels's cruise intervals.

To improve pure endurance, Pfitzinger believes that your long runs should be completed at between 70% and 85% of your maximum heart rate. This, he suggests, is approximately 0:45 to 1:30 per mile (0:28 to 0:56 per km) slower than your marathon race pace or 1:00 to 2:00 per mile (0:38 to 1:16 per km) slower than your 15 to 21-km race pace. He also suggests that you should start these long runs at the slower end of the range and gradually increase your pace during the run. Recovery runs should be at less than 70% of your maximum heart rate, as also advocated by Daniels. Pfitzinger's specific training programs for 5 to 21 and 42-km races are presented in chapters 9 and 10.

Pfitzinger also expresses strong views on two additional aspects of training. He very expressively portrays the mental dilemma faced by many runners in the last few weeks and days before an important race: *To taper effectively for a marathon takes about three weeks. Unfortunately, our self-confidence is fragile. Our egos require the positive reinforcement of a hard workout every few days. If we take a few days easy---let alone three weeks---we go through withdrawal. Our distance runners' paranoia makes us fear that our muscles will turn to mush and that we will waste all those months of hard work. (Pfitzinger and Douglas 1999, p. 92)*

The section on tapering in this chapter indicates that tapering for three weeks improves rather than hinders racing performance. In chapter 6, world champion triathlete Mark Allen describes how, once you start to train vigorously, your body becomes over stimulated and unable to recover properly. Pfitzinger describes a similar observation: constant sympathetic stimulation (induced by heavy training) leads to the feeling that your mind and body are always engaged; your fight or flight response is always activated (meaning that it's controlling you, rather than the other way around). As a result, you are simultaneously "on" and fatigued and therefore unable to relax fully or perform at your best.

Additional Advice on Training Intensities

Additional guidelines for the correct pace during interval training are provided by Galloway (1984). He suggests that you should run 400-m repetitions 5 to 7 seconds faster than your goal race pace, 800 m in 10 seconds faster than your goal pace, and the mile 15 to 20 seconds faster than your goal pace. The athlete who is unable to achieve these goals during interval training is almost certainly putting in too much mileage and will need to cut back to benefit optimally from this type of training.

Burfoot and Billing (1985) also believe that optimum training is achieved by including regular runs at three different intensities in your weekly training. They suggest that most of your training needs to be done at intensities between 65% to 75% VO_2max, which correspond to the pace below that at which you run the 42-km marathon. The purpose of these runs, they suggest, is to improve running efficiency.

These authors also prescribe a once-a-week run of 5 to 10 km at 85% VO_2max to shift the lactate turn point to a higher percentage VO2max. This exercise intensity corresponds to the speed you can maintain during races of 10 to 21 km. It is not necessary to run the 5 to 10 km of this session continuously. Rather, the authors suggest that this workout be run on the track or road as a series of repeat runs of 2 to 3 km.

Finally, run one session per week at a running pace eliciting VO2max. This intensity corresponds to the fastest speed at which you can run 3 km. Burfoot and Billing suggest 3 to 6 X 800 m or 8 to 12 X 400 m. However, these distances may be too short for less competitive marathon runners. If you find running these distances too demanding, you might try running 1-km to 1-mile intervals.

David Costill (1986) has also provided a list of what he considers appropriate times for different intervals, based on your best 10-km time (table 5.7). He divides the interval sessions into anaerobic, aerobic, and aerobic-anaerobic. He suggests that the anaerobic sessions should be 10 X 200 m with 2 minutes' rest between intervals; the aerobic intervals 20 X 400 m with 10 to 15 seconds' rest; and the aerobic-anaerobic intervals 10 X 400 m with 60 to 90 seconds' rest between intervals.

Table 5.7 Optimum running times for interval training based on best 10-km time

	Intervals		
Best 10-km time (min:sec)	200 m (anaerobic)*	400m (aerobic)*	400m (aerobic-anaerobic)
46:00	00:46	2:00	1:51
43:00	00:43	1:52	1:44
40:00	00:40	1:45	1:37
37:00	00:38	1:37	1:29
34:00	00:36	1:30	1:16

*These terms are not physiologically based (chapter 2) but refer to intervals that are either more (anaerobic) or less (aerobic) stressful because they are run either faster or slower after rest periods of different durations between intervals.

Adapted from Costill (1986, pp. 98, 101, 103). Permission granted by D.L. Costill.

Law 10: Prevent Overtraining

Perhaps one of the chief points is to regulate your training so as to be sure of always being on the safe side: the least sign of overdose will surely lead to trouble. Go so far every day that the last mile or two become almost a desperate effort. So long as you are fit for another dose the following day, you are not overdoing it. But you must never permit yourself to approach real exhaustion; you must never become badly tired. A good way to judge whether you are overdoing it is by your appetite. A really fearsome thirst is a definite sign that either the pace or the distance has been too much. Not only are you unbearably thirsty, but your appetite disappears entirely, even for many hours after the event.

Newton mentions some symptoms that the athlete who is doing too much will experience. The probable reason why he only lists a few is because he seldom, if ever, wore himself down by training too much and was unaware of the myriad other symptoms that appear when an athlete trains too hard. Of course, Newton lived in the era before runners had learned to train as hard as or harder than their bodies would allow. In addition, there were fewer races to run and few financial incentives to entice runners of that amateur era into racing too frequently.

Once again, Newton was 50 years ahead of scientists in his observation that an increased thirst at night is an indicator of overtraining. Richard Brown, exercise physiologist and former coach of Mary Slaney and of the Athletics West Club in Eugene, Oregon, has since shown that one of the earliest indicators of overtraining is an increased fluid intake in the evening (RL. Brown 1983).

Chapter 7 contains a complete description of the overtraining syndrome and offers readers guidelines on how to avoid this major problem.

Remember also that if you follow the approach and guidelines proposed under Law 6 (achieve as much as possible on a minimum of training), you should only overreach or overtrain once in your career. Once you have identified your individual training threshold (figure 5.6), you need never again risk overtraining.

Law 11: Train With a Coach

When I began running, I was totally unaware of the potential value of a coach. Now that I have read more widely and have met and worked with some excellent coaches in different sports, including team sports, I liken the successful coach to a highly skilled artist whose work is infinitely more difficult than that of scientists like myself. Performing experiments in the laboratory, in which virtually all factors are rigorously controlled, is so much easier than trying to do the same with athletes who live in the real world and must therefore cope with the problems that life brings and that, inevitably, affect their running performances. I now also appreciate that, at least in international competition, the margin between success and failure is razor thin. It takes a special person, different from the more risk-averse scientists, to choose to live a professional career on that margin.

The more I have read, the more I have realized that a running coach is needed not necessarily for the physical preparation of the athlete but for inspiration and support, and to provide an objective analysis of when the athlete is doing too much. Franz Stampfl (1955, page 146) said as much himself: "The coach's job is 20% technical and 80% inspirational. He may know all there is to know about tactics, technique, and training, but if he cannot win the confidence and comradeship of his pupils, he will never be a good coach." In Testament of a Runner, WR. Loader (1960) said much the same, and James Counsilman, the brilliant swimming coach of Indiana University, pinpointed another important role of the coach: "the most practical judgment of the point at which the swimmer has had exactly enough training is exercised by the coach. Perhaps the ability to do this effectively marks the difference between a good and a poor coach" (Counsilman 1968, page 234). He also wrote that the coach must contribute enthusiasm, create team unity, and provide guidance. "I prefer to visualize our experience as that of a well-informed coach talking to an intelligent group of athletes in a situation in which everyone has a common goal, that of achieving the full potential of each person and of involving each intellect in the process" (page 4).

Few athletes are made exclusively by training. Chapter 6 shows that there really are no training secrets known only to the most successful athletes. Many runners train just as hard, if not harder in some cases, yet they never achieve the same degree of success.

Marti Liquori, the American miler who trained under Jumbo Elliott, the coach generally considered to be the greatest ever produced in the United States (Elliott and Berry 1982), wrote, "Much of running is mental, and the guru coaches probably have been successful more because they knew how to harness a runner's heart and mind than because of any mysterious secret training formula" (Liquori and Parker 1980, page 35). Of Jumbo Elliott himself it was written: "His coaching method was a non-method. He insisted on their attention to studies. His method was in the application of his knowledge of the athletes, knowing which psychological approach would be most effective and when his man was ready" (Elliott and Berry 1982, pages 186-187).

This is the crux of good coaching-treating each athlete as a person and knowing which psychological approach will work best. For the athlete, the challenge remains to find the coach to whom you best relate. That coach should be sufficiently knowledgeable to prevent you from overtraining and should be able to extract the most from you. In Arthur Lydiard's words, "Two brains are better than one" (Lenton 1981, page 69).

Law 12: Train the Mind

When you begin training you will find that the longest and most strenuous mental and physical exertions all come at the start. . . . It seems to me that stamina is just as much a mental attribute as a physical one. Make your mind healthy and it will do the rest. If it is not normally healthy, you will never make a decent job of anything. The idea that the mind is important in such an outwardly physical sport as running is also something that, even today, is not always appreciated. In fact, until very recently, there were very few contributions to running literature on the mental aspects of training, and even reviews on the evolution of training methods over the years pay scant attention to mental preparation for running (Burfoot 1981a).

It may be that success in running is ultimately determined not so much by training the body as by training the mind. This helps explain why consistently successful runners can always be relied on to perform well, why equally trained runners seldom perform equally, and why some runners who perform superbly in training never succeed in racing.
Percy Wells Cerutty was one of the first coaches to write openly about the importance of mental preparation for running. Certainly, Cerutty (1964, page 29) recognized that his greatest protégé, Herb Elliott, was mentally different: "Herb Elliott had the 'gift' of being able to exhaust himself. That is shared by very few. It is a type of personality, individuality, not of training. You have it-or you do not have it. Elliott had it 100%. His greatness as a runner rested in this."

Later, Elliott wrote, "If you emphasize the physical side of training you may become superbly conditioned but mentally not advanced at all. On the other hand, if you concentrate on the mental aspect, it is inevitable that the physical side will follow. My golden rule is to train for the mental toughness and [not to] train for the physical development" (Lenton 1981, page 32).

Another great miler, Marti Liquori, wrote: "The athletes who truly make it are mentally some of the toughest people in the world. No one is born with that kind of toughness, and it doesn't come overnight. You must develop it, cultivate it, cherish it!" (Liquori and Parker 1980, page 149)

In chapter 8, I focus on the mental aspects of training, as there is indeed a physiological basis to this concept of mental toughness required in running

Law 13: Rest Before a Big Race

Cut out all racing. . . during the last month of your training; you will need certainly three weeks to put the finishing touches to your stamina and reserve energy. When you consider what a vast amount of work you have already gone through, you will admit that a fortnight or so longer is a relatively trifling matter. Endeavor to keep all your spare time fully occupied with reading, writing: anything that will keep you still, anything to divert your mind from harping on the forthcoming event.

Before Newton, no other writers seem to have discussed the importance of resting up before a major race-a practice now referred to as tapering. Certainly, AU Shrubb trained hard right up to the day of competition. Four days before he set his 16-km and 1-hour world records, he ran a 16-km time-trial in 50:55, just 15 seconds slower than his subsequent world record. The reason Shrubb was successful, even though he did not taper, was probably either because he was remarkably gifted or because he was not a heavy trainer. He also did not compete in races longer than 18 km. I believe that the harder athletes train and the longer the distances they race, the more vital the tapering process.

The Science of Tapering

Most of the information on tapering in this chapter is based on the advice given by the world's most successful athletes. Only recently have scientific studies evaluated the effects on performance of different tapering regimes.

Perhaps the first scientific study of this kind was reported as recently as 1992. Shepley et al. (1992) found that a high-intensity taper in which subjects ran 5 X 500 m on day 5 before the race, 4 X 500 m on day 4, 3 X 500 m on day 3, 2 X 500 m on day 2, and 1 X 500 m on the last day before the race produced significantly better performances during a maximal run lasting 6 minutes than did either complete rest or low-intensity training entailing a total of 30 km of running at 50% to 60% VO_2max over the same five-day period. Certain metabolic changes were identified in the skeletal muscles of those who tapered with the high-intensity protocol. These changes included increased citrate synthase activity and higher muscle glycogen concentrations. However, it is difficult to understand how these minor changes could improve performance in a 6-minute run. It is possible that the main effect of this tapering program, which includes elements of sharpening training, may also be in the brain and its ability to recruit a larger muscle mass for longer during subsequent exercise.

A two-week taper in which cyclists reduced their high-intensity training by 88% and their total training by 66% improved their performance by 8% in a cycling test in which the work rate increased over 30 to 40 minutes (D.T. Martin et al. 1994). Interestingly, muscle power increased as a result of the taper, suggesting that recruitment of the muscles by the brain was altered with tapering.

Houmard and colleagues (1994) studied a group of sub-elite runners who reduced their daily training volume from about 10 km per day to about 1.5 km per day over seven days. Training during the taper took the form of 400-m intervals runs at 5-km race pace, with 100 to 200-m intervals added to complete the appropriate daily training volume. This taper resulted in a 2.8% improvement in 5-km running performance of between 9 to 30 seconds. Heart rate during the 5-km time-trial was higher after the taper, reflecting, in part, the faster running speed. Performance improved even though \o2max and blood lactate concentrations did not alter, indicating that the Cardiovascular/Anaerobic Model could not explain how this taper improved racing performance. These authors indeed concluded that "neural structural and biomechanical factors," consistent with the other performance models described in chapter 2, should be considered when explaining the beneficial effects of tapering. Further, they concluded that tapering seems to produce a 3% improvement in performance, regardless of the quality of the athlete or the volume or intensity of the preceding training. The surprising point is that simply reducing the volume of training by up to 70% does not have the same effect (Houmard et al. 1990; 1992). Thus, the key would seem to be to do very little training during the taper, but to train only at race pace.

Banister et al. (1999) have evaluated whether it is better to reduce training during a two-week taper either by a small stepped reduction in daily training volume, or by a rapid, exponential reduction in volume. They found that the more rapidly training is reduced in the taper, the better the racing performance. Thus, the most effective taper was one in which training was reduced by 50% on the third day of the taper and by 75% on the sixth day with a continuing reduction for the next eight days.

In summary, the scientific evidence confirms that tapering produces a dramatic improvement in performance. The effect is greatest if there is a rapid reduction in training volume already in the first few days of the taper and if training during the taper is at high intensity, approximating 5-km race pace for runners. My advice is that once you decide to taper, do as little training as your mind will allow, but do that little training at a fast pace.

Other distance runners of the day were unaware of the importance of tapering. The day before the 1912 Stockholm Olympic Marathon, Christian Gitsham, the South African who finished second in that race, set out to run the complete marathon distance. Fortunately, his coach caught up with him after he had run 20 km and angrily returned him to his hotel. Some 11 days before the 1920 Antwerp Olympic Marathon, the team of four United States runners ran the course in 02:46:55, a time that they could barely repeat on race day (Temple 1981). On the race day, Joseph Organ ran 2:41:30, Carl Linder 2:44:21, and Charles Mellor 2:45:30 (Martin and Gynn 1979). The fourth United States runner did not finish.

One of the first authors to discuss the importance of resting before competition was Stampfl (1955), who insisted that his distance athletes rest for four full days before competition. But it was really Forbes Carlile (1963) who first emphasized the importance of resting up or tapering before competition. Incidentally, the term tapering was first coined by Carlile and Frank Cotton in 1947.

Carlile and Cotton found that after two or three months of hard training, their swimmers performed best if they eased their training for the last three weeks before major competition. At the end of the first week of tapering, the swimmers would complete a time-trial. "A poor time generally indicates that the swimmer needs more rest" (Carlile 1963, page 33). The 1962 European Swimming Championships proved the correctness of this approach. Before these championships, Carlile was appointed national coach to the Dutch swimming team, which had previously performed very poorly. Carlile's approach was to send each swimmer a document alerting them to the dangers of hard training during the last three weeks before competition. At the championships, all members of the team swam their best times of the year and all but two achieved personal bests as they "swept all before them."

Runners have only recently begun to realize that, as in the case of swimming, adequate taper also enhances running performance. Physiologist Ned Frederick (1983b) used the term "the Zatopek Phenomenon" to emphasize the importance of resting before competition. Frederick recounts that Emil Zatopek (chapter 6) was training very intensively for the 1950 European Games in Brussels when he became so ill that he had to be hospitalized for two weeks. He was released two days before the 1O,000-m race, which, thanks to the enforced rest, he won by a full lap. A few days later, he won the 5000-m race by 23 seconds.

Other famous examples exist (see chapter 6). Dave Bedford set the 1O,000-m world track record in 1973 after a minimum of training. Towards the end of 1973, Derek Clayton ran a 2:12:00 marathon after one of his "easiest preparations" (Clayton 1980). Four months later, he failed to complete the 1974 Commonwealth Games Marathon owing to injury. "I think," he later wrote, "there is a message here as I often thought I trained harder than necessary." (Clayton 1980, p.130) British marathoner Ron Hill reported essentially the same experience. When 37-year-old Carlos Lopes won the 1984 Olympic Games Marathon in commanding style, he did so after an accident had prevented him from training for the last 10 days before the race. Similarly, Joan Benoit-who later became the first woman to win the Olympic Marathon gold medal-won the 1984 United States Olympic Marathon Trial only days after arthroscopic knee surgery for a condition that had interfered with her preparation. Later, she concluded that the surgery was probably the most important contributor to her victory since it forced her to train less.

I have also wondered whether the long and harsh Scandinavian winters, which forced former Norwegian world marathon record holder, Ingrid Christiansen, to train indoors on a treadmill for some months, in any way explained why she set the women's world record in the London Marathon in early spring 1985. Perhaps training indoors reduced the probability of overtraining as might have happened had she trained outdoors.

Thus, our understanding of the value of reduced training before competition has come a long way. It seems that no one knows how long the optimal tapering period before a big race should be. My own view is that it may take at least 10 to 14 days, and possibly even longer, for the body to recover fully from months of heavy training and racing and that this may be an individual response. Mark Allen would, for example, taper for four weeks before the Hawaiian Ironman Triathlon. The optimum volume of training needs to be determined by each person, so each runner needs to experiment with different tapering programs to determine which program produces the best results for the different distances. Guidelines for tapering are provided in chapter 10.

Law 14: Keep a Detailed Logbook

The runner's logbook serves the same function as the scientist's notebook, for it records the result of each day's experiment. When sufficient raw information has been collected, the data can be analyzed, theories developed, and new experiments planned. The goal of each runner's training experiment is to be a better or, perhaps, healthier runner. The hypothesis under investigation is that this can be achieved effectively by a certain type of training. Thus, the key experiment that each runner must undertake is to determine the exact amount of training, appropriately quantified, that will achieve the desired result at the least possible cost in terms of time and the lowest risk of injury, illness, or overtraining (see figures 5.6 and 5.7).

As many athletes do not understand that they are involved in any such experiment, the outcome of which is not initially predictable, they fail to record those crucial daily measurements that will enable the necessary conclusions to be drawn and their optimum individual training programs to be developed by continual experimentation over a lifetime of running.

As a result, those ill-informed runners continue to wander, lost in the training wilderness, never quite knowing exactly how they should be training. If you do not wish to join those lost souls, you must learn early in your running career to record that daily information that will help you become an effective trainer, reaping maximum benefit from a minimum input.

Besides these advantages, a well-kept logbook is a runner's best friend, as it records the path that has been traveled in the search for fitness. It also provides a continuing source of motivation, as well as providing those important clues as to which training methods have been successful or, alternatively, not so successful.

Ultramarathoner Bruce Fordyce believes implicitly in the importance of keeping detailed logbooks, which he calls "textbooks" (Fordyce 1983). By comparing his performances in the same training sessions over the years, he was able to judge his fitness at any time of the year with pinpoint accuracy. The result was that he was always right on race day and thus established a degree of consistency never before seen in ultra-distance running and equaled by very few other athletes.

The essential information to include in the logbook are the date, the training route, the details of the training session, the shoes worn, the running time and distance, running partners, and the weather conditions. These are the basic descriptive data to which you will return over the years to see, for example, how much and how fast you are now running in comparison with what you did in the past.

There are nine additional pieces of information that may be included in the logbook, not because they have any historical value initially, but because they will tell you whether or not you are overtraining. I have listed all possible indicators that you may wish to include; with experience you will learn which you find to be the most useful.

How the run felt. Pay particular attention to muscle soreness, the level of fatigue, and the intensity of the effort. In chapter 7, I describe how this information is used. The athlete who consistently trains on broken-down legs should rest until the legs recover.

Effort rating. Use the Borg Scale (tables 5.2A and 5.2B). This information tells you when you are reaching your peak, as you will run at a higher intensity but will feel less fatigued. In contrast, high perceived exertion ratings during exercise of low intensity indicate that you are tired and that you need to rest.

Enjoyment rating. On this scale, a score of 1 indicates a run that was not enjoyable at all; a score of 3, a neutral run; and a score of 5, a very enjoyable run (J.E. Martin and Dubbert 1984). If the runs score consistently low on the enjoyment rating scale, then you need to analyze the cause. You may be running too much and may be overtired, or you may be running at too high an intensity. If the runs continue to be unpleasant, the chances are that you will drop out and stop exercising. In such instances, my advice would be either to rest completely or to do gentle exercise until the desire to exercise returns and the exercise-related symptoms disappear.

Training load. A method for determining the training load was described on page 290. Figure 5.6 details how that information can be used to determine optimum training load.

Waking pulse rate. Measure and record your pulse rate within a few minutes of waking in the morning. If your waking pulse rate suddenly increases more than five beats a minute above the normal value, you have done too much the previous day and should either train very little that day or rest completely (chapter 7). You may refine the technique by re-measuring the heart rate exactly 20 seconds after first getting out of bed in the morning. Your heart rate increases when you stand up, and the degree of this increase can also indicate overtraining. Although there are as yet no publications to support this theory, we have collected some evidence to suggest that elevated sleeping heart rates may also be an early indicator of overtraining the previous day. Perhaps there is some value also in recording sleeping heart rates. If they too are consistently elevated, you may be training too hard.

Early morning body weight. As you become fitter, your body weight will fall progressively before stabilizing. But if it falls too much you may be overreaching or overtraining, or you may have an eating disorder. Indeed, a continuing loss of weight is a late indicator of overtraining (see chapter 7). The idea that you can never be too light to run is false. As originally observed by Arthur Newton, there is an optimum racing weight for each athlete; going below the weight will result in poorer performances, not better ones.

Post workout body weight. This is a valuable indicator that can be used to quantify your sweat rate. It will help you calculate how much you need to drink while exercising (see chapter 4).

Bedtime and number of hours' sleep. Again, changes in sleeping pattern provide another easily measured indicator of overtraining. The changes that should arouse concern include going to bed progressively later at night, sleeping restlessly, waking earlier, and, as a result, sleeping less than normal (chapter 7). A restless night may also be shown by frequent, sudden spikes in the sleeping heart rate.

Record your heart rate and times during all training sessions (especially during speed work sessions and races). The value of any training information is greatly enhanced if there is additional information from the heart rate data measured during exercise. This can be achieved if a heart rate monitor is worn during every training session, especially if the monitor has the ability to download the information to a computer-based training logbook like the PC Coach or to interact with exercise scientists via the Body iQ system. This information allows you to calculate the weekly training load in terms of the strain of your body. This is roughly proportional to the number of heartbeats expended during training. In addition, this information enables you to compare your heart rates during similar training sessions, not just from month to month, but from year to year. Provided your heart rate is the same or lower during sessions in which you performed equally (presuming equivalent environmental conditions), then your fitness is either the same or improving.

An alternative testing method proposed by Philip Maffetone, and subsequently dubbed the Maximum Aerobic Function (MAP) test, is to determine your running speed at the "180 minus" training heart rate (the 2nd Law of Training). This can be done weekly or biweekly on any measured running track. If your running speed at that heart rate continues to improve, so too will your fitness level. Once your heart rate at that running speed is no longer falling, it may be time to include some training of a higher intensity in your overall training program.

Women should record their menstrual cycles so that they can determine whether their performance is influenced by their menstrual cycles or vice versa, and, if so, whether they wish to alter the timing of menstruation, particularly before competition. Women should also evaluate whether training or their diet influences their menstrual patterns.

Law 15: Understand the Holism of Training

The term *holistic running* was first coined by Kenneth Doherty (1964), who made the very simple but profound observation that most training methods "limit their attention to what happens during the few training hours each day and ignore the remaining 20 or more hours, which are often just as effective in determining success in running." (page 121)

Thus, you need to be aware that you are in training 24 hours per day and that everything you do can affect your running. But you should also be aware that there is a holism to training itself. In his analysis of the different methods of training, Doherty (1964) suggested that the success of Lydiard's training was due to the balance Lydiard achieved between training and competition; between races that were important and those that were merely training; between mileage and enjoyment; between different kinds of terrain; between endless year-round training and maintaining motivation through six different types of training; and between steady-state and uneven speed running. Clearly, it is important for runners to achieve this balance in their own training. Equally important, runners must balance a commitment to running to all the other components of life-family, work, recreation, and other relationships.

Everything affects how you run and train. Unfortunately, only the professional athletes are ever able to control their lives so completely that running becomes their central focus. For the rest of us, running must compete with various other activities. But to do our best, we must first recognize these enemies and try to keep them from interfering with running.

There are four major factors that must be taken into account when you are training hard-eating an appropriate diet, getting the right amount of sleep, avoiding physical effort during the day, and reducing work stress.

When training heavily, most athletes probably take in slightly fewer kilojoules than they burn and, as a result, lose some weight. Many will also reduce the amount of fat they eat, although few runners actually eat as little fat as the dieticians suggest they should (Hawley et al. 1995.) This paradox was addressed in chapter 3. Galloway (1984) has suggested that fatty foods seem to impair running performance and that this effect becomes more marked with age. However, in chapter 3, I discuss the possible value of fat in the ultra-endurance athlete's diet.

Most runners generally sleep an additional hour per night on those days that they train hard or long. Even Plato observed that "the athlete in training is a sleepy animal." Another essential training trick is to avoid, where possible, excessive work stress, such as working overtime, endless traveling, and meetings. These aspects are discussed later in this chapter.

A book I've mentioned before, *Lore of Running*, dedicates an entire chapter to the contributions of Arthur Newton, who raced in the 1920's and 30's. Newton was what we would call today an ultra-marathoner. He ran a large number of races between 60-100 miles - but, his ideas helped to modernize training for all distance runners. In *Lore of Running,* Tim Noakes identifies 9 "rules" of Newton's training that have have become "common sense" in long distance training.

1) Train frequently year-round: Before Newton most world class runners trained only part of the year - and not very strenuously by today's standards. In fact many books of the time suggested walking as good training.

2) Start Gradually and Train Gently: Since many runners didn't train all year long - they tried to get back into training too quickly. Newton praised the benefits of what we would now call long slow distance (LSD). Which Noakes defines as 20-25% slower than race pace.

3) Train first for distance (only later for speed): I would say that's the major feature of my training for Boston. I'll be doing quite a bit of distance before I ever hit the track.

4) Don't set a daily schedule: Well, I've kind of messed up on this one. My days are scheduled for the next 25 weeks. However, I know I need to be flexible. If something comes up or I'm too tired or the weather is crazy on a "quality" day - I have no problem postponing the workout.

5) Don't race when you are training, and run time trials and races longer than 16 km only infrequently: This basically relates to the idea of "periodization" discussed earlier. Set aside a good chunk of time that's just for training - not racing. Now, his idea of "infrequently" is a little different than mine. He suggested that marathoners should not race more frequently than every two months - running a marathon about every 2 years is enough for me!

6) Specialize: Noakes interprets this as make sure that you train for a specific distance. Training for a 5k is very different than training for a marathon. Another way to think about it is to concentrate on the distance that you are most talented at - although, i'll admit that if that was the case I'd never run a marathon.

7) Don't overtrain: This is a pretty simple one - of course it's sometimes hard to tell when you've crossed the line. Marathon training is so difficult that simply being tired might not be a sign to ease up your training. But, on the other hand, you can't ignore what you're body is telling you. If your pace is way off in workouts - or you're getting sick constantly you should probably back off.

8) Train the mind: People probably don't appreciate the importance of training your mind to overcome pain. Many runners who don't start until they are adults train at the same pace that they race. Of course, part of that is they are not necessarily competing - but, another part of it is that their minds are used to pushing their bodies as hard as someone who has been competing since they were a kid.

9) Rest before the race: As I said before, the taper is very important. Noakes argues that no other running writer seems to have said anything about tapering before Newton. In fact, many would run time trials just days before big competitions.