33 Optimizing Training and Performance

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33.1 General Training Concepts

"**Sports training** is a complex pedagogical-educational process based on the organization of repeated physical exercise. Volume and intensity must progressively increase stimulating the physiological processes of supercompensation of the organism and favour the increase in the athlete's physical, mental, technical and tactical abilities, in order to enhance and consolidate his performance in the competition" [1].

This definition simply summarizes the aim of sports training that is to allow the athlete to achieve the best result throughout his career and to reiterate it on scheduled occasions. In practice, it includes all the principles that regulate sports training and determine its final result, emphasizing the essence of this process: adaptation. Adaptation is the consequence of the supercompensation process, and it consists of the growth of all conditional, coordinative, psychic and mental qualities, which in fact allow the achievement of the best result [1].

In addition, the following clarification that characterizes sports activities in which the coordinating factors are very important, and among them, also various athletic disciplines are important: "Training is a complex pedagogical-educational process based on the organization of repeated physical exercise in quantities, intensities, forms and degrees of difficulty such as to favour and consolidate the assimilation of skills (general and specific), which are progressively more complex and effective" [1]. Coordinating factors must interact with the various expressions of strength in order to reach the best execution of complex technical action.

This training consideration can be applied to athletes of the highest level and to who do not reach the highest level, but who nevertheless intend to improve their results according to the possibilities, time and energy to devote to the chosen sport activity. Genetic factors and individual qualities are the other cornerstones that determine the training result [2].

Volume and intensity (articulated and measurable in different ways depending on the disci-

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pline) combined with the coordinating factors determine the external workload. This is the stimulus from which the body's response derives. This response represents the internal load: it is individual, complex (since it involves different apparatuses and systems of the organism) and can change according to the moment [1].

The challenge for every coach is to define a short-, medium- and long-term programme, as suitable and specific as possible for each individual athlete. In practice, it is a matter of organizing the training following a method, using certain exercises, combining them with each other, have the athlete involved and aware of it and get the best possible response in order to achieve the best result. An example of training exercises categorization is presented in the throws training paragraph.

First of all, the performance model of the specific track and field discipline needs to be analysed according to different aspects [1]:

- Technical
- Biomechanical
- Physiological (metabolic).

The example of a relatively simple athletic speciality like the 100 m race can be explanatory (Figs. 33.1 and 33.2):

Technical aspects are more difficult to represent in a graph, but some indications can also be given in this regard:

- Start from the blocks pushing simultaneously with both feet;
- Be in a clear pushing phase until the end of the acceleration phase;
- Keep your feet taut when run and look for maximum relaxation of the cutaneous and shoulder muscles especially in the high-speed phase.

Even more important than the performance model of a discipline (from which the choice of the exercises to be used and therefore the training programming derives) is the individual performance model. This is based on the individual characteristics of the athlete, which takes into account the level of its qualities at that moment in time and all the variations that may occur, including the morphological ones.

A peculiarity of the training is its complexity. The relationship between the proposed training and the result obtained can be explained by the "supercompensation" concept. This reaction is complex because it represents a set of responses provided by various physiological systems stimulated by the training stimulus: for this reason,

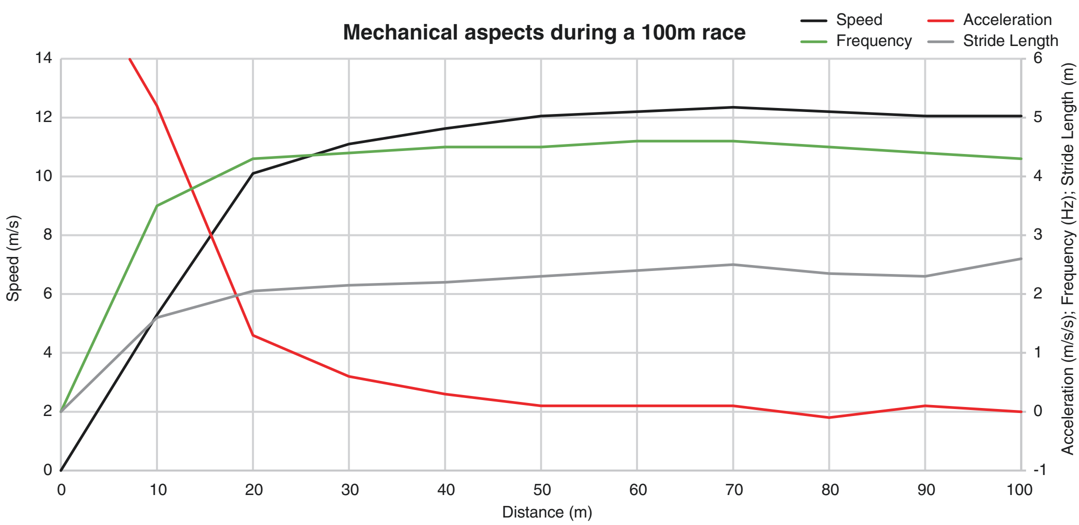

Fig. 33.1 Mechanical aspects during a 100 m race: speed in m/s; acceleration in m/s/s; stride frequency in Hz; and stride length in m

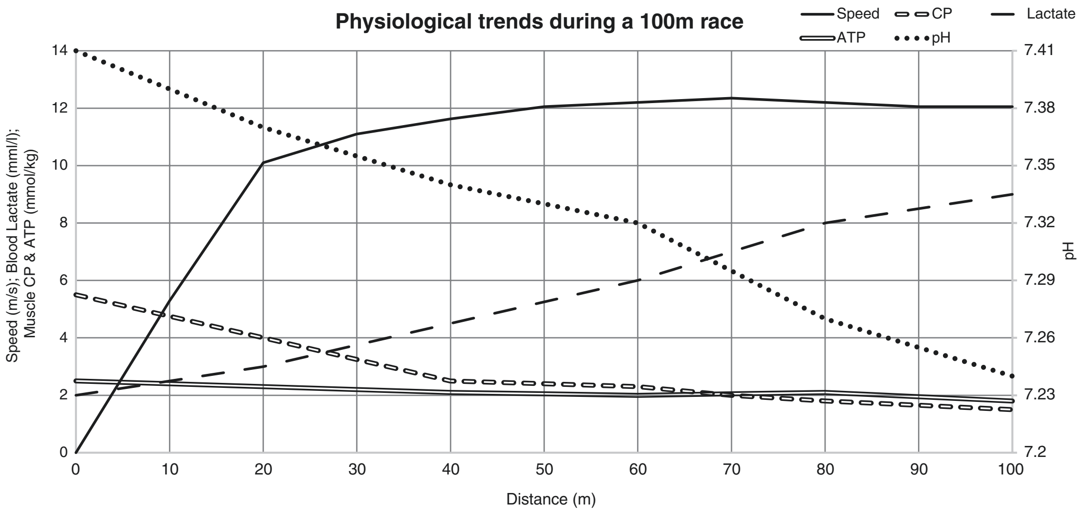

Fig. 33.2 Metabolic and biochemical trends during a 100 m race. Muscle CP and ATP in mmol/kg; blood lactate in mmol/l and pH. Speed in m/s is represented as well as a reference [3]

we generically talk about a "sum of responses". Therefore, a training stimulus produces not only a direct physiological adaptation, but also an indirect adaptation on other conditional and coordinative factors, which must be taken into account.

With regard to the training indirect adaptation (transfer), it manifests itself to a very significant extent especially in youth athletes, on both conditional and coordinative abilities. The lower the age (from 8 or 9 years old), the greater is the effect. It happens in fact that when a conditional capacity is stimulated, there is a positive impact on others as well. The same happens with regard to coordination skills: in this case, the objective is to take advantage of the "sensitive" phases, to constitute a good "motor expertise". By this term, we mean the set of motor experiences (suitable for the age) conducted in a global way and not necessarily aimed at the specificity of a discipline. From this interference of multiple motor experiences, gradually supported by an increase in conditional capacities, an expansion of the "motor expertise" derives, which will allow the athlete to acquire very complex skills. What has not been done in certain moments of great reception capability by the organism ("sensitive" phases) will no longer be fully recoverable later on. This underlines the importance of acquiring the widest range of motor skills possible that will be essential for subsequent technical specialization. The optimization of training must also take into account these intermediate steps [1].

Another aspect to consider is the heterochrony of the body's responses to the training stimulus. This aspect affects the recovery times of the various systems, and it must be taken into account when planning the training [4].

All these needs and other equally important factors characterizing the training (load increase in different times and modalities, alternation and variability of the load, evaluation of individual responses and athlete perceptions) must be taken into account with an adequate training plan in the short, medium and long term, and it must be the most specific and suitable for each individual athlete [4]. The main goal is to achieve their best physical condition at the time of the most relevant competitive events (tapering) during the season. **Periodization** consists in dividing the season into various training and competition periods, in order to achieve the aforementioned objective. Normally, the competitive season consists of an annual or semi-annual periodization (double periodization) and each macrocycle (annual or half-yearly) is characterized by a preparatory period, a competitive period and a transition period. Double periodization has become common in athletics, and it allows to reduce time between one competitive phase and the next one. Sometimes in a double periodization, the first period of competitions has a subordinate function to the second, where the most important competitive events are concentrated. Classic subdivision into microcycles (1 week), mesocycles (3/4 microcycles) and macrocycles (more mesocycles, up to an entire season) favours the alternation of load and recovery with all the benefits that derive from it. An example of throws training periodization is reported in the throws training paragraph.

Between all the conditional qualities, strength plays a role of primary importance in all athletic disciplines. According to Vittori, the prerogative of the muscle is to contract and its strength depends on the functional fibers. The same methodologist and athletic coach accurately defined this quality as follows: “Strength is a physical quality which is the foundation of human motility, responsible for bodies or objects movement and their speed” [5].

In his methodology, Vittori defined the different strength expressions with appropriate terminology, which does not always coincide with the most widespread (and less accurate) terms that have now become fashionable (Fig. 33.3).

The differentiation between active and reactive strength implies that the first one (active) occurs as an effect of the muscle shortening phase only (concentric phase only: e.g. an action carried out starting from a standstill position), while the second one (reactive) occurs as an effect of the stretching shortening cycle (with the eccentric phase followed by the concentric one, therefore with reference to the elastic component). Two examples of high jumps exercises can simply clarify the difference:

1. Squat jump (active strength): starting from a half-squat stationary position and jump as high as possible by solely extend the legs.
2. Countermovement jump (reactive strength): starting from an upright standing position, make a preliminary downward movement by flexing knees and hips, and then immediately extend knees and hips to jump vertically up off the ground.

Active strength includes both maximal dynamic strength and explosive strength:

- *Maximal dynamic strength* is what is needed to move the highest possible load. It is defined as dynamic in order to differentiate it from the isometric strength;
- *Explosive strength* can be expressed at the maximal speed allowed by the resistance (which can be represented by the body weight, an overload or any other tool) starting from a static situation so that the muscle contraction is purely concentric.

Reactive strength includes both explosive elastic strength and plyometric strength:

- *Explosive elastic strength* is expressed by the stretching shortening cycle that consists of an eccentric muscle contraction quickly followed by a concentric muscle contraction. In this case, the elastic mechanism is mainly due to the SEC (series elastic component).
- *Plyometric strength* is a particular expression of explosive elastic strength with a reduced stretching phase in terms of both articular range excursion and time. In this way, the effect of the myotatic reflex is more marked and more profitable, which further increases the extent of the elastic response. In addition, the quickness and the reduced amplitude of the eccentric phase also improve the stiffness effect.

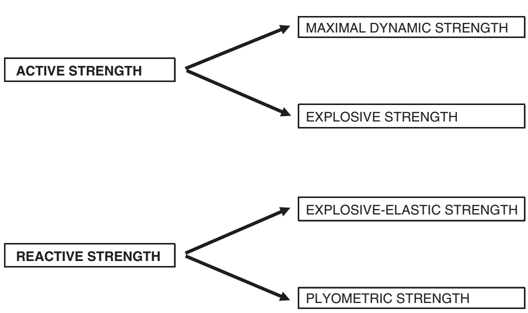

Fig. 33.3 Differentiation of strength expressions according to Vittori [5]

An example of the combination of the aforementioned expressions of strength can be found in the analysis of a 100 m race (Fig. 33.4):

In summary, maximum dynamic strength and explosive strength ("explosive strength" in Fig. 33.4) are those most used in the starting phase, taking into account that the athlete starts from a stationary position. Successively, the explosive elastic strength comes into play during the acceleration phase when the ankle, knee and hip angles are initially marked and gradually become smaller at the end of the acceleration itself. Finally, during the maximal speed phase, articular excursions are smaller, and the plyometric strength becomes the most important (Fig. 33.4). Obviously, none of these expressions of strength completely replace the other ones at any point. They combine between themselves in a mix where, depending on the moment, one prevails over the other [5].

A fundamental part of training is also all the prevention activities, which, although not neglected in the past, have now taken on a more precise configuration, substantially affecting the workload [6]. Core stability, in essence, is the joint and balanced reinforcement of the deep and superficial abdominal and back-lumbar muscles that guarantee the stability and mobility of the vertebral column. The vertebral column represents a force transmission axis and because of that it must be protected and put in a position to function at its best.

A general and sectoral research for concentric and eccentric strength balance between agonist and antagonist muscles not only represents a guarantee of injury prevention but also leads to a higher level of effectiveness. The actual sport practice leads to the strengthening of the agonist muscles that perform the movement, while the antagonists are normally less stressed: Therefore, rebalancing becomes necessary. Nevertheless, the proprioceptive regulation that is stimulated through unstable equilibrium must be taken into account. The kinaesthetic sense that automatically allows to evaluate the position of the body segments and their movement is stimulated by different types of receptors stimulated precisely by instability.

The control of training has always been a priority in track and field. Obviously, over the course of the last few years, significant improvements have been made thanks to the most modern technologies (lasers, cameras, GPS, accelerometers, etc.). However, all these tools do not replace the

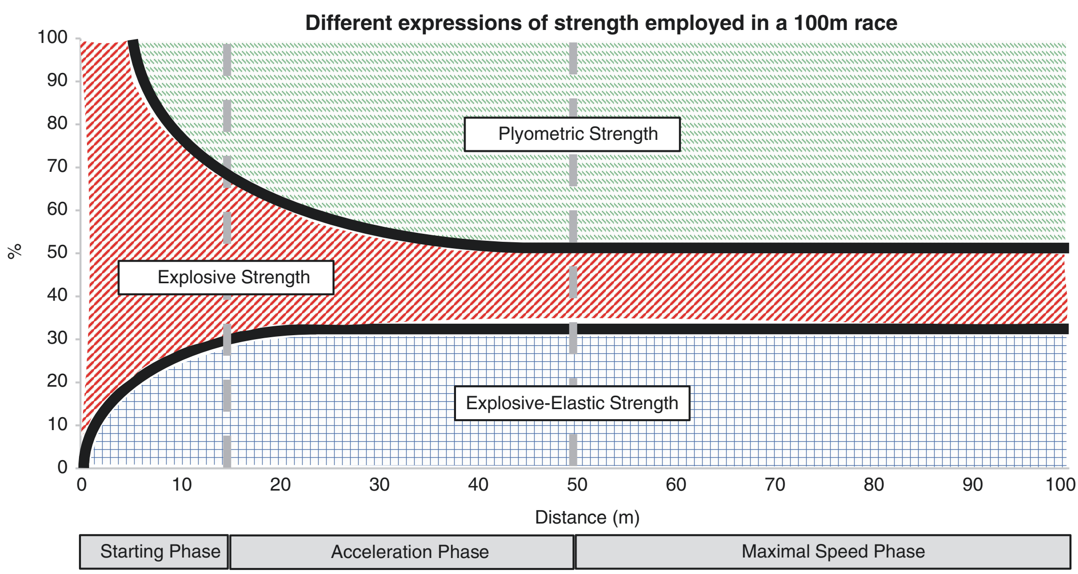

Fig. 33.4 This graph represents the influence (as percentage) of the different expressions of strength during a 100 m race [5]

attention, the observation and that attitude called "speculative" of the track and field coach. The ability of the coach consists of data evaluation, observing training sessions details, comparing the athlete over time (longitudinal analysis) and making deductions in order to modify the training sessions when necessary.

Directly linked to training is the nutrition. Perhaps in the past its importance has not been recognized as much as it is now. The individual characteristics, the nature of the discipline practised and in particular the type of training carried out day by day with the related energy requirements contribute to structuring the nutrition strategy. It must meet the needs of restoration and accumulation of glycogen reserves, the intake of water and electrolytes in their best combination and ensure protein intake not only as a function of building muscle cells, but also for the synthesis of hormones and enzymes [2, 4].

Finally, with the recent increase in length of many athlete's career, in some athletic disciplines there is a relative reduction in the use of very specific exercises in favour of the use of more general exercises aimed at guaranteeing the physical condition.

33.2 Speed and Hurdles Training

Track and field speed (100 m, 200 m and 400 m) and hurdles (100/110 m Hs and 400 m Hs) training follow some fundamental guidelines:

- The development of strength as a function of speed.
- The technique and the rhythm combined with rapidity in order to reach the maximal speed.
- The distribution of the effort.
- The specific endurance.

The development of **strength** follows a fairly linear direction that starts from working with more or less heavy load through classic exercises (such as squat, half-squat and half-squat jump) with all their variations. Afterwards, it moves on to the special exercises for strength (link between strength and speed) performed with light loads (e.g. sled sprints), with additional resistance to body weight (e.g. uphill sprints) or performed as bounds that allow a progressive approach to the technical gesture. With reference to the subdivision previously made with regard to the different expressions of strength, it can be stated that explosive strength, explosive elastic strength and plyometric strength are all involved. Therefore, these are solicited through the use of the aforementioned exercises to a different extent based on the time of the season, the characteristics of the race (race distances) and the individual qualities of the athlete.

Unlike speed, which can be considered a capacity derived from strength, **rapidity** is normally identified as a coordinative conditional quality. It is stimulated through specific exercises carried out in conditions particularly favourable to its development. It is associated with running technique and rhythm to help increasing speed. Therefore, it can be deduced that technical and rhythmic exercises of speed and rapidity are essential. They require neuromuscular freshness and complete recovery to be performed with the right intensity and quality.

Among the **speed** and hurdle races, only the 60 m indoors can be performed without really the necessity to dose the effort that must be maximal from the beginning to the end of the race due to its short duration. On the contrary, during all the other speed races (100–400 m), the distribution of effort is important in order to achieve the best result. This means that the 100 m, for example, will not be run at maximal speed, otherwise it will not be possible to achieve the optimal result. The maximal speed reached during the competition will be equal to the 98–99% of the personal maximal speed. This will allow the athlete to maintain it almost until the end of the race. It is obvious that by extending the distance from 100 to 400 m, the percentage of maximum speed reached will tend to decrease and it will be adjusted according to the consistency of the intervention of the various energy-producing mechanisms requested (anaerobic alactacid and anaerobic lactacid above all).

In order to improve the efficiency of these mechanisms and in particular their power, the athlete specialized in speed and hurdles disciplines must perform an adequate training based on short and long distances (from 60 m to 400–500 m). These distances must be run at certain speeds (not maximal) with incomplete recoveries (increasing the mechanisms capacity) and at higher speeds with almost complete recoveries (in order to increase the mechanisms power). The current trend is to favour high-intensity training sessions in order to stimulate and improve power rather than the mechanism capacity.

33.3 Long-Distance Running Training

Endurance running training changed crucially over the course of the last century. At the beginning of 1900, the only known procedure was to run long distance following the athlete feelings. Training methodological fundamentals did not exist. At the beginning of 1930, an epochal turning point happened in Freiburg: track and field coach Woldemar Gershler together with doctor Herbert Reindell studied a new training method on more than 3000 University students. Their study showed how alternating short distances run at high speed (in particular 200 and 400 m, heart rate 180–190 bpm) with slow recovery run (heart rate 120 bpm) was the most effective training method to improve the cardiac activity. This method is known as “Freiburg Interval Training”. The most emblematic product of that method was the German Rudolf Harbig who established in 1939 the 400 m race European record (46″) in Frankfurt and the 800 m race World record (1′46″6) in Milan during an epic race with Mario Lanzi.

During the same period, Swedish track and field coach Gosta Holmer studied a variation of that method, which had an important impact in longer distance runs. Gosta trained the best Swedish athletes (Gunder Hägg and Arne Andersson) introducing during their continuous run long periods of running at competition speed with recovery periods running at 85% of competition speed. This method called “Fartlek” (literally “Run Game”) allowed Gunder Hägg to be the first man in the World to run 5000 m race below 14′ (13′58″2 in 1942). German doctor Ernst Van Aaken was the first person to understand that beyond the cardiac work, there were peripheral circulatory limits that had to be overcome, in order to increase oxygen transport capacity. Van Aaken set long periods of training on continuous running at low intensity, in order to increase the number of capillaries (therefore the aim was called “capillarization”). His idea was followed in New Zealand by Arthur Lydiard and in Australia by Percy Cerutty. The two Oceanic coaches produced the best athletes of that time, leaving an indelible imprint in training methodology. Australian Herbert Elliot won the 1500 m race in Rome Olympic Games and established the World record (3′35″6) when he was just 22 years old, and this was the last race of a short but dazzling career. Peter Snell, New Zealander, won the 800 m race in both Rome and Tokyo in 1964. On the second occasion, he doubled the gold medal with the victory in the 1500 m race and was able to improve the two World records in the 800m (1′44 ″3) and in the mile (3′51″ 3) races. Peter Snell was not the only Lydiard top athlete: in fact, for many years the trio composed of John Walker (first man in the World to run the mile more than 100 times under 4′), Dick Quax and Rod Dixon (which eventually also managed to win the New York marathon) remained at the highest levels in the track and field disciplines from 1500 m to 5000 m races. However, the Lydiard method, called “Marathon Training”, produced striking results in the disciplines up to 5000 m race, while, despite the name, it proved absolutely unsuccessful on the marathon.

The period from 1970 to 1985 saw an exasperation of the volume, which allowed the athletes to bring themselves slightly below 27′30″ on 10000 m race and 13′10″ on 5000 m race, when the limits of 800 m race (1′41″73) and 1500 m race (3′29″77) were already at the same level as the best current athletes. The search for superior quality initially led to a contraction of the top results, to the point that, in 2003, the

Table 33.1 Progression of the World record in endurance disciplines since 1970

	1970	1980	1990	2000	2010	2020
800 m	1′44″3	1′42″33	1′41″73	1′41″11	1′41″01	1′40″91
1500 m	3′33″1	3′31″36	3′29″46	3′26″00	3′26″00	3′26″00
5000 m	13′16″6	13′08″4	12′58″39	12′39″36	12′37″35	12′37″35
10,000 m	27′39″69	27′22″47	27′08″23	26′22″75	26′17″53	26′17″53
3000 m SC	8′21″98	8′05″40	8′05″35	7′55″72	7′53″63	7′53″63
HM	1:03′53″	1:02′16″	1:00′10″	59′17″	58′23″	58′01″
Marathon	2:08′34″	2:08′34″	2:06′50″	2:05′42″	2:03′59″	2:01′39″

Table 33.2 Male World record improvements during the last 30 years (since the professionalization of African athletes has taken place)

800 m	(1′41″73 → 1′40″91) = 0″82	(0.80%)
1500 m	(3′29″46 → 3′26″00) = 3″46	(1.65%)
5000 m	(12′58″39 → 12′37″35) = 21″04	(2.70%)
10,000 m	(27′08″23 → 26′17″53) = 50″70	(3.11%)
3000 m SC	(8′05″35 → 7′53″63) = 11″72	(2.41%)
HM	(1:00′10″ → 58′01″) = 2′09″	(3.57%)
Marathon	(2:06′50″ → 2:01′39″) = 5′11″	(4.09%)

best British marathon runner was Paula Radcliffe, with no man able to run under 2 h 15′ (Table 33.1).

Table 33.2 clearly shows how modern **training methodologies** for short endurance distances (800 m and 1500 m races) have not produced substantial improvements, while current long-distance training methodologies have led to very significant progress, particularly in the last 10 years. What has essentially changed in the current advanced methodology?

1. Modulation in the intensity of training in the various sessions: training with specific high intensity is more frequent and the recovery between them is longer.
2. Balance in the total distance run: decrease in the total volume (180–220 km per week instead of 280–320 km usually run in the 1980s) and simultaneous percentage increase in km run at specific race speed (30–35% per week, equal to 60–70 km, compared to 20% in the past, equal to 55–60 km).
3. Clarification of the role of low-intensity running, as a simple support for running at specific race speed.
4. Maintenance of what has already been achieved with training, even during the fundamental period (never lose what the athlete already has, in terms of aerobic power).
5. Promote the intensity (therefore starting from the concept of speed, obviously relative to the race distance), rather than the volume as it happened in the past. In other words, nowadays athletes run “fast” over distances of 5–10 km and then try to run longer distances at a similar speed, looking at the “extension” of the intensity, while, on the contrary, in the past it was required first to reach a great general resistance, running 40–50 km at moderate pace, to then try to “speed up” the athlete. From a methodological and mental point of view, it is easier to extend the speed than to speed up the distance.
6. Use of speed variations, both short and long, which allow to improve the permeability of cell membranes in order to favour the clearance of lactate produced in shorter times. Since lactate can be considered a limiting factor in performance, if the level of saturation in the muscle fibres is too high, but at the same time a percentage of it is capable of producing energy, it is obvious that, if the athlete carries out a training capable of speed up the clearance action then the athlete can run faster, according to the equations:
   (a) Faster lactate clearance = Less lactate accumulation in muscle fibres
   (b) Less lactate accumulation in muscle fibres = Possibility of producing more lactate by running faster
   (c) Higher lactate production = Higher percentage of energy available.

This means that nowadays there is the possibility of running the entire marathon faster, increasing the resistance coefficient. Up to 10 years ago, the best athletes could run the marathon at 94–95% of the half-marathon speed. Currently, the resistance coefficient has risen to 96–97%, also thanks to the new energy gels that allow a quick energy recharge.

Some examples of **specific training** currently adopted with the best World athletes are reported here:

1. 5 × 5 km at the race pace, alternated with 1 km run at 90% of the race pace. For example, if an athlete runs the marathon at 3′/km = 2:06′36″, 5 × 15′ with 1 km recovery at 3′15″/3′20″, for a total of 30 km in 1: 31′15″.
2. 20 km on the track: 2 × 3000 m at 105% of the marathon rhythm (MR), in the previous case in 8′33″, + 3 × 2000 m at 107% MR (in that case, 5′36″) + 5 × 1000 m at 108% MR (in that case, 2′45″) + 6 × 500 m at 112% MR (in that case, 1′19″).
3. 24 km alternating speed every km (2′55″/3′05″).
4. Continuous run at even pace for 40 km at 97% MR (to be performed 4–5 weeks before the competition).
5. "Special block", which consists of prolonged training of specific quality, both in the morning and in the afternoon. Example, 10 km at 90% MR in 33′ + 15 km MR in 45′ in the morning, 10 km at 90% MR in 33′ + 6 × 2000 m on the track at 103% MR in 5′48″ with 2′ recovery jogging in the afternoon, for a total of 47 km of specific training +8 km of warming up on the same day.

33.4 Jumps Training

In track and field, **jumping events** are characterized by the presence of a run-up, a take-off (three in the case of the triple jump), a flight phase and a landing phase [7]. During the run-up, the athlete builds up horizontal velocity. Later, part of that horizontal velocity is converted into vertical velocity during the take-off. In all the events but pole vault, the jumper's stance leg is planted in front of the athlete and applies a force to the ground that generates a reaction force in the opposite direction (GRF). This GRF acting on the athlete's body is generated in a very short time (150–200 ms) and, although partially reducing the horizontal velocity, thrusts the athlete centre of mass (CM) upward. It has to be noted that, during the take-off, the athlete stance lag is unable to convert horizontal velocity into vertical velocity without a loss of energy [7], but this can be minimized by planting the take-off leg faster and straighter [8]. The resultant velocity and projection angle of the CM dictate the jumping performance achievable by the athlete. Alternately, considering pole vault, the pole acts as the stance leg of the jumper and converts horizontal velocity in vertical velocity and during the take-off there is a net energy gain, thanks to the muscular actions performed by the upper body of the athlete on the pole [9].

Another factor to be considered is the horizontal and vertical distance travelled by the athlete's CM during the take-off, which can be controlled by the athletes by purposely swinging their arms forward and/or upward and [7, 10]. In the horizontal jumps, measuring starts from the end of the take-off board; therefore, the athlete must be precise in their run and plant their foot as close as possible to the end of it. In all jumping events, the athletes' ability to control the position of body segments, while in the air is also a contributing factor. In vertical jumps, it allows for clearing bar set higher than the athletes' CM and in horizontal jumps it allows for a further reach when landing in the sandpit.

The most important characteristics for an athlete to succeed in the jumping events are speed, showing always the greatest predicting power towards performance, and strength [11, 12]. Therefore, **speed** development should be prioritized over strength development [13] and can be pursued by means of sprint training. The emphasis should be placed on top speed and step length awareness and control (e.g. 30- to 60-m sprints or 10 m fly-ins with 3 to 6 min of recovery). Pole vaulter should perform sprint training carrying the pole, as it alters sprint kinematics and reduces sprint velocity.

Table 33.3 Example of strength training programme for a horizontal jumper

Phase	Hypertrophy	Strength	Power
Duration (weeks)	0–4	4–8	2 – 4
Sessions/week (n)	3	3	2
Exercises/session (n)	5–6	4–5	3 – 4
Sets x repetitions (n)	5 × 10/3 × 10	5 × 5/3 × 5/3 × 3	3 × 3/3 × 2/2 × 2
Intensity (%1RM)	60–70%	70–85%	40–60%/80–95%

1RM One repetition maximum

Strength and the ability to generate large GRF in a brief time can be developed effectively by resistance training (2–3 sessions per week) and plyometrics (1–2 sessions per week) [14]. The implementation of a block periodization paradigm (consisting of the sequential development of hypertrophy, strength and power) is to be preferred, as it leads to improved maximal and explosive strength adaptations over other periodization paradigms (Table 33.3) [15, 16]. Resistance training should prioritize multi-joint movements involving lower limb triple extension (e.g. squats, pulls), and exercise selection should allow for a variation in range of motion, muscle action and specificity throughout the training plan (e.g. squat, ½ squat, ¼ squat and countermovement jump). Regarding pole vaults, additional emphasis should be put on shoulder girdle strength (e.g. horizontal bar gymnastic derivatives exercises), especially so for women.

Alongside strength and speed development, **jumping skill** can effectively be trained with varying emphasis through the training phases. A way to improve jumping skill consists of the use of dynamic drills, which replicate the take-off or action with a reduced run-up (three strides). The lower speed allows the athlete to elicit a greater control over his body segments, without a substantial alteration in the kinetic of the movement [17]. An effective training method to obtain straighter and stiffer plant leg consists in the use of raised flat and inclined boards at take-off [18]. When jumping off the flat boards, the athlete enhanced the pivot of their body over the stance leg and reduced flexion at the knee. This can be effectively transferred to the standard take-off condition.

To allow for optimal performance, the coach should select and integrate the proper means for speed, strength and skill development based on the biological, psychological and technique level of the athlete being trained.

33.5 Throws Training

Training is represented by the different physical exercises that directly or indirectly influence the improvement of sports performance. Many authors have divided sports training exercises into categories that characterize the development of the qualities related to the specific sports disciplines [19]. Training exercises can be divided into three main groups:

- **Exercises for general (conditional) preparation.**
- Exercises that do not represent any element of the technical model and which differ in terms of execution time, position and movement with respect to the competition.
- **Exercises for special preparation.**
- Exercises that represent the technical model but modify the spatiotemporal characteristics of the technique and reduce or increase the speed of it compared to the competition.
- **Competition or specific exercises.**
- Exercises that correspond to the technical actions carried out in conditions close to the competition ones.

In throws disciplines, **exercises for general preparation** are not very correlated or even have no correlation at all with the competition action. For this reason, sometimes the use of some of these exercises can lead to the development of physical qualities that are not very solicited in the competition, limiting the possibility of improving specific qualities. In order to have maximum effectiveness, sports training must respect an important principle: it must be highly specific. It must have a high correlation in its exercises (stimuli) with the competition exercise. This means that each exercise must have at least one technical component that makes it correlated with the competition action. By following this principle, competition or specific exercises are those with the highest correlation as they consist of performing exercises identical to the competition ones, or exercises that are extremely close to it, with respect to the rules and condition of the competition itself.

General exercises do not correspond to the competition actions; however, they promote the development of the organism's functional capacities. Their goal is to increase the training effect on certain physiological systems and on certain functions of the organism [20]. It is evident that in order to increase the effectiveness of these exercises and to increase the correlation with special exercises, general exercises must respect an important principle: they must have correlation with the physical characteristics of the discipline.

In sports characterized by neuromuscular factors such as throwing, general preparation contents have three very important parameters: the expressions of maximal strength, explosive strength and explosive elastic strength. These three parameters are very important for the athlete's functional status and must be constantly monitored.

Among the exercises for the development of maximal strength, there are:

- ½ squats, deep lounges, squats, deadlifts, snatch, upright barbell row, inclined bench and horizontal bench.

Among the exercises for the development of explosive and explosive elastic strength, there are:

- ½ squat jump performed from standing still position (explosive), continuous, with countermovement, with countermovement jump (explosive elastic) and continuous jumps. With regard to the development of explosive strength, we can also consider all forms of bounds since they have no correlation with the throws technical action. On the contrary, with regard to jumps training, these exercises would have been considered as special exercises.

Exercises for special preparation have a high correlation with the technical model since they contain elements of the competition itself but ensure the possibility of expressing higher or lower strength commitments compared to the one expressed in the competition making its speed to decrease or increase.

In throws, for example, special exercises are throws with tools of a different weight from the standard (competition one) or throws with overload such as weighted belts or weighted vests. In addition, are also considered special exercises in throwing those exercises with overload that reproduce only a part of the whole technical action such as only the hips movement or only the transaction in shot put.

Specific exercises are those exercises of global and segmental technique without overloads and performed with standard equipment. Throws made with tools that are slightly lighter and heavier than the standard weight also fall into this category as well as those with reduced actions like the standing throws.

Most of the track and field disciplines are classified as power activities since during those performances there is a high development in explosive strength such as in throws, jumps, sprints and hurdles races. All these disciplines have in common a single objective: to improve the **speed of execution**. That means to run faster, to increase the exit speed of the tool in the throws or the take-off speed in jumps. The difference between the various disciplines is the modality of developing speed in cyclic or acyclic movements, but the concept is that speed is the only parameter able to improve the performance. Therefore, a modification of the athlete's functional status must lead to increase in this parameter. To be able to do that all the training contents (general, special and specific, mentioned above) must lead to an increase in speed. This factor is the only one that can, over the years and for many disciplines (in particular for throws), continuously vary and influence the performance.

The most important part of throws training plan is the special physical preparation. Increasing maximal strength for example carrying out bench press exercises or squat exercise does not mean that there is an improvement in the throwing performance. There is no correlation between those exercises and the throw. In order to make the most of all the adaptations obtained with the exercises of maximal and explosive strength, it is necessary, without anticipating or delaying the development of speed, to selectively intensify the work regime through the special preparation.

The objectives of the special physical preparation are to improve intra- and intermuscular coordination and thereby to create better conditions for technical improvement. Special strength exercises must have the following characteristics:

- high correlation between the strength exercise (special) movement and the competition movement (complete movement).
- high correlation between the strength exercise (special) movement and one or more elements of the technical action (segmental movements).

An example of throws **training periodization** leading to a competition is shown below (Fig. 33.5). The objective is to bring the athlete to his best competitive condition in 17 weeks. These are divided into a first period (first 8 weeks, in red) mainly focused on the development of maximal strength and explosive strength by using general exercises. In the following period (from the 6th week to the 14th week, in yellow), the percentage of special work prevails over the general one and the specific work increases. In the competitive period (last 3 weeks, in light blue), specific work prevails over special work and only a small percentage of general work remains.

In Fig. 33.5, five mesocycles are schematized, the first two are 4 weeks each (in red) while the other three are formed by 3 weeks each (in yellow and light blue). Each column represents a week that makes up the cycle and the height of the column shows the training load of the entire week. The first week of each cycle is the one where the maximal volume of work is expected. The volume of work in the first week is dictated by the intensity used in the respective period and the level of development of the subject's physical abilities. In the second and third weeks, for the 4-week mesocycle and only the second for the 3-week one, the volume of work is reduced by 20%, while the number of exercises and the methods used in the respective cycle remain the same. The exercises must remain the same for 3 or 4 weeks (a mesocycle) since that allows the athlete to obtain the best effects and effective physiological adaptations lasting over time. The 20% reduction in training load must be implemented to respect the ratio between external load and internal load. At the beginning of the second week of work of the cycle, the organism of the athlete is at a lower performance level if compared to the starting level, due to the stresses suffered in the first week. As a consequence, to have an internal response equal to the first week a slightly lower training volume is sufficient. The

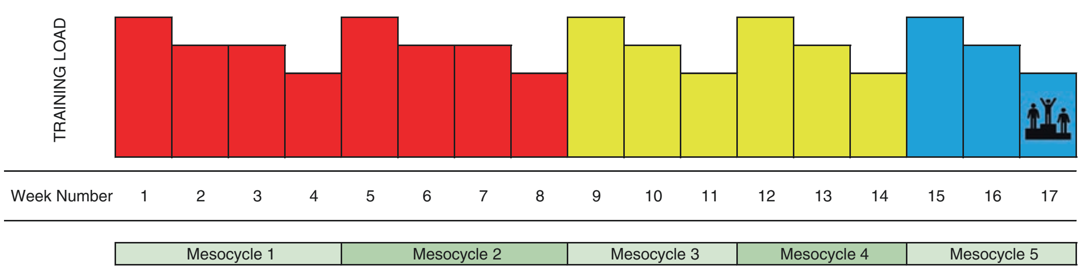

Fig. 33.5 Example of 17 weeks of throws training periodization leading to a competition

fourth week for the first two cycles and the third week for the others refer to the unloading week where work is reduced by up to 60% compared to the first. This is to allow the body to recover and have the effect of supercompensation.

Going into more details, general exercises carried out during the first 8 weeks (in red in Fig. 33.5) include three sessions of strength of which 70% is maximal strength and 30% is explosive strength with prevalent pyramidal programmes and fixed repetitions. The most used exercises are horizontal bench, inclined bench, snatch, upright barbell row, squats and half-squats. During this phase, special exercises are carried out three times per week and they include exercises with heavy load that mainly reproduce segmental technical movements, for example exercises with barbells, weighted belts, weighted vests and very heavy throwing. Specific exercises in this phase are very limited, and only a few throws are performed.

In the following 6 weeks (in yellow in Fig. 33.5), special physical preparation prevails and specific work increases. In this phase, general exercises are reduced to two sessions per week of which 50% maximal strength and 50% explosive strength. The exercises remain the same as in the previous period. There are four sessions per week focused on special physical preparation in which the speed of execution during the exercises increases considerably. Complete throws are performed. In shot put, for example, in this phase, the weight of the shot can range from 9 to 6 kg for men and from 6 to 3 kg for women. At the same time, specific training increases. The number of throws increases including the use of competition tools and great attention is paid to the throwing technique.

Finally, the last 3 weeks (in light blue in Fig. 33.5) represent the competitive period. In this phase, general exercises are still used for two times per week but with a percentage of 30% maximum strength and 70% explosive strength. Special exercises are performed three times per week. Complete throws are carried out with heavy and light tools. In shot put, throws are carried out with heavy and light tools ranging from 8.30 kg to 6.26 kg for males and from 5 to 3 kg for women. Official competition weights in shot put are 7.25 kg for men and 4.00 kg for women. Specific exercises prevail over the others especially in order to refine the technical movement.

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