The European School in sprint training: The experiences in Italy

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by Carlo Vittori

The article discusses the concepts of sprint training developed by the author from his long experience as an athlete and coach. The theoretical basis upon which these concepts were founded is described, as well as the methods used, with the assistance of several other experienced coaches, to validate it.

It is claimed that the methods used to develop speed in the past were artificial; they were based mainly on technical analysis and neglected the all-important study of the energy systems and the types of muscular strength applied in sprinting. With this in mind, a tripartite system of training to develop speed was evolved, the core of which took the form of running or running related exercises. A detailed description is given of the methods used, in this system, to develop alactic capacity and specific muscular strength and to perfect the balance between stride length and stride rate.

Photo: Scuola dello Sport

Carlo Vittori is a Technical and Scientific Committee member of the Italian athletics federation FIDAL, a former national sprint coach for Italy and personal coach to Pietro Mennea.

I have been involved in Athletics for nearly sixty years, practically all my life, just like my father and my brothers before me. It must run in the family! My natural attraction was further enhanced by Riefenstahl's superb film on the Berlin Olympics.

I was a sprinter up to 1954, the year of the European Championships in Bern, and after that I dedicated myself to coaching, probably because of the many feelings of dissatisfaction I had experienced during my career as an athlete.

Even in those years, I was firmly convinced that coaching cannot be based on more or less reliable suggestions, intuitions or improvisation. There must be a method. I, therefore, tried in every way to reject the prevailing opinion in Italy, which saw training as mere technical instruction; it had no vigour, no "soul", because it was not sustained by an adequate training of the physical component.

It must be said that, in those years, 1950-60, sports technicians got little help from sports physiology, as regards training for speed. Scientists dedicated the greater part of their research to aerobic activity.

The following three considerations urged me to make a careful study of the phenomenon of speed.

1) I was convinced that each and every one of the various components of this composite capacity, normally referred to as speed, would respond to training, even though sports physiologist maintained the existence of genetically predetermined, and therefore unalterable, limitations. I found this attitude irritating as well as disconcerting, because it restricted my range of action as a coach, and also because it was inconsistent with the first results I had obtained on the track.
2) I also believed that running itself – various types of runs with different intensities – should be considered, not only from the technical aspect but also for the biological and physiological implications. Training programmes would, therefore, have to contain more running. The quantities would have to be greater than those currently in use, and

the percentage of running, as against strength training, would have to be higher.

3) I felt the need for more direct, specifically aimed exercises, which would favour the transformation of muscular force into speed capacity; i.e. a link between general strength and speed.

An ambitious programme, especially if we consider the context. The idea was that a number of sports technicians, working with various different biotypes, should develop common methodological experiences, so as to obtain a wide range of proposals that would be better tailored to individual requirements.

Unfortunately, this proved impossible. Sports technicians had a distorted understanding of the word "pluralism"; many had a tendency to reject outright the ideas of others, to work countercurrent just for the sake of independence and give no thought to the construction of a methodology.

Only five people made themselves available for what proved a long and productive collaboration. I would here like to thank them: Professor Locatelli and the athletes he coached in the seventies; Professor Castrucci, who trained a number of sprinters, including Tilli; Professor Preatoni, Zuliani's coach; Alessandro Donati and Pasquale Bellotti, both Maestri di Sport, who worked with me at the Scuola dello Sport and at the Italian Athletics Federation.

I will here deal only with the methodological experiences that moulded our strategy and represented a turning point in sprint training in Italy.

During the first years, we focused on muscle bioenergetics in sprinting. We wished to acquire a better understanding of the phenomenon – to understand the development modalities, the type of "fuel" used – in order to define performance models that would be more coherent than those presented at that time by sports physiologists, so as to avoid the risks of inadequately organized training methods.

In the seventies, the inconsistencies in sports physiology were such that, during a world symposium on biochemistry applied to sports, a highly respected physiologist having gone through an athlete's training programme, said to the auditorium: 'the athlete surely died!'. Quite on the contrary, a few months previously, that athlete, Pietro Mennea, had established the new world record over 200m. I distinctly remember the issue was speed endurance.

We examined all the energy processes, from the standpoint of power and of capacity. In due time, a specific methodology was elaborated for each of these, using runs as the training means. Distances and intensities varied, according to the specific goal.

All these methodologies were based on the same principle: a positive response can be obtained only by creating a "crisis" in the system or sub-system that the means employed are supposed to stimulate.

We focused on training means and methods that would affect the alactacid capacity together with lactacid power and capacity, because we believed that a sprinter's endurance depends on an increased capacity of the 2 energy "reservoirs". We were well aware that, in the 100 and 200 metre sprints (particularly the latter), the incidence of lactacid energy had to be much greater than what was then maintained. This was later proved true, when researchers measured blood lactate levels after a 200 metres race and found values over 25 millimoles per litre.

We also believed that high volumes of fast runs (the intensity was never lower than 85%, while the quantity could be 15km at the end of a fourteen-day cycle) could influence the mechanics of running, improve muscle viscosity and restore agility, suppleness and swiftness after intensive strength training.

The lactacid and alactacid processes are correlated and interdependent. This misled many coaches into believing that a single training method was sufficient to stimulate the 2 processes simultaneously.

The innovation we introduced was to identify the training means and select, for each process, runs at distances and intensities that varied according to its specific characteristics. We believed the consequent summation of effects would prove more efficient.

At first, we trained alactacid capacity, using runs over 60 metres. We later added runs over 80 metres, because the first distance proved to be too easy, despite the high work volumes. We gradually progressed to 5 series of 5x60m, with 2min and 7min rests between runs and series, respectively. The intensity, calculated as a percentage of the athlete's best performance in the previous year, began at 90% and progressed to 95% during the second cycle.

The best athletes averaged, over a total of 20-25 runs, 6.52sec for the 60m, and 8.60sec for the 80m. The 2 distances were combined differently in each training unit.

After a few years my method was criticised because, allegedly, it had a predominate influence on lactacidemia and was, therefore, a repetition of the one used for lactacid capacity. I refuted these remarks, pointing out that the blood lactate levels measured after a training session

were never greater than 15mmol/l. For high level athletes, such values cannot be considered sufficient to discontinue exercise. In any case, my attention was no longer focused primarily on muscular phenomena, because I had reached the conclusion that the limiting factor for a sprinter's endurance was the efficiency and autonomy of the central nervous system. I therefore changed the method's denomination to "speed endurance".

During the training sessions dedicated to this capacity, we observed a very interesting occurrence concerning the pattern of stride rate and stride length in relation to speed.

As the work loads increased, we noted a decrease in stride length (especially during the acceleration phase) that had to correspond to an increase in stride rate, since no significant changes in the performance times were observed. Indeed, it is the acceleration phase that requires a higher output of explosive strength and, therefore, a greater involvement of the central nervous system , because of the required increase in the instant recruitment of muscle fibres. It must be said that the pattern observed for the two parameters was possible only because the velocity during the exercise was lower than maximum and, therefore, sustainable, despite an imbalance between the two determining factors.

Reduction of stride length and increase of stride rate, as a consequence of fatigue, are a reproduction of the results observed on a larger scale at the end of each functional cycle.

These observations urged us to study and to evaluate the development modalities of these two parameters and their relation to speed.

This was, in fact unavoidable, since training can stimulate only factors that will, in the end, affect either stride length or stride rate, and monitor the efficiency of the chosen means to improve the two components. The difficulty was to know which of the two to concentrate on, and to what extent, in order to improve an athlete's speed. We decided to study the athlete's behaviour during competition and thus elaborate a working programme, with a view to possible corrections of this behaviour. We were looking for a formula to calculate an athlete's ideal stride length. We would then have to work on only one variable to obtain a further improvement.

This proved a long and complex procedure. Using a biomechanical evaluation carried out at the CAR in Barcelona with Dr Rosa Angulo, I arrived at a model by which the displacement of the athlete's pelvis during ground contact is approximately equal to the length of the athlete's leg, while the distance covered in the air is approximately one and a half times that length (*Figure 1*). Despite quite a number of measurements and evaluations, the data obtained did not provide explicit indications. TABATSCHNIK's publications on the subject were a great help. We used the index he mentions, 2.60, and obtained more reliable results, although I think this index is sometimes excessive. As we proceeded, we came to consider the stride length calculated on this basis as a point of reference, a goal. I believe the potential, in terms of stride length, to be very important for male athletes (it now appears it is very important also for women). Stride length is the component that is influenced by the greatest number of factors: strength of the flexor muscles (I disagree with TABATSCHNIK who ascribes this capacity to the strength of the extensor muscles), flexibility of the hip joint and of the lumbar segment of the spine, rhythm and running technique.

Using the index as a multiplication factor of the athlete's leg length, we calculated the stride length in a run from a flying start; we then calculated the number of strides needed to cover 100 metres with a flying start and added 10% to allow for a start from the starting blocks, which gave us the number of strides taken in a 100 metres race. On the basis of the hypothetical time we thought the athlete would be able to achieve that year, we built a model that would serve as a control test.

However, the control could obviously not be postponed until the competition period, since it would then be too late for any corrections. Therefore, starting from this first model of performance, I designed two other models, using two fundamental exercises closely related to the parameters, stride length and stride rate – 100m runs with longer than normal strides, and 100m runs with shorter, faster strides. Data from these were compared with the athlete's results during training and the two exercises were used as control tests.

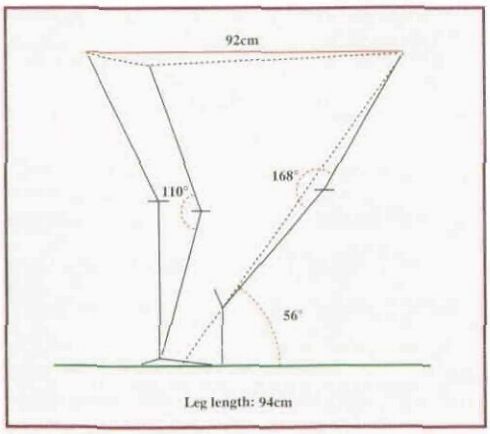

Figure 1: Athlete's pelvis-leg model

PARAMETERS	RUN WITH SHORTER THAN NORMAL STRIDES		HYPOTHETICAL 100 M MODEL	RUN WITH LONGER THAN NORMAL STRIDES	
	Result	Model		Model	Result
TIME		10,68	10,50	10,68	
N° STRIDES		52,9	46	40,70	
AVERAGE RATE		4,95	4,38	3,81	
AVERAGE LENGTH		189,2	217,4	245,7	

leg length: 92cm

Average stride rate in runs with shorter than normal strides is 13 % higher than in performance model.

Average stride length in runs with longer strides is 13 % higher than in performance model.

Figure 2: Model of different parameters

We assumed that, if the athlete's results during the exercises were close to the respective model, then, in competition, he should be able to achieve the hypothetical target time.

In the first exercise, a 13% reduction (referred to the hypothetical performance model) of the average stride length was accompanied by an increase of the average stride rate, and on the second, a 13% reduction of the stride rate was accompanied by an increase of stride length (cf. *Figure 2)*. The times that were to be obtained during the exercises were derived from the above data.

These data, i.e. time and average stride rate for the runs with shorter strides, and time and average stride length for the runs with longer strides, were plotted on a graph, so that the results obtained during the control tests could be easily compared to the model.

We also designed two series of specific training exercises that would influence the two factors more directly. The first group, aimed at increasing stride rate, mainly involves the extensor or antigravity muscles; the second, aimed at increasing stride length, mainly involves the flexor muscles (*Figures 3 and 4*). I must emphasise that such a distinction can be made only when the runs are carried out at close to maximum speed. At lower velocities it is impossible to distinguish the effect of stride rate or of stride length on the development of speed.

As regards lactacid capacity, the training method for sprinters embraced runs over distances varying from 150 to 400 metres, the latter

1) STRENGTH exercises for the ELASTIC REACTIVE STRENGTH of thighs and feet.

2) PACING exercises with and without overloads for the feet (REACTIVITY exercises).

3) Vertical TWO-LEGGED BOUNDS over obstacles with different heights, for a total of 50-100 bounds.

4) FAST SKIP exercises with low knees over 60-100 metres (calculating the rate).

5) KICK-BACK RUNS with 50 or 100 contacts, recording time and distance.

6) SKIP exercises with weighted belt, with 50 and 100 contacts, recording time.

7) SPRINT runs over 30 metres drawing a weight.

8) SPRINT runs with weighted belt over 60 – 80 – 100 metres, performed also with a towing system.

9) FAST CIRCLE RUNS over 100 metres, recording time and number of strides.

Figure 3: Exercises mainly affecting stride rate

1) STRENGTH exercises with overloads for explosive elastic strength (for the thigh extensor muscles)

2) STRENGTH exercises with light overloads for the thigh and leg flexor muscles.

3) BOUNDED runs over 100 metres, recording time and number of bounds.

4) SKIP exercises with and without ankle weights, with 200 or more contacts.

5) 30-60 metres RUNS with ankle weights.

6) 100 metres RUNS with longer than normal strides, recording time and number of strides.

Figure 4: Exercises mainly affecting stride length

in very limited quantities for 100m specialists. The intensity of the runs at the beginning was 85% of the athlete's best performance in the previous year over the same distance. It was raised to 100% during the part of the competitive season devoted to minor competitions. The total distance covered in each training unit varied between 1200 and 1800 metres, according to the athlete's endurance. 400m specialists covered a greater distance. We averaged two training sessions a week; added to the two sessions devoted to speed endurance, the total coming to four training sessions over seven days, for two fourteen-day cycles.

The short sprinters used repetition runs and the 400 metres specialists also used series of repetitions. When we used runs over different distances in the same session, the 400 metres specialists would perform them either in increasing or in decreasing order, while the short sprinters would perform them only in increasing order, so as not to disadvantage the shorter runs.

During the special preparation phase and the phase devoted to minor competitions, i.e. when the athlete was already in condition to run quite fast, we decided to add exercises that would stimulate simultaneously alactacid and lactacid power: runs over 60, 100 and 150 metres, to be performed at increasing speed, as the athlete's condition improved. The first two distances were performed from a standing start. Times were taken for each half of the distances and the times registered for the second halves (30 and 50 metres) provided an indication of speed endurance. We also counted the number of strides of the flying phase and this allowed us to monitor speed and the manner in which it was achieved (ratio length/rate).

The runs over 150 metres, used especially by the 200 metres specialists, were considered "synthesis tests" (*Figure 5*), because they could be used to monitor a number of technical and conditional aspects: the crouch start, running technique on turns; effort distribution; relaxation technique and peak velocity. These runs are preferably carried out with a partner so as to stimulate performance. Blocks and starting pistol should be used and the athletes should run the whole bend. Separate times are taken every 50 metres, to check the average times of the last sections of the runs. In a balanced run, the times of the last two sections should be about the same, while the time of the first section should be about 1sec slower than the second one. The times of the two last sections can be used to calculate the probable time of a fourth 50 metre section, which would bring the distance to the full 200 metres.

If an athlete's times for the second and third sections are very close, his time over a fourth fraction should be about 0.25sec slower than the third section. If this is not the case, the reasons could be an error in effort distribution, lack of endurance or an inadequate balance between stride length and stride rate.

In a 200 metres race, the time clocked for the first 100 metres should be about 0.25sec slower than the athlete's best performance over the

1st 50m fraction	2nd 50m fraction	3rd 50m fraction	total time
5.65sec	4.65sec	4.70sec	= 15.00sec

probable time for 200m

15.00 + 4.95 = 19.95sec

Figure 5: Synthesis test

same distance, (the clocking system must be consistent, either manual or electronic). The difference between the two sections should be at least 0.80sec. If the coach does not perform this kind of "synthesis test", he will never be sure why one of his athletes, who, for instance, clocks 15.0sec over 150 metres, achieves only 20.35 in competition instead of 19.95sec. This kind of test helps the coach to avoid irrelevant judgements.

A fast run from a standing start over 60, 80 or 100 metres will allows a quick evaluation of an athlete's capacity to develop speed. The time difference between the first and second sections should average about 0.80sec. In the case of a crouch start and manual timing, the difference comes to about 1.0sec, and, with electronic timing, it comes to 1.20 to 1.30sec. Therefore, in the case of two runs over the same distance, one performed from a standing start using manual timing, the other from a crouch start using electronic timing, the difference should be 0.45 to 0.50sec.

There was a further problem – how to develop the different types of strength involved in sprinting. To this end we carefully examined the biomechanical behaviour of the lower limbs, the propulsion system, from start to finish of a 100 metres race; in particular we studied the postural changes of the various body segments during the race and the progression of the contact times.

From this we were then able to deduce the strength components involved (*Figure 6*).

We timed the driving phase on the first starting block, 0.260sec and the driving phase of the first seven strides, 0.115sec. We also observed a very peculiar behaviour of the lower limbs in this phase of the race: the knee and ankle joints showed no rebound; in fact it appeared that the extension occurred immediately on ground contact. We deduced that a large portion of the strength used in the first phase of the race could be described as 'explosive strength', particularly in the case of the drive from the first starting block. As the race progressed, the ground contact times decreased to about 0.85-0.90sec, showing that force was produced by 'reactive reflex strength', the dynamic pre-requisite of which is muscle-tendon resilience. Only this type of strength can be produced so swiftly.

Figure 6 clearly shows that force is produced always from a mixture of different types of strength, the percentage involvement of each one varying according to the phase of the race. It can also be seen that reactive strength is involved to a greater extent.

Our experiences regarding maximum dynamic strength with overloads did not contain any original feature but I should like to touch on the means used to improve special strength. These, combined with those used to develop stride length and stride rate, form the "system" that evolved from our experiences.

The means used were: horizontal bounds, harness runs, vertical bounds over obstacles, bounding runs and fast runs with weighted belts, in some instances performed supramaximal speed using a towing system. Jumps of various types are nothing new to sprint training, but A. Donati carried out research to identify a methodical strategy that would answer specific require-

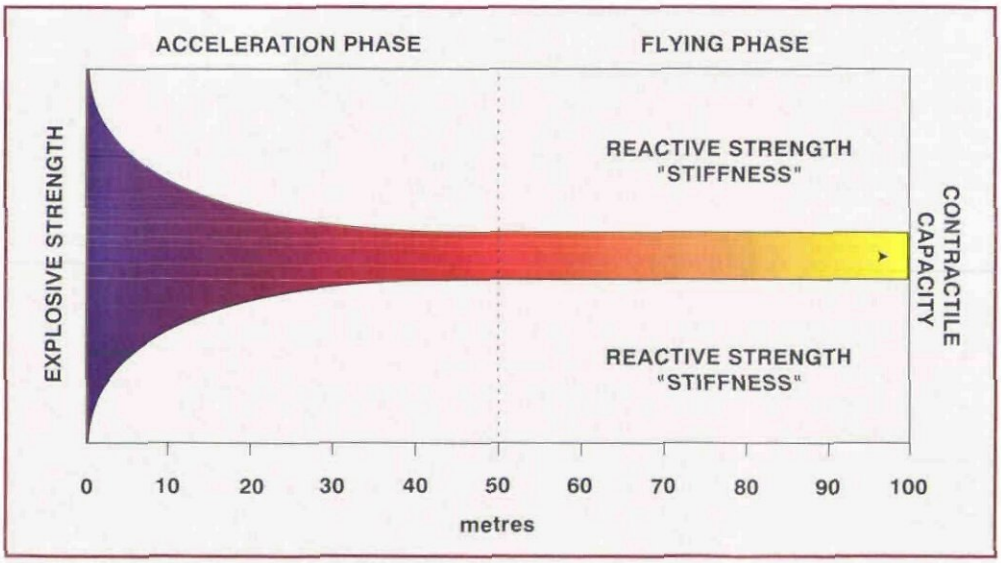

Figure 6: Different expressions of strength employed in a 100 metres race

ments. We observed a high correlation with the acceleration phase, particularly in the first few metres. We used multiple bounds from the standing start position - three, five, ten - performed alternatively or, in the case of the first two repetitions, also in in the form of single leg hops or bunny hops. Since we observed an improvement in explosive strength during the acceleration phase, we hypothesised that the rebound stimulated a part of the active force, in particular the contractile and the recruitment capacities. We observed, however, that the effect of these exercises on explosive strength soon began to taper off. This probably meant that the early improvement was due to the athletes' lack of strength during the early stages, and the levelling off occurred because it was impossible to increase any further the only stimulus, i.e. intensity of the load.

This experience was important in that it led us understand the significance of such exercises for young athletes; in their case, natural growth ensures a year by year increase of the stimulus. In older athletes, bounds could be used in combination with other, indirect means, as a method of transforming maximum dynamic strength capacity into speed strength capacity.

After careful thought, we included in the exercises bounds with weighted belts. These have been commonly used for straddle jumpers, to bypass a plateauing of the stimulus. We used weights of about 10% of body weight and the bounds were performed with and without belts in varying combinations, reflecting each athlete's individual requirements. This choice proved significant, because it was consistent with one of the basic principles of training - it is easier to obtain a continuous and substantial improvement when the progression of the work load intensities varies, i.e. when it is possible to vary the influencing factors.

This consideration convinced me that, since the weighted belts would increase the effect of the bounds on the contractile capacity of the leg extensor muscles, they should be used, for short periods, to substitute or to diversify exercises aimed at maximum dynamic strength. They could constitute a further variation to modulate work loads in the framework of a long term training programme.

We deliberately conferred order and specificity to all the training means employed. Similarly, we were very careful in the dosage of the weights the athletes towed over 30m runs from a crouch start. This exercise is much more specific than bounds; it stimulates the active and swift production of cyclic explosive strength (instant recruitment capacity).

The weight must not be so heavy as to hinder the dynamic performance, nor can it be too light, since it would then be an insufficient stimulus. We chose a weight that would increase the best time achieved by an athlete over the same distance by about one second.

The load caused a lengthening of the driving phase in the first 5-6 strides; about 0.300sec for the first stride; about 0.130sec for the others. The effect of adding a resistance to the athlete's efforts to gathering momentum is to increase the duration of muscular tension and so stimulate a greater recruitment of muscle fibres, thus increasing the production of explosive strength.

The most significant exercises, in my opinion, are two-legged bounds for height over obstacles. They provide an indication of the neuro-muscular capacities that determine muscle-tendon resilience and characterize high level sprinters.

A test devised by Bosco measured contact time and flight time, by means of a capacitance platform. This test allowed us to calculate the quantity of force (height of the flight) and the swiftness with which it was applied (contact time).

The last item within the framework of muscle conditioning, which would link this preparation to speed, was cyclic reactive strength. This we chose to develop by means of two specific exercises, bounding runs and runs with weighted belts, the latter performed also using a towing system to develop supra maximal velocity.

The degree of specificity of these two exercises differs. Bounding runs are used in the early preparation phase, both as a training means and to monitor the athlete's strength in terms of stride length. At this time, the athlete is not in a condition to perform the exercise that will later be used to evaluate the degree of efficiency he has attained: fast runs using the optimum stride length.

A comparison between the results obtained and the parameters set down for each test provides a forecast of the future development of increasingly specific capacities.

We established an index for cyclic speed strength, starting from the concept that the bounds had to be longer than the strides used in the long striding runs. After various attempts, we found that they had to be about 25% longer, to require the athlete to apply a relevant amount of force and apply it quickly. Having calculated the number of bounds necessary to cover 100 metres, the index was obtained by dividing the average length of the bounds by the time achieved. It was important to keep one of the parameters constant, as otherwise the same index might indicate

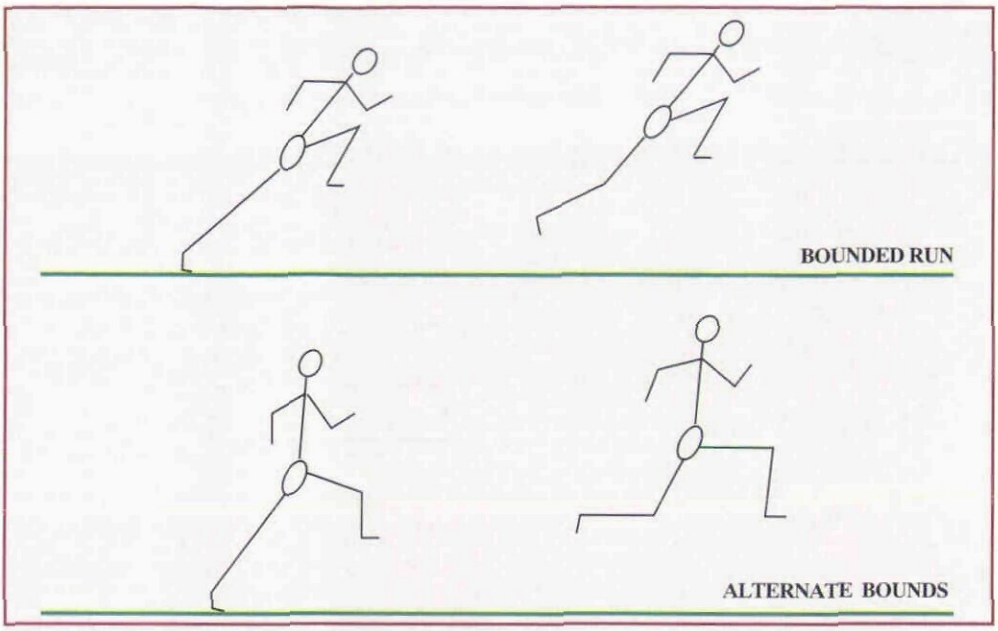

Figure 7: Sprint specific exercises

different conditions and not necessarily be related to cyclic strength capacity.

In this exercise, the bounds must be performed with the emphasis on forward drive and a swift separation of the legs, achieved through a powerful extension of the driving leg and a swift flexion of the free leg. The trunk should lean forwards, in line with the back leg. Good co-ordination, swiftness and continuity movement are the technical and dynamic bases of this exercise.

The last group of exercises - fast runs with weighted belts and sprints performed with a towing system - constitute a dynamic counterpoint, involving the two aspects of reactive reflex strength: eccentric tension and the contraction proper. Runs with weighted belts mainly affect eccentric tension, while the other exercise primarily affects active contractile strength. The two sides of the coin, muscle-tendon resilience, can be enhanced by a very special exercise: runs with a weighted belt, performed at supra-maximal velocity using a towing system. In my opinion, this expedient touches the highest degree of methodological sophistication and achieves the highest possible stimulation of specific muscular resilience.

This issue has always greatly interested me, and I have given it much thought. I should here like to quote a few lines I wrote and discussed with my pupils at the Scuola dello Sport back in 1960. "Muscle elasticity (in those days this term included all the aspects of reactive strength) is the property by which a muscle that has been stretched tends to return to its original condition".

The muscle regains its original condition at a speed that is inversely related to the degree of deformation (eccentric contraction moment), which in turn is inversely related to the cohesion force (or attraction) of the inner components of muscle fibres (myofibrilla), i.e. to the quantity of energy produced by the muscle.

Finally should like to repeat what I have already said on various occasions. The use of a parachute cannot substitute for towing and weighted belts. Such an exercise will never achieve the degree of specificity of the exercises illustrated in *Figure 7.*