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FLAT RACES AND RELAYS.

1.- FLAT RACES

Official distances programmed by Spanish Athletics Federation (RFEA) adapts progressively to the intensity and volume of the training in minor categories. Table 1 shows the events in which a child can compete both in Indoor and Outdoor Championships:

Distance (flat)	Indoor	Outdoor
50 m	Under 9 (Benjamin)	U9 (Benjamin)
60 m	U11 (Alevin)→Senior (Absoluto)	U11 (Alevin)
80 m	X	Under 13 (Infantil)
100 m	X	U15 (Cadete) → Senior (Absoluto)
150 m	X	U13 (Infantil)
200 m	U17 (Juvenil) →Senior (Absoluto)	U17 (Juvenil) → Senior (Absoluto)
300 m	Under 15(Cadete)	U15 (Cadete)
400 m	U17 (Juvenil) →Senior (Absoluto)	U17 (Juvenil) → Senior (Absoluto)
4 x 50	Sometimes 4 + 3 + 2 + 1 laps	U9 (Benjamín)
4 x 60		U11 (Alevín)
4 x 80 m		U13 (Infantil)
4 x 100 m		U15 (Cadete) → Senior (Absoluto)
4 x 300 m		U15 (Cadete)
4 x 400 m		U17 (Juvenil) → Senior (Absoluto)

Table 1.- Sprint distances performed in competition in each Spanish category.

1.1.- THE ATHLETICS TRACK.

The official track has usually 6 or 8 lanes of 400 metres, with lines of 5 cm wide to separate each of the lanes, the finish lanes, and the different starting lines (see Figures 1 and 2). As seen in the figure the starting lines of the 200 to 800 m are “ladder-shaped” (compensation). The compensation depends on the radius of the curves of the tracks (not all tracks are the same, but is about 7 metres by lane, so the last runner in a 400 ml starts almost in the centre of the curve.

There are also 300 metres tracks for training, and indoor tracks of 200 metres with a slope in the curves to compensate the centrifugal force and avoid losing too much speed in them.

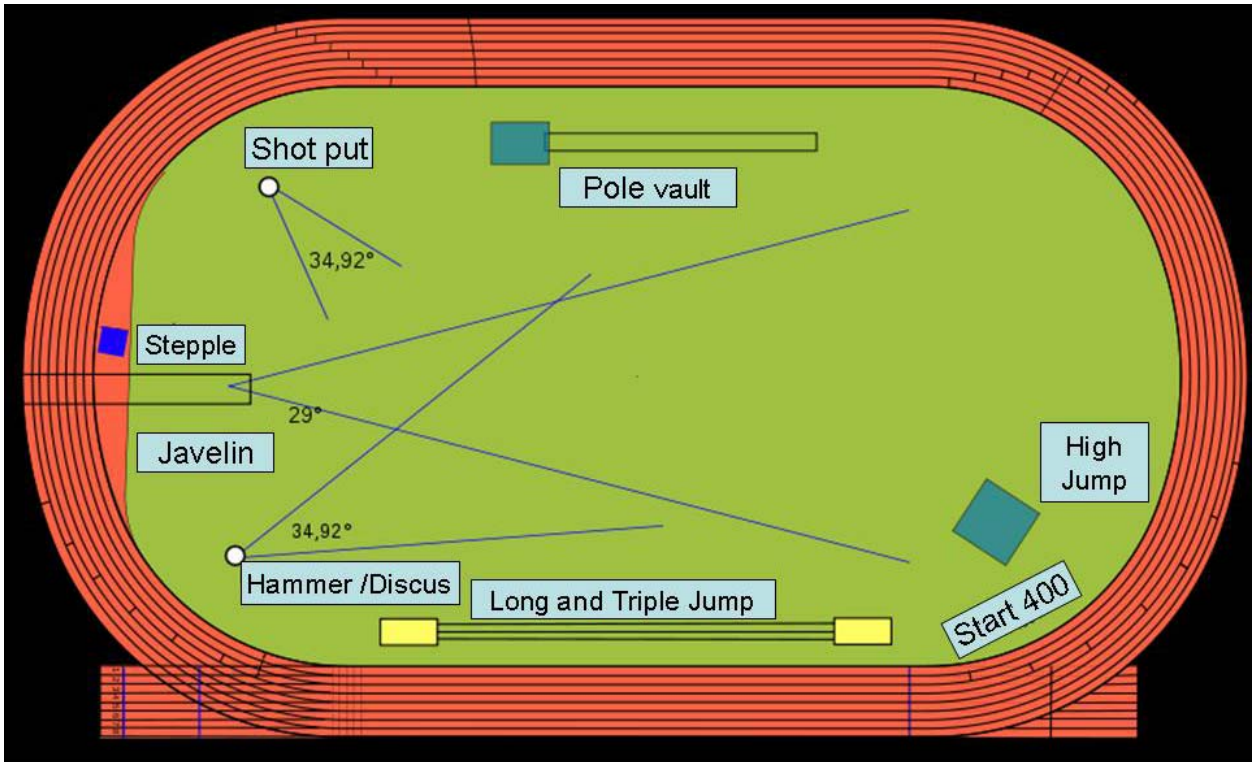


Figure 1.- A 400 m track with some of the starting lines and locations of different field events.

The lane width is 1.22 cm (see Figure 2), and the length of the lane should be measured at 30 cm from the inner edge at the first lane and 20 cm in other areas.

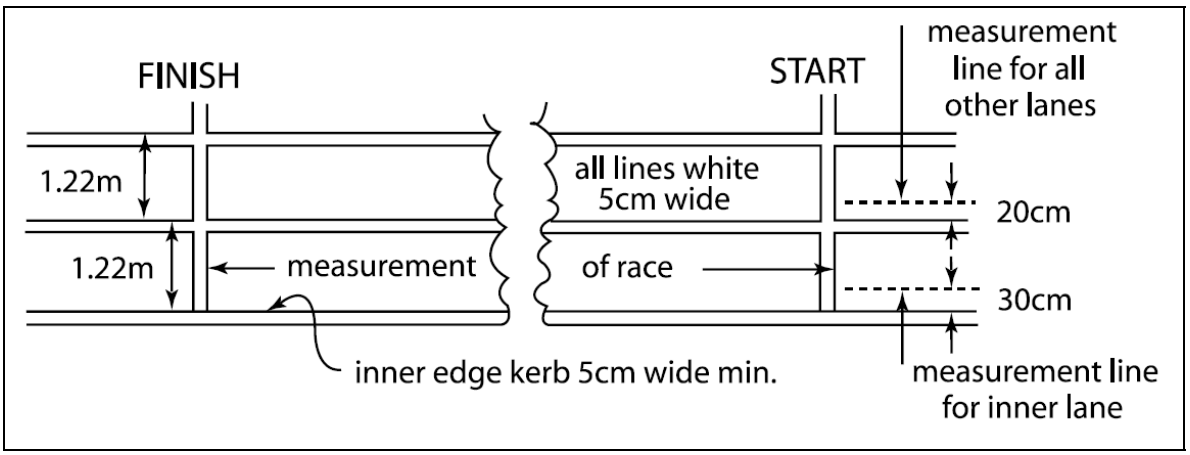
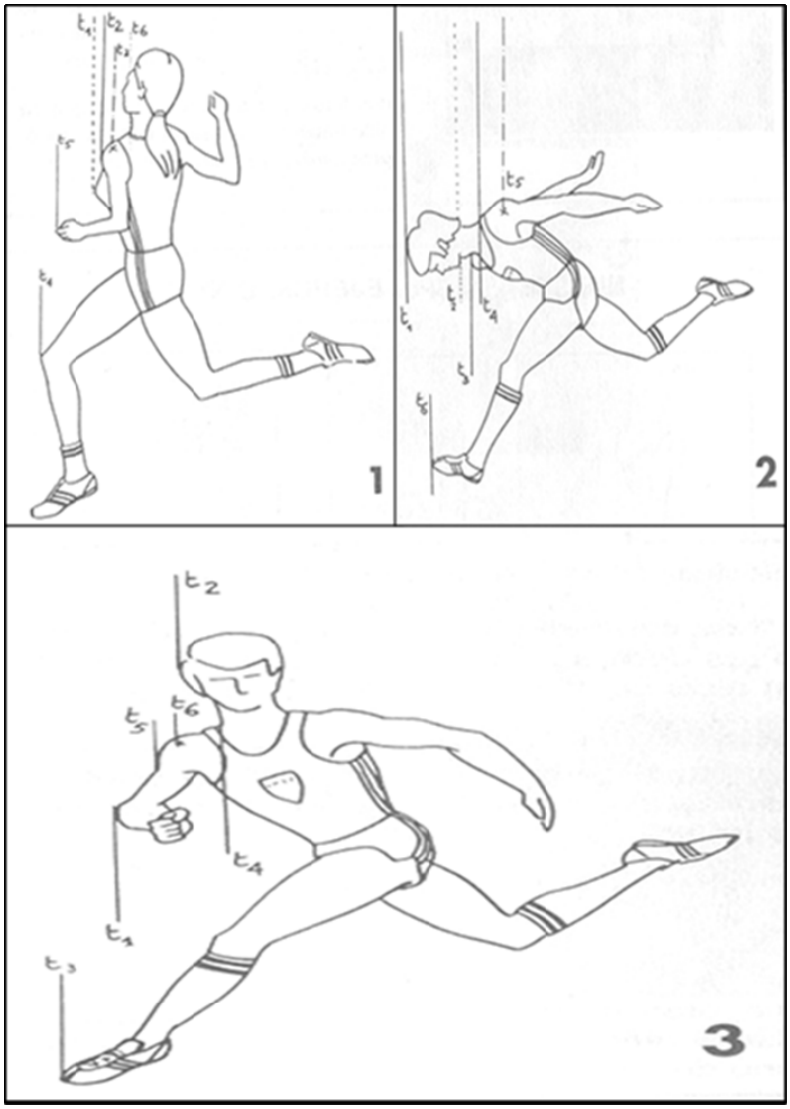


Figure 2.- Track measurements. (IAAF competition rules book 2010-2011)

According to the Competition Rules, the final time will be measured from the start's shot, to the moment in which any part of the athlete's body (trunk, excluding head, neck, arms, legs, hands or feet) reaches the perpendicular plane of the nearest edge of the finish line. Jacques Piasenta (2000) suggests some exercises (see Figure 3) to understand this rule and the inaccuracies that can occur due to its ambiguity.



In Figure 3.1, since the athlete is a woman, the valid time will be determined by the T1 line (breast).

In Figure 3.2, it could be the t3 (right shoulder) or T4 (base of the neck).

In Figure 3.3., the exact time could be the t4 (base of the neck), the t5 (right shoulder), t6 (front part of the right shoulder). Even presenting these images to international experts in photo finish they had doubts determining the exact time.

Figure 3. - Exercise to determine the exact time of arrival using photo finish (Piasenta, 2000).

1.2.- STARTING BLOCKS.

The individual starting blocks technique varies enormously from one athlete to another. There are athletes with explosive starts (for example, Ben Johnson in the 80's), which were not so orthodox. The technique described below would be a standard model for teaching children, but may be amended in order to allow a starting action as comfortable an efficient as possible.

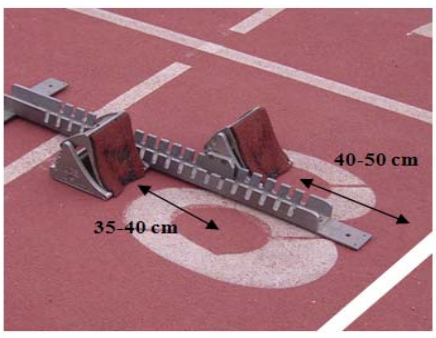
1.2.1.- LOCATION OF THE STARTING BLOCKS.

Following the studies by Ballesteros (1992), who showed that the drive times on the starting blocks of the back leg are where faster than the ones of the front leg, we assume that, in order to apply the maximum quantity of strength, we should allocate the strongest leg in the front block, although the first step will take place with the theoretical weak leg. The reason is, as we will see later, because the advanced leg is pushing for a longer tim on the blocks

Blocks are placed in the middle of the lane (See figure 3), perpendicular to the starting line, with the advanced block 40 - 50 cm away from it, depending on the anthropometry and the physical capacities of the athlete (girls usually start with the starting blocks closer to the starting line). The delayed block will be 35 – 40 cm behind the advanced one (see figure 3). The feet lateral space should be of 12 – 15 cm, and it is fixed by the width of the starting blocks structure.

As an initial reference for children, the length of the advanced block will be situated where the forefoot lands while the children places the knee on the starting line. Delayed block should be placed one foot behind.

Inclination of the advanced block should be 40º - 50º (with respect to the horizontal), and inclination of the delayed block is usually a higher angle, of approximately 60º - 80º, also fixed bu the design of the starting blocks. (See figure 4).



Figures 3 and 4.- Starting blocks with respect to the starting line and starting blocks angles.

1.2.2.- ON YOUR MARKS!

This position, as shown on Figure 5, starts with the hands on the floor, the front leg should be placed on the advanced block, and then the back leg in the delayed block. The back knee must be on the floor.

Subsequently the athlete places the hands behind the lane's lines with a width greater than the shoulders and with the thumbs facing inwards and the rest of the fingers outwards.

The head is positioned with the neck in extension of the body, looking slightly beyond the line. Shoulders should be on the starting line or slightly behind.

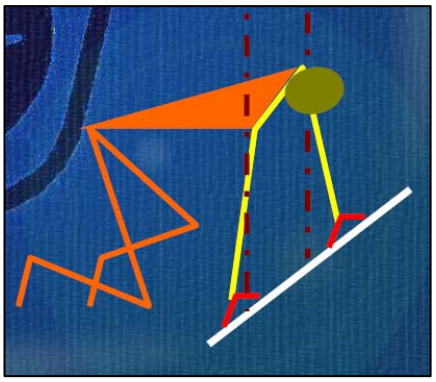


Figure 5.- "On your marks" position

1.2.3.- SET!

At the "Set" position athletes must gradually raise the body up and forward to reach a final position where the hip is slightly above the shoulders, and those are advanced to the hands and start line (see Figure 7).

In this position we should have a sense of imbalance, and the bodyweight distributed between the hands and feet. Feet have to be completely flat on the blocks, and pressing them hard.

The front leg knee's angle before the extension should be about 90º, and the back leg's 120º to 130º. These parameters can vary depending on the genre, the anthropometry and the fitness of the athletes.

Jacques Piasenta (2000) shows a few different static positions for the "Set" position (See figure 6). Not all of them are right, and they can be used to study this phase.

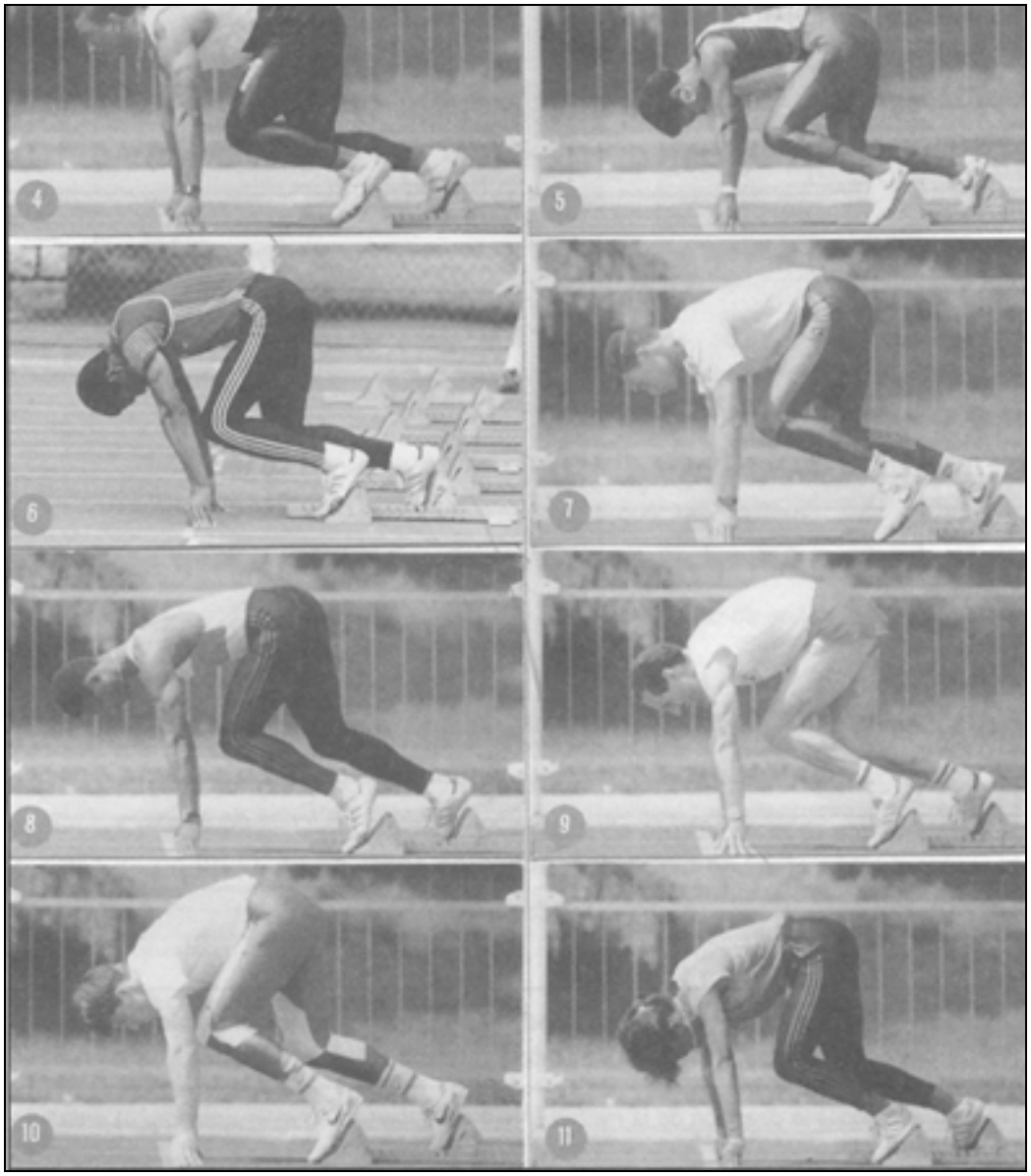


Figure 6.- Eight different final positions for the "Set" position (Piasenta, 2000).

1.2.3.- START SHOT (DEPARTURE).

When the revolver (or other similar apparatus) is fired, athletes must impulse with both legs simultaneously (back leg usually impulses for 0,2 seconds while the front leg, or impulse leg, takes 0,5).

After impulsing, the back leg moves forward, flexed and bringing the knee forward and upward. Also the arms help to raise the center of gravity: the impulse leg's arm moves forward fast, while the arm of the free leg goes backwards (Tandem position).

When the impulse leg extents completely, the body takes an angle of approximately 45º with respect to the vertical. The head facing forward, looking 4 metres in front, and being a prolongation of the body. Progressively and over the next contacts, body is going up until the vertical (as described by Ballesteros "starting like an arrow"). First contacts are shorter than normal in order to have a shorter landing time and to obtain the maximum frequency possible.

The movement out of the blocks must be fluid, looking for the acceleration. First step's contacts should be done under the center of gravity (CG), and even, at first, slightly behind. Stride length increases progressively at each step, in about 20 cm since the first steps, reaching normal stride length after 13 or 15 steps (approximately at 20 – 30 metres).

There has been some amendments to the rule of false starts in the last years. Before all athletes were allowed to do a false start, and only after the second one they were disqualified. Later, the rule changed and one false start was allowed to all the athletes in a race, after the 1st false start any other false start meant the immediate disqualification. And recently, the final amendment to the rule of false starts states that no false starts can be done. The first false start in a race means an immediate disqualification of any athlete. This rule prevents the excessive duration of the sprinting events while providing them with excitement and making them more spectacular, but is a big concern for all the sprinters which can lose all the work of a year.

Also, some false start detection equipment is used at national and international level. This equipment detects any movement on the blocks, and if it happens before 0,10 seconds after the start shot is fired, it is a false start (the reaction time cannot be below 0,09 seconds which is the normal auditory reaction time as stated by Roca, 1983).

1.2.4.- BENDED STARTS.

In the events started in a side bend (200 and 400 metres), the most efficient start is the one tangent to the bend. Starting blocks should be placed facing the bend (see figure 7) and the left hand will be slightly behind the starting line. When we start running, the body must lean into the bend to compensate the centrifugal force generated.

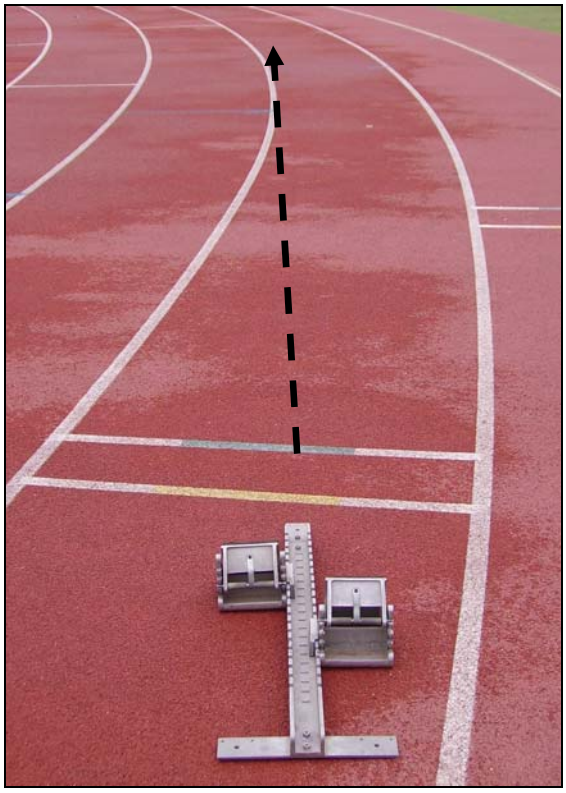
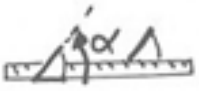
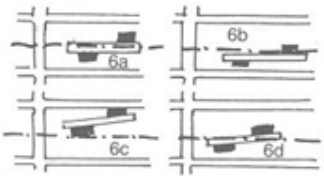


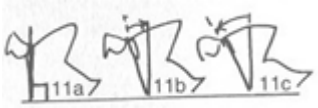
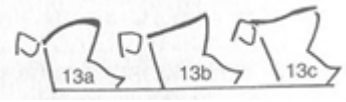
Figure 7.- Positioning of the Starting Blocks in the bend, and the running path tangent to the bend.

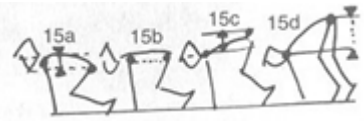
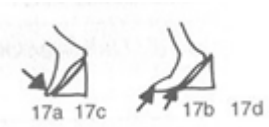
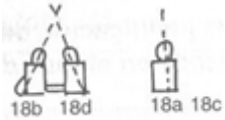
1.2.5.- PIASENTA'S ANALYSIS SHEET OF THE START

Jacques Piasenta (2000) presents in his book an analysis sheet with different parameters to watch in the starting blocks ; anyhow, he does not choose any of the models as the right one to do a start.

ANALYSIS SHEET OF A SPRINTER IN THE "SET POSITION" AT THE STARTING GUN. (Piasenta, 2000)

A – ADJUSTMENT OF THE STARTING BLOCKS	
1	Front foot indentification. 1a – Left foot in front. 1b – Right foot in front. 
2	Gap between the advanced and the delayed blocks. 2a - Small gap (5 to 10 cm). 2b – Medium gap (20 to 30 cm). 2c – Big gap (40 to 50 cm or more). 
3	Adjustment of the inclination of the advanced block. 3a – Angle α higher than 60º. 3b – Angle α lower than 60º. 
4	Adjustment of the inclination of the delayed block. 4a – Angle γ close to 90º. 4b – Angle γ close to 60º. 
B – POSITIONING OF THE STARTING BLOCKS WITH RESPECT TO THE STARTING LINE	
5	Distance from the starting line to the advanced block. 5a – Advanced block close to the line (15 to 20 cm). 5b – Medium distance (approximately 1 foot, 25 to 35 cm). 5c – Front block far away from the line (45 to 50 cm). 
6	Orientation of the starting block with respect to the lane's axis. 6a – Parallel and in the lane's axis. 6b – Parallel and displaced to the inside. 6c – Parallel and displaced to the outside. 6d – Oblique and in the inner half of the lane. 6e – Oblique and in the outer half of the lane. 

C – POSITIONING OF THE SPRINTER	
7	Layout of the hands with respect to the starting line. 7a – Both hands aligned next to the starting line. 7b – Left hand displaced backwards. 7c – Right hand displaced backwards. 7d – Both hands behind the line.
8	Quality of the hands support. 8a – Fingertips' support. 8b – Bent fingers' support. 8c – Other.
9	Gap between the arms. 9a – Arms spaced. 9b – Arms parallel or close to parallel. 
10	Upper limbs extension. 10a – Arms outstretched. 10b – Slight flexion of the arms. 10c – Significant flexion of the arms. 
11	Positioning of the arms with respect to the hands. 11a – Shoulders in the hands vertical. 11b – Shoulders slightly forward. 11c – Significant imbalance. 
12	Head's axis. 12a – Head extended. 12b – Head as a projection of the back. 12c – Head flexed. 
13	Positioning of the back. 13a – Rounded back. 13b – Flat back. 13c – Bent back. 

14	Positioning of the pelvis. 14a – Marked retroversion. 14b – Free. 14c – Marked anteversion. 
15	Elevation of the hip. 15a – Hip lower than the shoulders. 15b – Hip at shoulders level. 15c – Hip slightly higher than the shoulders. 15d – Hip really high. 
16	Feet support on the blocks. 16a – Left foot, total support. 16b – Left foot, partial support. 16c – Right foot, total support. 16d – Right foot, partial support. 
17	Feet support on the track. 17a – Left foot, tip support. 17b – Left foot, sole support. 17c – Right foot, tip support. 17d – Right foot, sole support. 
18	Feet axis with respect to the vertical. 18a – Left foot, vertical axis. 18b – Left foot, oblique axis. 18c – Right foot, vertical axis. 18d – Right foot, oblique axis 

2.- RUNNING TECHNIQUE: SPRINTS.

Running differs from walking because of the higher intensity of the impulses into the ground, and the existence of a suspension phase that makes the stride go longer. In Figure 8, we can see the running phases of Jacques Piasenta ideal running technique.

<table>
<tr><th colspan="3">SUPPORTING PHASE</th><th>FLYING PHASE</th></tr>
<tr><td colspan="3">From the landing to the take off</td><td rowspan="2">Lack of contact</td></tr>
<tr><td>CONTACT PHASE</td><td>(Cushion)</td><td>IMPULSE PHASE</td></tr>
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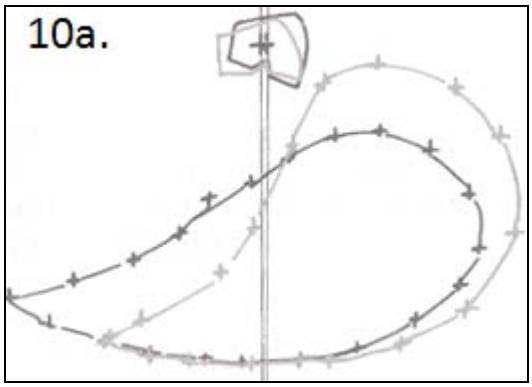
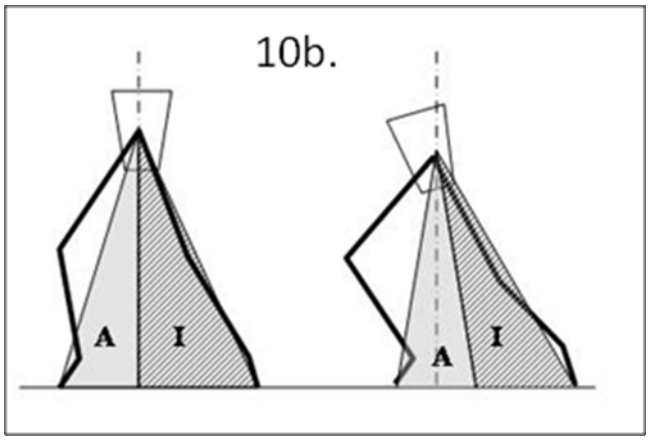
Figure 8.- Ideal running phases in Piasenta's model (Anterior Cycle).

The author considers two running techniques well differentiated (see Figures 9a and 9b):

1º.- ANTERIOR CYCLE RUNNING: Ideal for sprints and jumps since it is the most efficient in terms of applying the strength from all the possible muscles. Hips are in a neutral position (no anteversion) during the entire race. The area that would generate the trajectory of the ankle (dark path in Figure 10a) would be balanced with respect to the vertical projection of the centre of the hips.

2º.- POSTERIOR CYCLE RUNNING: It is much more economical from an energetic point of view, and the impulse backwards is easier because the hip is in anteversion (light path in Figure 10a). However, if the impulse action does not keep the hips high, the projection of the free leg is too long, and the knees do not rise enough.





Figures 9a y 9b.- Comparison between anterior and posterior cycle running (Piasenta, 2000).

Also we need to know two basic concepts involved in the running technique, the stride and the step. For many of the Spanish coaches a stride involves a full running cycle, and we count it from the contact of one foot to the next contact of the same foot. On the other hand the step is just a half cycle, and goes from the contact with the ground of one foot to the contact of the other foot. However, as an English concept, and on the forthcoming uses of these words in this text, both words are synonymous.

2.1.- LANDING.

The foot contacts the ground first with the outer edge of the foot slightly in front of the body, later with the central metatarsals, and the final impulse before taking off is given with the toes.

It is very important to land on the right place with respect to the vertical line of the hips. If we land forward (Figure 10-A), and because an excessive cushioning is needed before the hips go over the contact point, the CG will slow down in its displacement. On the other hand, if we land too close (Figure 10-B) the cushioning will be performed when the hip is over the contact point, making a late impulse much less effective.

The landing point will depend on the running speed. Usually, the faster you run the farther you can contact; slow running allows bigger cushioning and closer feet contacts, making the running technique more economical.

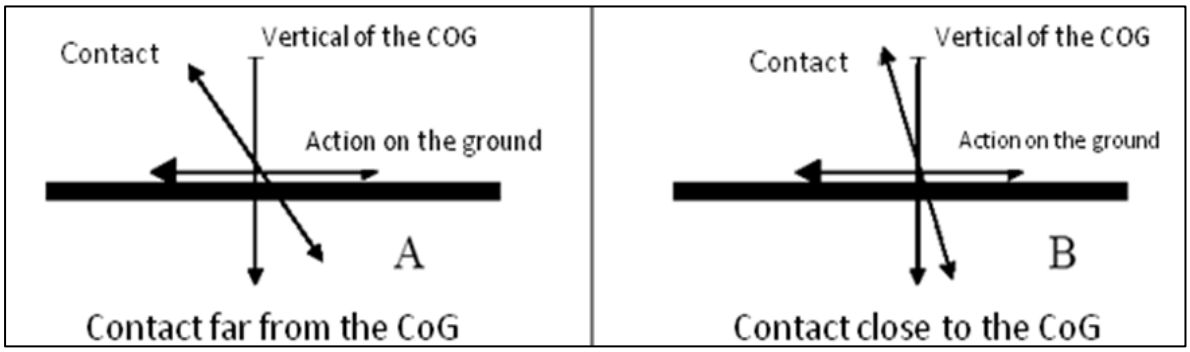
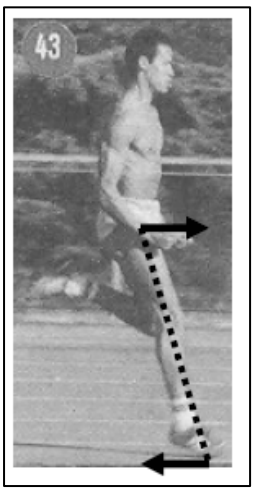


Figure 10.- Farther and closer contacts with the ground, from the vertical projection of the CG.



The heel should never touch the ground, especially in sprinting, and running with spikes. However the greater the distances, the harder it is to keep the necessary strength to prevent it from occurring, especially at the end of the race.

Following the contact, a "pulling back" occurs (it should have started before the landing). The foot should contact from the front to the back, to generate impulse that projects the hip forward (see Figure 11). Simultaneously the free leg must pass grouped forward to reduce the pressure of the contact and help in the CG's forward displacement.

Figure 11.- Torque generated after landing the feet.

The contact time will depend on the running pace; while sprinting it can be of 100 milliseconds. In order to minimize the contact time flexion and extension movements of the hip, knee and ankle joints must be reduced, since this actions increase the cushioning phase, and therefore, the contact phase.

The height of the CG should not be changed too much (between 4 and 5 centimetres).

2.2.- THE IMPULSE

Physically, the impulse should begin when the contact on the ground goes through the projection of the CG. However, it is possible that thanks to the grip given by the spikes in contact with the synthetic surface, this phase can start a little earlier (Figure 12).

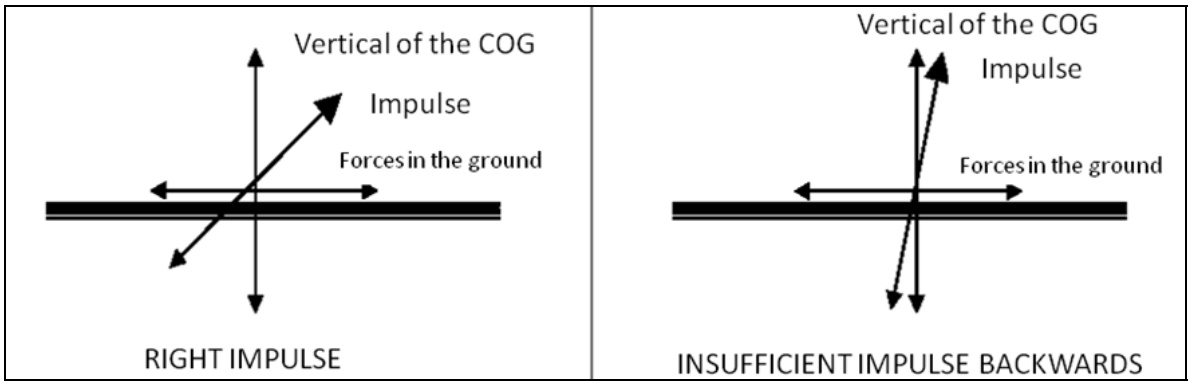


Figure 12- Right impulse and insufficient impulse.

The arms balance the action and help to maintain the hip's elevation in what is called the "tandem" position. The arm opposed to the free leg rises, while the one of the impulse leg goes backwards.

Maximum strength work is very important for a sprinter, even though the impulse phase is really fast (0.100 seconds) and only a tiny part of this strength can be used. The action is done with the "elastic strength" and the prior eccentric tension of the muscles (especially used are the calves, soleus and gluteus).

During the race it is important to alternate the muscle activity between contraction and relaxation of the muscles. When the flexors of one side of the hip raises the free leg's knee, extensors of the impulse leg side of the hip, are contracted and, simultaneously, the antagonistic muscles should be relaxed alternatively to make the action efficient and without unnecessary stress (in this case the extensors of the free leg's hip, and the flexors of the impulse leg's hip). This inter-muscular coordination is quite difficult to acquire but it is also very easy to lose when the athlete is tired, at the end of the race

Apart from the action of arms and legs while running, the action of the trunk is also important. It should stay vertical, with out lateral movements or rotations. A vertical inclination forward causes an anteversion of the hip and prevents the correct impulse.

2.3.- FLYING PHASE.

In this phase the CG starts a parable as wide as possible, but without rising more than 4 or 5 cm. away from the ground. It is important to maintain the CG stable, since a higher elevation of the CG will increase the cushion phase and, therefore, more strength will be needed to perform the next impulse.

The impulse leg becomes free leg, and moves going forward and upwards, with the feet as close to the thigh as possible. The loss of speed during the flying phase is 0.35 to 0.60 m/sg. The longer the flying phase, the greater the loss of time, since there is no backward forces that increases the movement of the CG forward. That is why runners should anticipate the contact moment as much as possible without losing stride length.

At the end of the flying phase the free leg becomes contact leg, so it should reach the ground with a previous tension to withstand the impact without flexing too much ankles, knees and hips. It is important to notice that there is a strong relationship between the tension performed on the ankles and on the wrists, knees and elbows, and on the hips and on the shoulders. In order to get a good previous tension of the lower body (legs) we should also get some tension on the upper body (arms).

The arm action also helps adopting a balanced position during the flying phase. Flexion of the arms should be of approximately 90º, while the hand should stay relaxed. As a reference, when the hand goes backwards it should not exceed the hip's level, and when it goes forward it should not exceed the shoulder's height. The head must always stay high and lined-up with the trunk.

The stride length will depend on:

- The length of the legs of the athlete.
- The joint mobility of the athlete.
- The power and muscle elasticity.
- The tiredness of the athlete.
- The technical expertise and the inter-muscular coordination.

For sprinting the stride width is optimized following the biomechanical model, and with little regard to the energy cost; but in long distances, economy will be over the technique.

In Table 2, we can see some instructions given by Ballesteros about the running technique.

	AVOID	TRY TO
TECHNIQUE	1. Inadequate impulse and knee's lift. 2. Contact the ground with the heel. 3. Trunk lean forward or backward. 4. Swinging head or excessive lateral movements of the shoulder. 5. Arm movements too high, or with lateral movements at the chest (instead of linear movements). 6. Bring forward too early the impulse leg. 7. "Zigzag" or "stiff" running. 8. At the "set" position, raise the head, move the hip too high or low, legs too extended or flexed, inadequate impulsion or raise the COG too early.	1. Try to match up the highest point of the front leg with the maximum extension of the impulse leg. 2. Foot support with an eccentric action of the ankle (like a "spring"). 3. Trunk vertical (lying just a little bit). 4. Head vertical (as a prolongation of the trunk) looking forward. 5. Movement of the arms close to the sides of the hips and flexed, making a 90º angle. 6. Complete action of the impulse leg, not too vertical. 7. Run "in line" placing the feet one in front of the other. 8. At the "set" position move the body up and forward and, at the start shot, forward action of legs and arms.

Table 2.- Running technique instructions.

2.4.- RUNNING STRATEGY

GENERAL FORMULA: $$\text{Speed} = V * L\ (m/sec) = \frac{L}{Tc + Tf}$$

Where "L" is the length of the stride, "Tc" the contact time, and "Tf" the flying time. The length of the stride should be as long as possible with minimum contact and flying phases to reach the maximum speed. To do so the frequency should be maximal with a wide stride.

The time between the start and the first support should be of approximately 0.35 sg. At the beginning of the race we use explosive strength, as the race progresses and momentum is gained, we will use more elastic strength.

The cadence goes from 2 to 4-5 steps/second, and the stride length varies depending on the exact moment of the event:

- 20 mts = 2.05 to 2.10
- 40 – 60 mts = 2.50 to 2.55
- 80 – 100 mts = 2.55 to 2.60

A balance between length and cadence is necessary.

3.- SPRINT RELAYS (4 X 100).

In the short relays the transferring of the baton's technique is really important, not to lose the speed.

In Figure 13, we can see the changeover box, marked in the track, where the first and third changes are done. There are two different areas marked by three lines:

1ª.- THE PRE-PASSING AREA: It is 10 metres long, and the outgoing runner must wait inside.

2ª.- CHANGEOVER BOX: It is 20 metres long, and is marked by two half arrows, that in the case of being together would form an "M" letter.

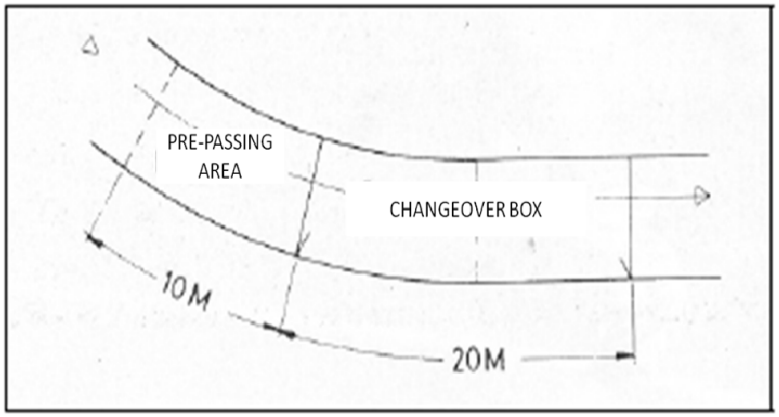


Figure 13.- Pre-passing area and changeover box situation's diagram.

When the outgoing athlete decides, he will start at full speed. A reference is set 5 to 10 metres (depending on the speed difference between the two runners involved) ahead of the incoming runner, so that as soon as the incoming runner goes through it, the outgoing runner starts. To be effective this distance should be set in advance, in trainings with attempts at maximum speed,. When the outgoing runner reaches the changeover box, the baton can be passed. Ideally the changeover should be done after 16 to 18 metres of the changeover box. If the baton is transferred after or before the changeover box the team will be disqualified. There is always, at least, one judge to check that the baton is passed inside the changeover box.

In Figure 14, the path of the baton can be seen. It should always be inside of the lane. Usually athletes running the first and third leg (bends) run inside, holding the baton on the right hand; while the second and fourth qualifiers (straights) run in the outside part of the lane, holding the baton on their left hand. The baton should not be changed from one hand to the other, in order to avoid dropping it and being disqualified.

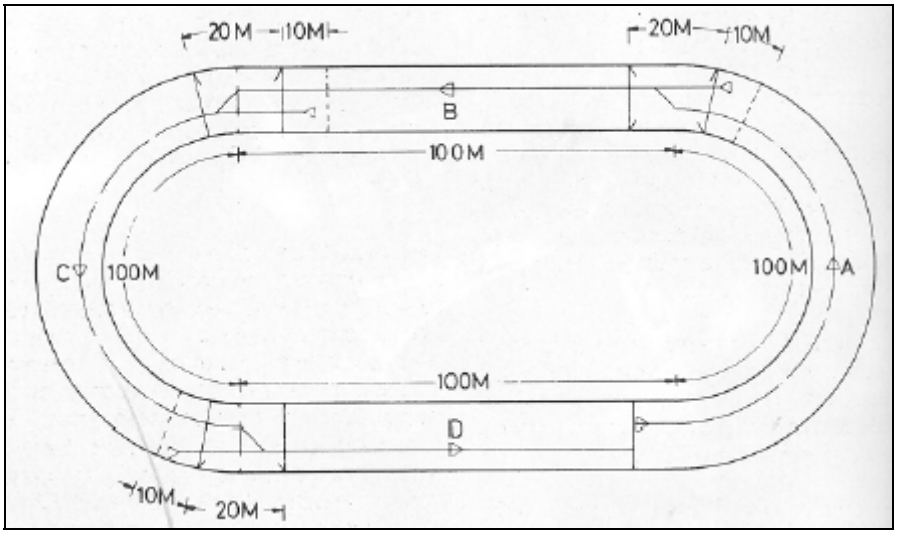


Figure 14.- Path of the baton and runners in the sprint relays.

The main characteristics of the runners of each leg are:

1st Leg: This leg runs approximately 106 metres, corresponding to the 100 of the bend, plus part of the changeover area. The starting blocks technique is modified, since the runner has to hold the baton with at least three fingers of the right hand. The runner should have a good start and, if possible, run with a good cadence. Also, since he runs the most metres, should not be the slowest.

2nd Leg: This leg runs 100 metres on the straight, in the outer part of the lane and holding the baton on the left hand. This runner can use more stride length than cadence.

3rd Leg: This leg runs 100 metres on the bend, close to the inner part of the lane and holding the baton with the right hand. This runner should run with cadence, and usually 200 metres specialists run this leg since they are used to run the bend at full speed.

4th Leg: This leg has only 94 metres, the baton is usually taken with the left hand and the runner runs in the middle of the lane. This runner is usually the most competitive since he is the last one.

The starting technique of the relay runner (except the first leg) can be done with two or three supports as shown in Figures 15 and 16. You should never look back once you start running, and you must rely on the orders from the incoming runner to reach a straight arm backwards as soon as he makes a verbal sign. Relays specialists have the passing technique so automated that they do not even need the verbal signs to transfer the baton.

Figure 15.- Relay's start using 2 supports.

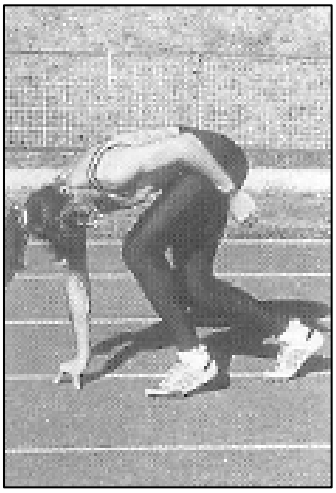


Figure 16.- Relay's start using 3 supports.

The changeover can be done:

a) Top-down: The outgoing runner must reach a straight arm backwards in pronation, with the palm facing up, and close the hand as soon as the baton is felt touching the palm. This technique is less secure, but no displacement of the baton is required while running. Also the athletes have to be further away when changing the baton.

b) Bottom-up: the outgoing runner must reach a straight arm backwards in supination, with the palm facing down, and close the hand as soon as he feels the baton between his index finger and the thumb. This technique is safer, but if the the supination of the arm is not done the baton does not end up in the right place of the hand, and needs to be slid up while running to make the next change over the best way possible. The athletes have to be closer to each other in the moment of the change.

In both cases, the incoming runner must do the change with an outstretched arm, and make a final action of the wrist to hit the outgoing runner hand, and thus enable the grasp reflex of the receiver to grab the baton effectively.

4.- LONG RELAYS (4 X 400).

In the long relays there is not a pre-passing area, and there is only a changeover box of 20 metres. The first 400 metres and the first changeover are done in lanes. The second leg runner must start in lanes and then move to the inside of the track in the back straight (opposed to the home straight). The baton is usually held in the right hand and the outgoing runner takes it in the left (changing it to the right again while running, usually at the beginning).

Only specialists make a blind change over. Usually the outgoing runner is responsible of the change, since the incoming one is exhausted by the effort of the 400 metres run. Usually the 2nd (in charge of moving to the inside lane of the track) and the 4th leg (the one who finish the race) have the strongest and most competitive runners.

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