The development and training of young 400 metres runners

Carlo Vittori

Carlo Vittori presents a case for a more scientific approach to the development of 400 metres runners from the age of 13. He stresses the importance of fostering the right mental attitude at this age and then describes the functional prerequisites of the 400 metres specialist and appropriate methods of testing and selection for this event. He then illustrates in detail the training programme best suited to the development of these abilities.

1 Introduction

In Italy, 400 metres running has always been adversely affected by two main factors. Firstly, the Mediterranean somatotype is poorly adapted to withstand fatigue or prolonged stress and tends to lack stamina, an essential prerequisite for success in this event. Secondly, an erroneous interpretation of this phenomenon has all too often inspired inadequate and inconsistent training methods. Moreover, 400 metres specialists have never been selected on the basis of the necessary specific physiological and mechanical performance requirements, so that the inadequacy of the training methods is even more pronounced.

In most cases the training plans designed for younger athletes are better suited to sprinters. The total work-load is not sufficient and the running distances are too short, especially since these athletes start to compete over the full 400 metres distance quite late, at around 16 years of age. The necessary physical factors for this event are seldom sufficiently developed by the type of training used, nor are the necessary mental qualities stimulated, particularly that of stress endurance. The latter aspect is even more serious than the former. The future 400 metres runner must acquire the correct mental attitude quite early on, so that he may fully understand the importance of a positive approach to training.

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Translated from the original Italian by Alessandra Lombardi
Very often athletes with average performances in the shorter sprint disciplines are persuaded to undertake 400 metres races because they are capable of achieving reasonable speed. Such a transfer is difficult and results are limited by the fact that these athletes lack what might be termed a callousness towards fatigue. They are not accustomed to make efforts beyond their individual 'fatigue threshold'.

As the problems I have identified are, to a greater or lesser degree, common to many countries, there is a need for better understanding of the process of development and training of young 400 metres runners. The purpose of this article, therefore, is to examine this process in the light of the latest knowledge and to give principles and practical advice on training to coaches.

2 Introduction to running

Young athletes should be introduced to running at about 13 years of age. Their training and competitive activity should be comprehensive, embracing short and long sprints as well as endurance running. They must become athletes before they can decide whether to be a sprinter or a distance runner.

Eventual specialization can only be based on a thorough knowledge of the young athlete's attitude and capabilities. This may be acquired through suitable training which satisfies the dual purpose of preparing the athletes and investigating their potential. It is only after two or three years of work that the coach will be able to appreciate an athlete's potential and the athlete learn enough about himself to ensure that his chosen speciality will be consistent with his capabilities.

Training should incorporate a wide range of running exercises with varying rhythms and speeds, as well as methods which can test and develop different strength capacities. Specific strength of the muscle groups directly involved in running and general strength of all other muscles ensures a balanced and harmonious development; variety in the training methods and the use of a wide range of exercises are essential in that they facilitate the progression of work-loads and promote the athlete's physical development.

It is always difficult to identify and to develop a young athlete's physical and mental capacities. These are obviously age-specific, and the accurate evaluation of an athlete's potential is hindered by complex auxological phenomena.

Muscular development is among the more age-related features: muscle strength and efficiency gradually improve as the endocrine system matures. However, individuals vary greatly. In two youngsters of the same age we may easily find that one has hair growth evident on the face and chest, and well-defined muscles, while the other is smooth-faced and has less developed muscles. This is an external sign of a difference between chronological and biological age, but the evaluation of such differences is best left to a specialist in auxology. It should not be surprising to find that the performances of the more 'mature' boy suggest he has more potential than the boy whose biological development is delayed. What is surprising is that all too often the latter is overlooked for this reason. It is in fact quite likely that the boy with a slower biological development will eventually equal and even exceed the other boy's performance. In later years, growth and development will tend to be more substantial and complete in the 'slower' boy as compared to the one whose development began earlier, but will therefore probably show less progress later. It has often been observed that the best results are frequently achieved by athletes who were not particularly remarkable as juniors.

For this reason the training method described above - a wide range of exercises and great variety in the training means - should continue up to about 16 years of age, when a preliminary selection is made between sprinters and middle- and long-
distance runners. Training programmes are modified accordingly. The second, decisive selection occurs at around 18 years of age: at this point the athlete commits himself either to the short sprints (100 metres and 200 metres) or to the longer 400 metres sprint.

3 The somatotype of the 400 metres runner

It is not easy to arrive at an exact definition of the somatotype of the 400 metres specialist, but it is necessary if the training methodology is to be suited to the specific requirements of the event. Such a definition emerges from the combination of somatic, functional and psychological factors. In the following study we shall dwell particularly on the functional factors because we have already briefly touched on the psychological factors; as for the somatic factors, the number of variables we would have to examine is too vast.

The functional factors are the ones which determine the physical characteristics of the 400 metres runner. They influence the technical behaviour pattern that allows an athlete to express his capabilities and achieve a given performance.

4 The functional requisites

4.1 Speed

Speed is the fundamental requisite for this event. We should here distinguish the acceleration phase from the full-speed phase. These two dynamic moments are determined by different physical capacities and, as we shall see further on, by different expressions of strength. They should consequently be developed using distinct training methods.

4.2 Strength

Strength is a prerequisite for the achievement and maintenance of speed. The expressions of strength that influence the acceleration phase are 'maximum dynamic strength' and what we shall define as 'explosive elastic strength'. We shall define those that influence the full-speed running as 'explosive elastic strength' and 'reflex elastic strength'. This latter form of strength is that which produces the highest peaks in the shortest time (8-9/100 sec.), as in the case of ground contact of the foot during the full-speed run.

Explosive elastic strength and reflex elastic strength are the prerogative of fast twitch fibres, and a 400 metres specialist should possess a large percentage of these - no less than 70%. The development of this type of strength should be extended to all the antigravity muscles, in particular to those of the lower leg, of the foot and of the gluteus because these muscles help to maintain the pelvis in the correct position during full-speed running. The foot action of the 400 metres specialist differs from that of the short sprinter: it is more elastic and better suited to an economical run at a reasonably high speed. When the muscles of the foot are correctly employed, it is possible to reduce significantly the involvement of the pelvic and thigh muscles: these are flesher and thicker and consequently muscle fatigue is more substantial.

Muscle viscosity also affects the energy expenditure: it should be as low as possible in order to conserve the energy necessary to overcome muscle friction. This factor can be improved by training, using all the sprint drills, with frequent runs over longish distances. Short runs, involving more powerful types of work, would tend to create harder, less elastic muscles.

It appears obvious that effective training methods for this event should give prominence to the development of all types of strength, both general and specific. In addition, all strength work should be followed by exercises that will enable the athlete to transform this newly acquired strength into greater power.

4.3 Endurance

Endurance is the quality necessary for an athlete to continue his efforts despite increasing fatigue. It is synonymous with
'stamina'; more a mental than a physical quality that urges the athlete to conquer new limits.

Because of the intensity and brevity of the effort, endurance in this instance comes from the ATP recharge anaerobic energy system. It is a product of glycogen breakdown and is called anaerobic lactacid because the final product of the reaction is lactic acid. Anaerobic lactacid energy occurs in the fast twitch fibres, of which the 400 metres specialist must have a high percentage.

These considerations allow us to make the following three points:
- All sprinters have the capacity to obtain excellent results in the 400 metres as long as they possess the right mental attitude and are capable of achieving a fast pace with economy of effort.
- 400 metres runners make little use of aerobic energy since the latter is produced by slow twitch fibres.
- Consequently, their training should not include long runs requiring aerobic energy. The intensity of effort should always be just above the anaerobic threshold, so that the exercise is sure to involve the fast twitch fibres. Otherwise, with training involving mainly the slow twitch fibres, there is a risk of altering the metabolism dynamics of intermediate fibres into those of slow twitch fibres. This is particularly important for elite athletes. It is slightly different in the case of very young athletes: here occasional continuous aerobic runs may be useful for the athlete's overall development, but they should never become a habit.

The 400 metres runner must therefore satisfy two fundamental requisites: one physical, the other mental. He must possess a large reservoir of anaerobic energy, and he must also have the will-power necessary to make full use of this capacity - to continue his effort despite the first symptoms of fatigue and discomfort caused by lactate build-up. In other words, he must have the ability to produce large amounts of lactic acid and to endure these high levels of lactate in the muscles. It is not quite clear which of these factors is the main cause of the inability to maintain effort.

The experiments carried out in Barcelona by Dr. Fernando A. Rodriguez showed that the lactate in the blood, measured after a 400 metres competition, is lower than that measured after a test consisting of two full-speed runs over 300 metres with 2 min. rest. Since the lactate level is higher when the build-up occurs gradually than when it is accumulated during one very intense effort, it may suggest that the athlete's difficulty in continuing his effort comes from a difference in the dynamics of lactic acid production.

These considerations on the endurance of a 400 metres specialist should be sufficient to clear up the misunderstandings arising from a training method which identifies a particular type of runner known as an 'endurance' runner. Some years ago, the comparison of an athlete's best performances over 400 metres and over 100 or 200 metres led to the definition of two different somatotypes: one for runners whose main quality is speed, the other for those whose main quality is endurance. All too often an athlete commits himself to the 400 metres event on the basis of a superficial evaluation of his performance over this distance. One should consider that a result of 48.6 at 16-17 years of age can be obtained by means of a fairly low speed that is more or less constant all the way. Such a result may be achieved by a runner whose main quality is endurance, not speed, because he probably uses less anaerobic energy and therefore produces less lactic acid so he can easily maintain his speed. This 'endurance' runner has a higher percentage of slow twitch fibres which prevent him from attaining high speeds but make it easier for him to maintain over a long period the speed level achieved. An average performance can easily be obtained, but will seldom lead to outstanding results. Unfortunately, this will become apparent when it
is already too late for the athlete to transfer to the 800 metres event, mainly for psychological reasons.

A 400 metres runner's endurance can be accurately estimated using the following method: his best time over 200 metres is multiplied by 2 and subtracted from his best time over 400 metres. The result is the *endurance index.* A low endurance index indicates excellent endurance. Usually the value is between 3 or 4 sec.; in some cases it may even be as low as 2 sec. A low endurance index combined with an average 400 metres performance indicates the athlete has little speed and speed-strength capacity; a low endurance index combined with a good 400 metres performance indicates a real 400 metres specialist. When the index is close to 4 sec, it may mean that the lactacid capacity is under-developed, that the effort distribution or the running technique are incorrect, or that the athlete has little stamina.

4.4 Effort distribution

One of the more important and fascinating items of 400 metres training is pace judgement. The athlete will acquire the ability to select the most economical stride length and frequency for a given speed, and this will be of great assistance in maintaining the proper rhythm.

This skill enables the athlete to select the most economical combination of stride length and frequency and so achieve a running pace that can be maintained unchanged right to the end of the race. This raises the average speed of the performance.

It is always better to begin the race a little too slowly, rather than too fast, because this mistake can be compensated for by a faster pace in the second half. On the other hand, too high a speed at the beginning of the race entails an excessive consumption of the powerful 'aerobic lactacid and lactacid' energy and consequently an early lactate build-up that will hinder the athlete's muscle efficiency. In the second half of the race the athlete will have to use the less powerful aerobic energy, produced by slow twitch fibres. Speed will decrease significantly and, in the end, the athlete will find he has lost more in the second half than he gained through a fast beginning. An error in effort distribution can have a devastating effect on the athlete's performance. It may raise questions on the adequacy and efficiency of the methodology of an athlete's training, but, what is worse, it leaves him with an acute feeling of discomfort that will be quite difficult to forget.

In my opinion, all work on effort distribution should be aimed at achieving similar partial times in the first and second half of the race. Among the better known athletes who follow this strategy we may mention the 1964 Olympic Champion Larabe, and the present World Record holder Butch Reynolds, who covered the first and second 200 metres in just over 21.6.

The timing of each 100 metres section gives a better idea of the progression of speed. Ideally, there should be a difference of about 1 sec. between the first and the second 100 metres. For instance 11.6 and 10.7 point to a more efficient distribution of effort than 11.2 and 11.1 because they indicate that the athlete has made better use of their muscle energy supply. The lactacid energy reservoir will last longer if a slow, controlled start is followed by a long, progressive acceleration. Consequently, the involvement of the glycolitic lactacid mechanism will probably be delayed and reduced with the obvious advantage of a slower lactacid build-up. We should not forget that it is in the acceleration phase that the sprinter burns the greatest amount of lactacid anaerobic energy; a large quantity of muscle fibres is required to set in motion his body mass. Once maximum speed is reached, the energy cost decreases and the yield increases. This is because during the drive the reflex elastic strength allows the athlete to use part of
the kinetic energy stored by the antigravity muscles during the negative phase.

This type of progression, with the highest peak about half-way through the first straight, allows the athlete to face the second half of the race with sufficient energy to overcome its most delicate phase. It is at about 250m from the starting line that the athlete experiences the first signs of a growing discomfort, which he will overcome with greater ease if he is conscious that his speed is adequate and that he still has sufficient energy to finish the race. Half-way through the second bend he must 'collect' all his remaining energy in order to maintain his speed despite the onset of lactic acid fatigue. The real effort begins here, when he has to hold his form and maintain speed under the stress of increasing fatigue. However, if the first 200m have been run too fast, the athlete will already be in a state of acute discomfort and still have to face the inevitable decrease in speed due to the involvement of the slow twitch fibres and their aerobic energy.

Ideally, the third 100m should be covered in about the same time as the second, and the fourth in about the same time as the first, so the partial times of the two 200m are nearly equal.

5 Progression of training

5.1 Introduction to running (up to 15 years of age)

As mentioned above, up to 15 years of age training and competitions should embrace all the running events. This should satisfy one of the fundamental requirements of pedagogy: the youth should be aware of the reasons behind the work, and understand how it is connected with his physical and psychological development so that he may take an active part in the training process and not be a mere 'object'. The young athlete must get to know his own potential, identify a reference point, understand how much work remains to be done and the degree of involvement required. He will then learn to love this difficult and fascinating game - in other words, he will be really motivated.

In this age group there should be quite a number of competitions. In fact, training can be turned into a competitive situation; this helps to make real competitions less awe-inspiring. At the end of each preparation period there should be regional or inter-club competitions featuring all the events covered by the training programme.

The training programme should be divided into three cycles as shown in Table 1. There should be no less than three training sessions a week, lasting about 2 hours each.

5.2 Preliminary specialization for the sprint events (16-17 years of age)

A preliminary selection can be made at about 16-17 years of age. Athletes will be directed towards short and long sprints, or middle- and long-distance events, according to their inclination.

Potential specialist sprinters should at this age train and compete in all the sprint
2. Training programme

The content and objectives of each preparation period are substantially the same, but the training plan will have to be readjusted on the basis of an accurate monitoring of all the relevant capacities. At this age athletes are still subject to periods of rapid and significant physical growth.

The abilities which should be developed are:
- **strength** in the form of 'explosive elastic strength' and 'reflex explosive elastic strength'. Both are an expression of speed strength;
- **speed** acceleration and full speed running;
- **aerobic endurance**, especially the aspect of power. This can be developed with continuous runs, progressive runs and interval runs over distances ranging from 100-300 metres;
- **specific or lactacid endurance.** This capacity can be developed with runs over distances ranging from 60-300 metres. Speed should be higher than in the previous exercises and recovery longer.

In this age group, the first rest period immediately follows the preparation period to allow a more complete regeneration. In the second cycle, regeneration occurs during the first part of the competitive period which includes only minor competitions. The training in this period is not particularly stressful.

5.3 Specialization

The athlete now has to make the decisive choice between the short sprint events and the 400 metres.

A training programme for 400 metres specialists must consider two cycles that have different contents, different targets and use different training methods. This is a revision of training method which will lead to high-level performances. It provides a number of advantages:
- The possibility of adjusting the training plan before any mistake can cause serious damage;
- exercises accurately aimed at specific targets and performed continuously over a three month cycle will develop the necessary abilities more completely. A more pronounced specificity of training is necessary because, at this older age, the athlete's organism is more precisely defined and so would not respond to non-specific work;
- having different training contents for the two cycles avoids the mistake of repeating similar training plans for the indoor and outdoor season.

The basic requisites that should be developed in the first preparation period are: strength as 'explosive elastic' and 'reflex explosive elastic' strength; endurance as aerobic power; and the capacity that is on the opposite end of the biochemical chain, speed endurance. The first preparation period does not include speed and specific endurance or lactacid capacity. These will be included in the second preparation period when the athlete's condition will have improved, and the indoor competitions will
make the work more profitable. The two cycles should be organized as shown in Table 3. At the end of the two cycles the athlete should have attained an excellent condition and be able to achieve good performances.

For athletes aged between 18 and 19, the two rest days should conclude the weekly microcycle. This allows more time for recovery.

In the case of older athletes, the number of training sessions can be further increased to up to two sessions a day in the first preparation period before the indoor season, because the work here is less stressful. In the second preparation period there should be not more than 8 sessions a week, 5 in the afternoon and 3 in the morning.

The two preparation periods each contain 3 cycles, the first of which lasts one month while the other two last 3 weeks each. The first cycle contain 20 days of loading and 10 days of unloading; the others 14 days of loading and 8 of unloading. The work of the unloading period should be decreased to about 30% of the previous work-load, and the content and the intensity of the work should vary.

5.3.1 Strength

Strength exercises should be included in both preparation periods: modulation and distribution of the exercises will vary according to the specificity of the work. The exercises must involve all the muscles, in particular the abdominal and gluteral muscles and the lower leg muscles, including those of the foot. The exercises can be either complex, involving more or less all the muscles, or simple, aimed at a specific sector. The more important exercises are those that involve the extensor and flexor muscles of the legs in complex movements similar to the forward drive: high lift of the upper leg and complete extension of the support leg. This is the essence of the running action and there must be a good number of exercises aimed at developing the muscles involved. If the gluteal muscles are sufficiently developed they will help sustain the pelvis in the correct position, relieving the load on the pelvic and upper leg muscles and also allowing a better use of the foot and calf muscles through the expression of a more economic form of strength (i.e. reflex elastic strength). Some of the more significant exercises are listed below.

1. The two more common weight-lifting exercises, snatch and clean, including all the intermediate exercises (extension of the back and lift, extension, lift and clean to the chest; turns; thrusts upwards). All exercises must be performed feet together.
2. Fast half-squats with a load ranging from 150-250% of body weight.
3. Half-squat jump with a load equal to about 50% of body weight.
4. Knee pick-ups to the chest. This exercise should be performed with ankle weights (about 2 kg). The important points are the range of the knee pick-up and the maximum extension of the support leg, determined by the action of the gluteral muscles in support of the pelvis which is subjected to the load of the flexed leg and of the ankle weight. Maximum extension is favoured by the gluteral muscles rather than the extensor muscles. There should be at least 4 sets of a maximum of 50 repetitions.

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followed by three weeks of secondary competitions (at least 5 or 6) over 200 metres
A similar exercise to the above can be performed with one leg tied to a traction device. The athlete places his shoulders to the device, takes one step forward with the free leg and lifts the knee of the other leg towards the chest. The athlete then steps back and repeats the exercise 30-40 times, with four repetitions each set, 2 on each leg. The load with this apparatus should be greater than that when using ankle weights, because the step forwards and the fixed apparatus favour the dynamics of the exercise.

6 Short skips, running almost on the spot, with a high knee raise, moving forwards not more than 50 cm with each step. This exercise can be performed with or without ankle weights. Here again the important point is to raise the knees as high as possible and to extend the support leg. The athlete should soon be able to perform 300 steps in the time of 90 sec. and 80 sec. with and without ankle weights respectively.

7 Long bounding strides. The athlete must push harder to move forwards and increase the speed of execution. If the leg does not rebound swiftly with a high knee raise the exercise becomes a normal running action. Here too the support leg must always be fully extended and the trunk slightly inclined to favour the forward movement. The exercise continues as long as the athlete manages to control his speed, at least 50-60m.

8 Multiple bounds - a succession of different bounding exercises, in sets of 10 repetitions over 50-100m. The exercises should be performed on grass whenever possible, and combined so as to total about 120 bounds. In 10 bounds, the top-class athlete will cover about 35-40 metres; 50m and 100m are equal to 15 and 30 bounds respectively.

9 Heel raises (one foot at a time). The body is inclined forward, arms outstretched, hands resting on a wall. The heel must be raised as high as possible while the front of the foot remains on the ground. Loads, such as belts, may be used if necessary. At least 150 repetitions should be performed for each foot.

10 Bounds (bunny-hops) over hurdles. Two-legged jumps over 6-8 low hurdles (about 60 cm) placed at a distance of about 1m. The rebound must be swift and powerful to obtain good elevation over the hurdle. The ground contact must be as short as possible, without reducing the elevation.

The distribution of these exercises may be organized as follows:

Exercises 1, 2, 3, 4, 5, 9 in the first two cycles of the first preparation period with a frequency of 3 and 2 weekly units respectively. These same exercises are also included in the first cycle of the second preparation period and performed twice every 7 days.

Exercises 8 and 10 are performed twice a week in the second and third cycle of both preparation periods. They can also be performed during the period dedicated to secondary competitions but, in this case, the work-load should be reduced by about 30%.

The two skip exercises are part of the special step exercises for speed training and should therefore be distributed accordingly.

5.3.2 Endurance

The development of aerobic power is the fulcrum of the first preparation period. I suggest the following training methods: fast continuous runs; progressive continuous runs; interval runs. At the beginning of each of the three cycles the work-load should progress rapidly to maximum volume, with the intensity adequately proportioned. The quantity will then remain constant while the speed of execution increases.

In the first cycle, two training sessions should be dedicated to continuous runs (one fast and one progressive) and three sessions
to interval runs, or vice versa where necessary.

In the second cycle, fast continuous runs will be replaced with speed endurance while the interval run sessions remain unchanged.

In the third cycle, as the competition period approaches, progressive runs will be replaced by more specific exercises, often known as ‘mixed endurance’ (aerobic power and lactacid capacity) work. In comparison with interval runs, there is an increase in speed and longer rest intervals. This allows the athlete to reach a condition that is better adapted to competition requirements without excessively increasing the intensity of the stimuli. The sessions dedicated to speed endurance are doubled, while those devoted to interval runs are reduced to two, using shorter distances where necessary.

In the second preparation period, aerobic power work is limited to interval runs which are included only in the first two cycles with a frequency of two sessions and one session a week respectively. From the beginning of the first cycle, one of these weekly sessions will be gradually transformed by increasing the speed and rest intervals, so that in the second cycle it will become normal lactacid training.

5.3.3 Speed endurance

For the development of speed endurance, repetitions over 60-80-100m are performed, initially at an intensity equal to about 93% of the athlete's best times over these distances. Each training session should include all the distances in various combinations and should total between 1200 and 1600m. The important point is that the intensity of the exercises should be constantly increased.

In the first preparation period these exercises are included only in the second and third cycle, once and twice a week respectively.

In the second preparation period they are included in the first and second cycle twice every week.

5.3.4 Specific endurance or lactacid capacity

Specific endurance pertains to the second preparation period. It is stimulated in the first cycle but actual training occurs only in the second and third cycles with running exercises over distances ranging from 100 to 600m. Each of the two weekly sessions dedicated to specific endurance should include all the distances. At the beginning, runs over the medium to long distances will be more frequent, while those over medium to short distances will be preferred towards the end of the preparation period because they are more consistent with 400 metres running. Initially, the intensity will be equal to about 85% of the athlete's best times for the shorter distances and 80% for the longer distances. The total distance run in each session should be between 1800 and 2200m with recovery pauses of 6-8 min.: these will become longer as the speed increases.

In the third cycle, when intensity becomes incompatible with volume, the latter will be decreased by about 30% and the recovery pauses lengthened in order to favour a further increase of intensity. It is also possible to adopt a different method - undulatory variations of the intensity. The volume remains the same and short runs are alternated with long runs without changing the length of the recovery interval.

Also in the third cycle, one of the specific endurance sessions is converted into effort distribution training with runs over 200 and 300m (two bends). The distances should be covered in the ideal intermediate times of a 400 metres competition, calculated as described in the paragraphs dealing with this issue. The rest intervals here should be quite long so that fatigue does not interfere with the number of repetitions, which should be sufficient to stimulate the lactacid capacity.

An alternative exercise is to arrange the runs in order of length and start either with the longest or the shortest distance. In the
first case the athlete will have to run the shortest distance at the highest speed when he is already tired and therefore finds himself in a condition very similar to the final phase of a 400 metres competition.

5.3.5 Speed

Speed training, i.e. work specifically aimed at enabling an athlete to achieve increasingly high speed, is included only in the second preparation period, although some of the prerequisites are stimulated and developed in the first preparation period. The exercises can be divided into two groups: running drills and real speed runs. They can be performed with or without ankle weights and belts which are used to stimulate the flexor muscles (to increase stride length) and the extensor muscles (to increase stride frequency) respectively.

1) Running drills
   a. Toe-heel-toe steps
   b. Bounding runs
   c. Kick-back at each step
   d. Short skips (timing 50 steps)
   e. Long skips (timing 60m)
   f. Fast 'circle' runs (stride frequency can be calculated by dividing time over the established distance by number of strides)
   g. Long striding (stride length over 100m should be 13 % greater than the stride frequency in a competition over the same distance)

These exercises should be performed separately, paying great attention to the accuracy of the technique. Some of them (namely d, e, f, g) can also be combined into a sequence that can be very stimulating and teach the athlete subtle rhythm variations. For example, start with a short skip, which becomes a long skip and then a fast circle run. The exercises should obviously be very carefully selected so that the progression may always be fluent and fast.

The exercises, divided into two or more groups, can be used to conclude the warm-up units and so make full use of the available time. They are particularly useful because they stimulate the expression of speed strength and also enable the athlete to master rhythm variations, an extremely important feature of the preparation of a specialist whose performance is closely connected to his ability to interpret the different modulations of speed.

2) Speed runs

These are fast speed runs over 60-80-100m and progressive runs over 80m. The aim is to achieve the highest speed in the last 20m; accurate timing of the last 20m is necessary. In the speed runs, acceleration should be marked and powerful, while in the progressive runs it should be longer and more gradual. The athlete will begin running lightly and then select a constant rate of acceleration that will bring him smoothly to his maximum speed in the last 20m. This exercise requires great skill and is very useful in that it teaches the athlete to understand the use of strength and the swiftness of its expression in a controlled progression of speed.

These drills and runs should be included only in the second and third cycles of the second preparation period with a frequency of two sessions per week. Belts with a load of about 15 % of body weight should be used only at the beginning of the second cycle, and not in all the sessions. Times obtained with the belts will give an indication of the eccentric strength of the various propulsive mechanisms, especially of the muscles of the feet. Rest intervals should be sufficiently long to allow near-complete recovery. Belts are not used in the third cycle unless a particular need is observed.

6 Considerations on the distribution of training means

The distribution of training in various sessions is perhaps one of the more difficult points of training method. The aim is to achieve a structural unity by combining and connecting the various methods so that
each will enhance the efficiency of the others. This is all the more important when, as in our case, there is a great variety of essential exercises repeated during each weekly microcycle. The following are examples of distribution that in my opinion fully respect the compatibility of the training means involved.

All aerobic power work can be placed at the end of a strength training unit, but there should be a 20 min. warm-up run to relax the muscles and favour peripheral blood flow.

Speed endurance may be followed by aerobic power or even by lactacid capacity in the first cycle when the intensity of lactacid capacity work is not yet very high.

Speed runs may be performed separately, be followed by aerobic power work or precede one or two exercises for lactacid capacity work over long distances such as 600m.

Special 'step' exercises that conclude a warm-up unit may be followed by horizontal bounds and then by aerobic power or lactacid capacity work.

These concepts apply also in the case of older athletes who have two training sessions a day. The work-loads will certainly be greater but they will be divided between the two training sessions.