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LONG JUMP

1.- JUMPS OVERVIEW.

The main reference for these notes will be the book: "Atletismo II. SALTOS (COE y RFEA, 1992)". occasionally the text by Hubiche and Pradet (1999) has been used as a reference.

We will begin referring some general concepts for any athletic jump. In any jump there are, firstly a series of consecutive steps running done to acquire a certain speed; they have a certain direction and the body should be located in an appropriate position in order to execute the jump, and secondly, a suspension phase where we try to jump over a horizontal bar placed at measured heights or to leap as far as possible from a take-off point (Hubiche and Pradet, 1999).

A) SUCCESIVE STEPS PHASE. Inside this phase we can differentiate 3 sub-phases:

A-1) RUNNING PHASE.

Its main aim is to get a speed that increases the kinetic energy (E_k) of the jumper. It has, therefore, a **quantitative target.**

$$E_k = ½ \, m * s^2$$

Maximum speed should be reached, but allowing the right execution of the jump. Depending on the physical and technical capabilities, there is an optimum speed for each jumper in every moment while approaching.

The jumper's run is characterized by its wide range of gestures and the progressive acceleration over its perfornance.

A-2) LINK RUN-TAKE-OFF.

During the last two or three strides the body should be placed in the right position. This phase will have, therefore, a **qualitative target.**

There is an increased cadence of the run, with a variation, more or less pronounced, in the stride length, depending on the technique used by the jumper.

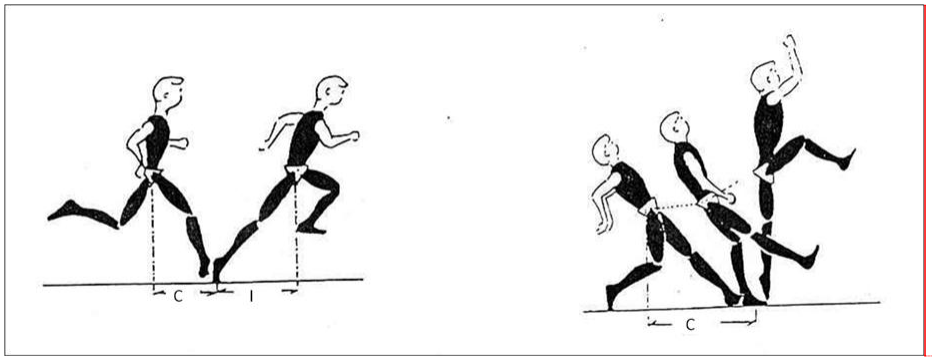
A-3) TAKE-OFF.

The take-off begins when the impulse foot lands, and ends when it detaches from the ground. Therefore, there will always be a Cushioning phase ("C") and an Impulse phase ("I") (see Figure 1).

- The Cushioning phase begins with the foot landing and ends when the CG passes over the support. The farther the support, the longer the Cushioning phase will be and, therefore, the loss of horizontal speed gained in the running phase.

- The Impulse phase begins when the CG passes over the support, and ends when the foot detaches from the ground. From this point no other effective forces can be done to modify the movement of the CG of the jumper. The take-off completely defines the suspension phase.

If the jump requires to be done in the horizontal, the Impulse phase should be large, and the Cushioning phase short, to lose as little horizontal speed as possible (Figure 1-a). However, If the main part of the jump is vertical, the Cushioning phase will be relatively large and the Impulse phase will be very short (Figure 1-b).



Figures 1-a and 1-b. Comparison between the long jump and the high jump takeoff.

Depending on the take-off, the jumps can be divided into:

- Vertical component jumps: Cushioning phase longer than the Impulse phase. (Ex. High Jump).

- Horizontal component jumps: Impulse phase longer than the Cushioning phase. (Ex. Long Jump, Triple Jump y Pole vault).

Comentario [m1]: Hacer stromotion

Poner kinopasos?????

In Table 1, we can see the relationship between the take-off speed and the take-off angle ("α").

	α	S_o (m/s)
Straddle technique ("rodillo ventral")	60	7
Fosbury-flop	50	8
Long jump	20	10,50

Table 1. Relationship between α and S_o in different jumps.

We can appreciate that the higher the take-off vertical component, the bigger the speed loss of the jump, because of the previous cushioning phase. If the approach was faster, there will be no time no transfer the horizontal component to vertical, because the vertical projection of the CG in the ground would pass over the support really fast, reducing the application of the horizontal component forces during the take off.

The take-off time is related with the running phase speed. If we arrive to the take-off faster than the optimal speed the jump will be difficult to control and there will be no time to perform the amount of force needed for the jump. On the other hand, if the running phase is too slow but the jumper wants to perform a big impulsion (using the longer take-off time), he risks not having enough strength to produce the acceleration required to increase the initial take-off speed of the jump.

B) SUSPENSION PHASE.

The lenght or height of a jump will be the result of the earlier movements. It is impossible to change the trajectory of the CG from the time when the impulse foot loses contact with the ground. Only in the pole vault the CG trajectory can be modified to give it a vertical component, because the pole is still in contact with the ground. During the ascent we can only modify the body position with respect to the CG. This can make a jump more or less efficient, however:

- The length of a jump depends on the take-off horizontal speed ("So_x") and on the take-off angle ("α").
- The height of a jump depends on the take-off vertical speed ("So_y") and on the take-off angle ("α").

Figure 2 shows how the positioning of the body can make a high jump more efficient, making the attempt valid. The subjects "A" and "B" have made the same exact jump, with the same initial speed and angle. The trajectory of the CoG in both cases is "C". H owever the subject "A" does not place correctly the body, making it a failed attempt, while subject "B" is able to jump over the bar.

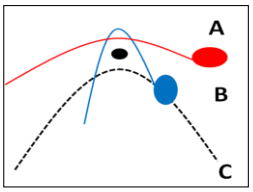


Figure 2.- Positioning of the body in the high jump.

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The impulsion should influence as much as possible the CG to avoid excessive rotational movements, although they are sometimes required (for example, when we try to jump over a horizontal bar in the high jump). The rotational movements can be compensated with the free segments (for example, arms in the long jump), and doing a better positioning of the body to make the jump more effective (for example, jumping over the bar in the long jump, or the landing of the long and triple jumps). In any case the CG trajectory would be modified.

2.- LONG JUMP.

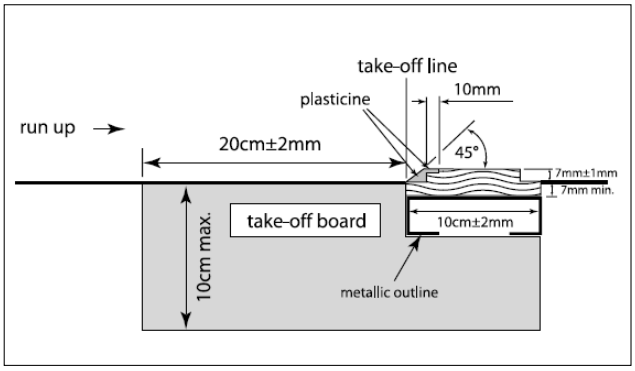


Figure 3.- Take off board and plasticine indicator board of the long jump. (IAAF, 2011)

It is not very difficult for a fast jumper to reach the 7 metres (5,50 in girls), that is why the long jump is considered an "easy" event. However, to jump over 8 metres (or 6,50 in girls), exceptional physical qualities and a great technical control are required.

Usually a long jumper is tall and slim (Dwight Phillips 1,81 m and 78 Kg; Irving Saladino 1,76 m and 70 Kg), very fast, and with high levels of strength, especially in the legs.

We will divide the long jump technique in four phases: Running, Take-off, Suspension (aerial phase), and Landing.

2.1.- RUNNING PHASE.

It was thought that the jump was dependent on the suspension phase actions: but now the speed and the body position in the last strides of the running phase are more valued. For Seiru-lo (in Bravo et al., 1992) the running phase represents 50% of the long jump, and its objectives are:

1º.- Approach the take-off board correctly. The length of the approach run should be fixed and the running completely automated. Some years ago the distance to start the running phase was measured with the jumpers feet, using the foot length as a reference ("talonar"). Trainings should be done carefully, especially in the competition periods. Working at a speed different than the competition can generate wrong propioceptive feelings that will lead us take-off mistakes.

2º.- Speed up in the direction of the jump (Sx). ¡Careful! It should be the maximum controllable speed by the jumper technique. If the jumper runs too fast he can have problems in the subsequent take-off.

3º.- Place the body in the right position for the take-off.

2.1.1.- RUNNING PHASE FEATURES.

Usually men run between 16 and 22 steps, making a total of 30 to 45 metres, and women run from 25 to 40 metres using the same number of strides. These figures may vary depending on the morphology, physical fitness, technology, meteorology and the mental state of the jumper. Therefore, it is impossible to set a fixed distance to start running. The coach plays a very important role in this event, since he has to correct the starting distance a few centimetres forward or backwards depending on the variables described before, that affects more on the competition day.

In theory, when running 50 metres at full speed, there is a moment around the 30 – 35 metres when the speed cannot raise more. That is the moment when the take-off should be done (see Figure 4).

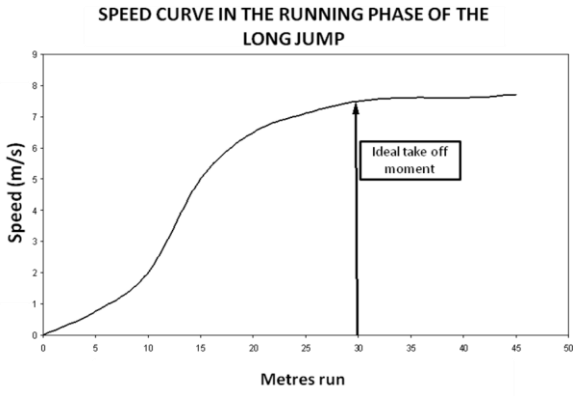


Figure 4. Test to find the ideal length of the running phase.

Jumper's running technique is slightly different than the sprinter's one. Both are supposed to reach the target (take-off board or finish line) at maximum speed, but the sprinter is supposed to run as fast as possible the whole race regardless of the final position, while the jumper can make a progressive run to end up with a controlled body position. On the other hand, sprinters do start from the blocks, and go up progressively, while jumpers don't.

The long jump running phase should be:

- **Balanced**. A proper alignment of the body segments looking to the race direction, should be maintained.
- **Controlled**. The CG position should be checked at all times, especially at the end.
- **Wide**. Knee's lift is higher than when we sprint (anterior cycle)
- **Rhythmic**. There are three main strategies for the run (see Figure 5):

1st.- Progressive speed, from the start to the end.
2nd.- Progressive approach speed and maintained in the final moments.
3rd.- Fast progressive speed at the start, maintained in the middle, and progressive again before getting to the take-off board.

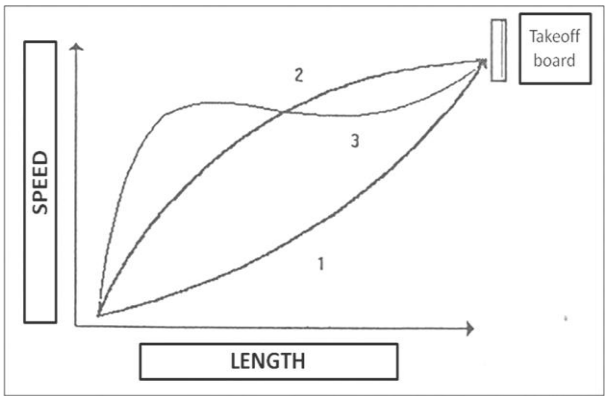


Figure 5.- Strategies for the long jump run.

Either possibility is valid. They should be chosen according to the characteristics of the jumper, and their individual preferences. In any case, the athlete should reach the final part of the running phase relaxed.

2.1.2.- LONG JUMP RUNNING PHASE PARTS.

The long jump running phases can be divided in three parts (see Figure 6):

1st.- STARTING: Usually the first 4 to 6 steps. The goal is to break the inertia and to get a cadence and a good body position that will be maintained for the rest of the running phase. The jumper can start from standing, with feet together, with one foot advanced, walking to a reference, with pre-jumps, with a progressive run, etcetera. Anyhow, the jumper has a reference in the ground that marks the end of the starting part, and the beginning of the running.

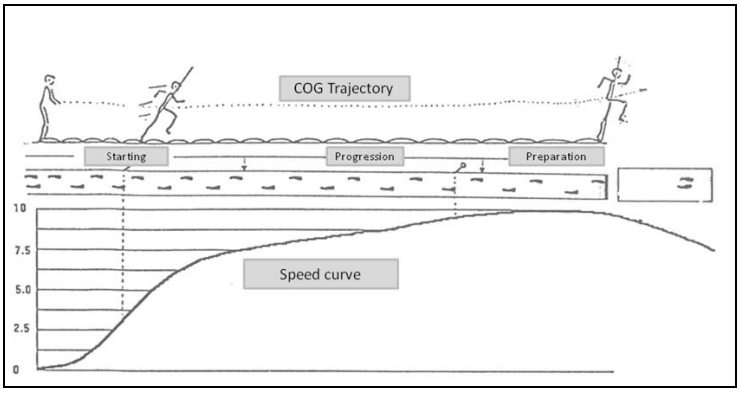


Figure 6.- Long jump running phase illustration.

According to Seirul-lo (Bravo et al., 1992) in this phase the jumper usually reached 2,5 m/s, quite slow compared with the higher speed of 7,5 m/s that can be reached at the take-off board.

2nd.- PROGRESSION or ACCELERATION: Usually the 10 to 12 intermediate steps (it finishes about 4 steps before the take-off). The necessary conditions of speed and balanced to make the jump are acquired in this phase. Length and cadence of the jump are stabilized.

If the speed of the jumper is below 9,5 m/s we should increase it through an increase of the cadence, whereas if the speed is over 9,5 m/s we should increase the length of the stride.

Jumpers usually place a mark at the beginning of the acceleration phase, and another one 6 to 8 steps before the take-off. These marks give confidence to the jumper and help him to automatically execute the jump. Sometimes these marks are only used by the coach to give instructions to the jumper between the different attempts of the event.

3rd.- TAKE-OFF PREPARATION: The last 4 steps before the take-off. Its aim is to place the jumper in the right speed and position to take-off with the highest possible efficiency.

The major transfer of energy of the race happen in the last three supports. There are two possible ways to prepare the take-off: "Sinking" and "Running" (see Figure 7 and 8)

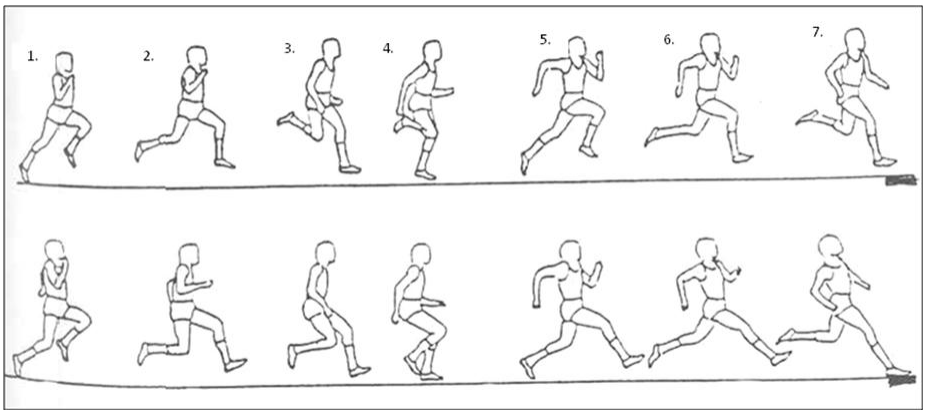


Figure 7.- Last supports for the long jump, using the "running" and "sinking" techniques.

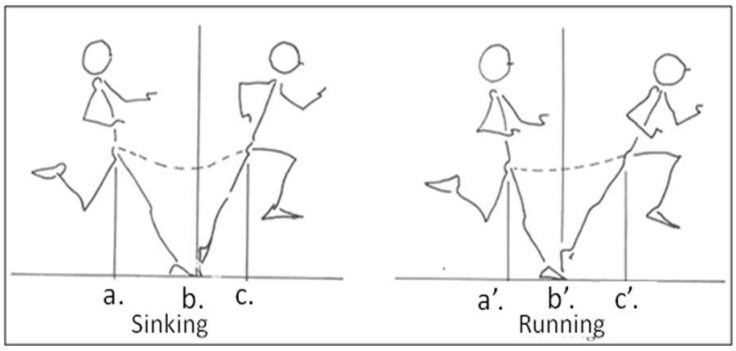


Figure 8.- "Sinking" and "Running" strategies to prepare the take-off.

Table 2 shows some differences between both techniques:

TECHNICAL DETAILS	SINKING	RUNNING
Second to last (penultimate)step	Slowing down. It is the longest.	Fast. Neither short nor long.
Last support (4)	Big flexion of the knee. Support in advance.	The knee does not flex much.
Last step	Fast. Landing far away from the CG.	Speeding up. Below the CG.
Support on the take-off board.	"Falling" on the board. Hip far from the board.	"Rolling" on the board. Hip closer o the board.
CG fall	Very pronounced.	Little pronounced.
Final body position	Slightly backwards.	Close to the vertical.
Ideal jumper	Strong but not so fast.	Really fast.
CG subsequent trajectory	Quite wide.	Flatter.
Last steps sequence	Normal – Normal – Long – Short	Normal – Long – Normal – Short
Final cadence	Slows down on the second to last step and speeds up in the last one	Slows down in the antepenultimate and speeds up in the last two steps.
Subsequent jump	Wide take-off angle	Narrower take-off angle (flatter)

Table 2.- Preparation for the take-off comparative ("sinking" and "running").

2.2.- TAKE-OFF.

The correlation between race and take-off is very high. It starts with the support of the take-off foot on the board, and finishes when the foot losses contact with the ground. Its purpose is:

1st.- To transform the kinetic energy gained during the running phase.

2nd.- To modify the linear trajectory of the CG into a parabolic one, transforming the initial horizontal speed in a suitable composition of horizontal and vertical speed.

3rd.-To place the jumper's CG in a certain angle and speed, necessary for the subsequent flight.

2.2.1.- LONG JUMP'S TAKE-OFF CHARACTERISTICS.

- The **take-off time** will depend on the jumper's level, but normal values are placed between 0,10 and 0,13 sec. of the best jumpers.

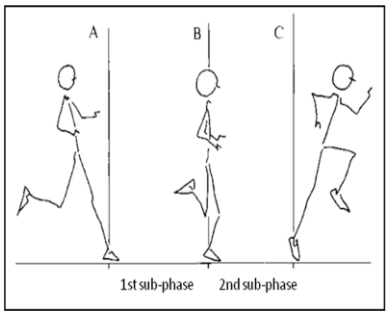


Figure 9.- Take-off sub-phases.

- The **CG trajectory and speed while taking off** will depend on many factor such as the take-off time, the jumper leg's length, and the jumpers proper technique.

- The **CG height** lowest point is at the end of the cushioning phase or "1st sub-phase", while its highest point is at the end of the impulse phase or "2nd sub-phase" (see Figure 9).

- The **foot's support** should be done with the sole and the external part of the foot (see Figure 10).The heel can touch the ground but never hit it.

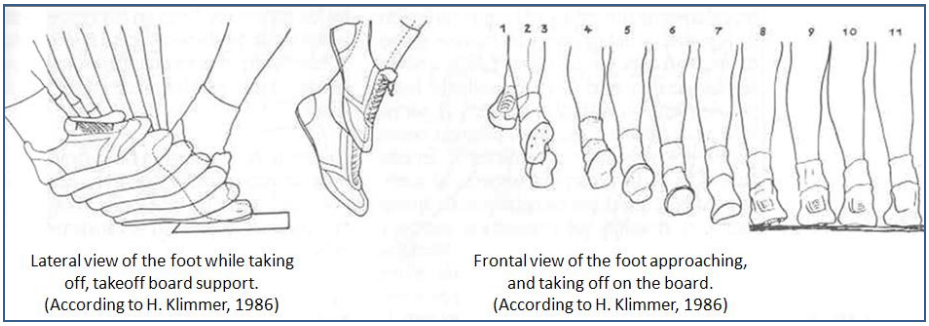


Figure 10.- Feet supports while taking off in long jump.

2.2.2.- TAKE-OFF PARTS.

Take-off is divided into two sub-phases, both for its study and training, (see Figure 7):

1st SUB-PHASE. CUSHIONING: Since the foot contact the ground to the moment when the vertical projection of the CG passes over the support.

The support should be done on the board. The sound of the shock between the foot and the board helps the jumper to know that the approach has been done correctly.

The trunk should lean back slightly, a little more when the "sinking" technique is used, but as a projection of the take-off leg. The head should be looking forward and never down.

At the end of the cushioning there is another absorption with the flexion of the take-off leg that brings the hip forward, (i.e. the CG). The free leg helps this action going forward. The CG displacement forward depends on the jumper leg's length, but it is usually of 0,70 to 0,90, and represents one third of the CG path while taking off.

The extensor muscles of the leg (hip, knee and ankle) perform an eccentric work (slowing down), even more intense if the "sinking" technique is used. In the cushioning phase there is an accumulation of elastic force in the extensor muscles that should be used later, in the subsequent phase. An excessive flexion of the take-off leg slows down too much the jumper, making a negative impact in the jump.

The slowing down effect of the horizontal speed should be minimized and optimized with the horizontal and vertical speed components generated later in the impulse phase.

2nd SUB-PHASE. IMPULSION: Since the vertical projection of the CG passes over the support to the moment when the foot is released from the ground.

The take-off leg should be extended strongly as fast as possible, while the free leg, flexed and in tandem position, helps projecting the CG up and forward. The knee of the free leg should reach the hip's height when the impulse leg is completely extended. At this phase the slowing down forces stop and vertical impulses are generated, allowing the jumper to do a high jump.

The arms should also use the tandem position, blocking themselves when the hand corresponding to the impulse leg reaches shoulder height. At this moment the opposite arm's shoulder is in full extension. While the block is maintained, both shoulders go up, helping the body to elevate. The trunk should be hard and strong, to maintain the forces generated by the upper limbs.

In Figure 11 we can appreciate 4 possible positions at the end of the take-off. Three of them are not well seen from a technical point of view, but are also possible. In 11.1, there is no tandem position, but a simultaneous action of both arms; in 11.2 there is an extension of the knee; 11.3 would be the right one, from a technical point of view; and to end up, 11.4 extends the right arm backwards, it generates an unbalance and the body goes forward too early.

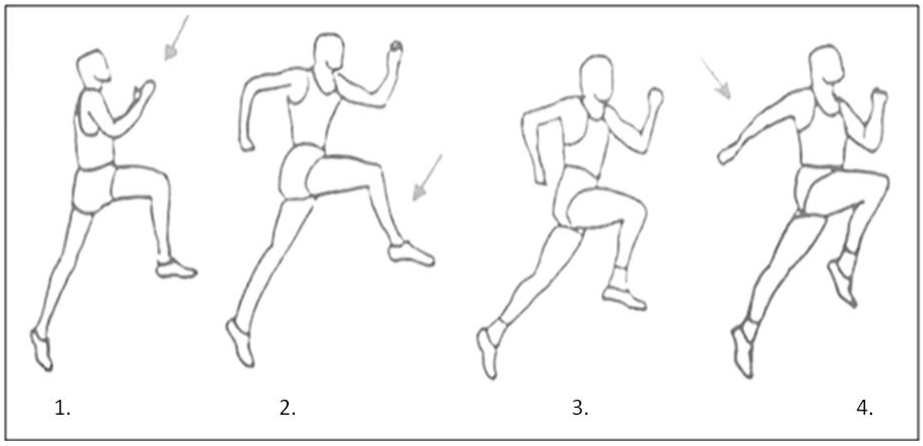
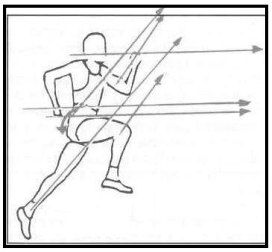


Figure 11.- Possible positions at the end of the take-off.



The extensor muscles of the legs go from eccentric to concentric almost instantly. This extension, assisted by the free leg and the upper body, should start right when the CG passes the support vertical

The jumper must feel his body initially going up, and at the end of the impulse going also forward (see Figure 12).

Figure 12.- Displacement feelings in the take-off.

Comentario [m3]: CAMBIAR POR UNA FOTO SIN FLECHAS

In Figure 8, we can see the vertical projections of the CG and its trajectory in the two main take-off techniques ("Sinking" and "Running"), we can see how the support is done farther in the "sinking" technique (a¯b›a'¯b'), while the impulse is more forward in the "running" technique (b¯c›b'¯c')

2.3.- AERIAL PHASE

This phase starts when the impulse leg lifts off the ground. Suspension time and the CG trajectory will be determined by the previous take-off. Movements performed in the air will not be very relevant, however, they will affect the positioning of the body in the landing, so they really influence the actual performance of the jump.

In this phase, the athlete should compensate the rotational forces generated in the take-off, with the limbs action to achieve a better performance of the CG trajectory, and positioning himself in the right position to land.

2.3.1.- AERIAL PHASE CHARACTERISTICS.

Usually the impulse direction of the take-off does not pass through the CG, so rotations happen in the transverse axis of the body. If the jumper would not compensate them with movements, he would go forward, or fall backwards, depending on the take-off. The action of arms and legs move the trunk backwards, and help lifting the legs, making the landing more efficient.

In Figure 14, we can see some parameters of the long jump. According to this image the distance achieved by the take-off corresponds to 86% of the measured jump (the height of the CG from the moment of the take-off until the moment when it comes down again represents this 86%). While the rest, 14%, is what can be gained with the movements of the aerial phase.

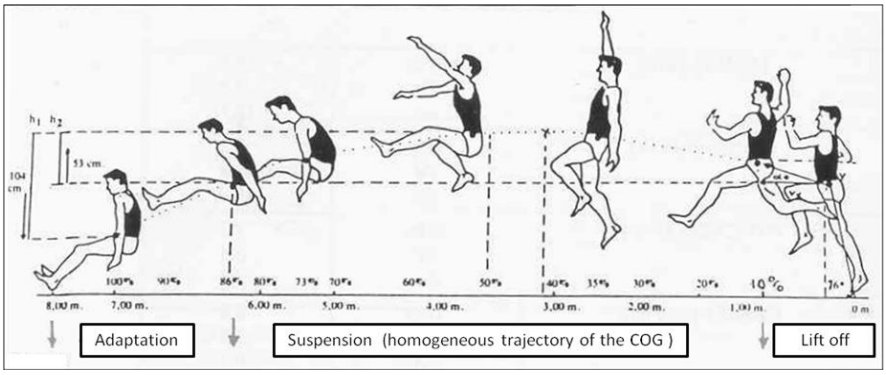


Figure 14.- Theoretical 8 meters jump illustration.

2.3.2.- AERIAL PHASE PARTS.

Seirul-lo (Bravo et al., 1992) divides the aerial phase in three parts (see arrows in Figure 14):

1ª) LIFT OFF: 10% corresponds to the initial flight. The jumper does not move and hold the tandem position acquired in the take-off. Limbs can relax before starting the subsequent movements (extension, one and a half, two and a half, etcetera)

2ª) SUSPENSION: It starts when the jumper begins moving the limbs. In the suspension the maximum height of the CG is reached. The elevation of the CG with respect to the take-off moment can be of 50 cm. The CG translation in this phase is very large, and corresponds to the 76% of the jump's length.

In the suspension phase the jumper's movements can be grouped into three main options:

- ALTERNATIVE "A": NATURAL MOVEMENTS (SAIL). It is a very basic technique, only valid for early stages or for jumpers with a poor technique. After the take-off, the impulse leg joins the free leg, arms go forward and the body is flexed at the hips (see Figure 15).

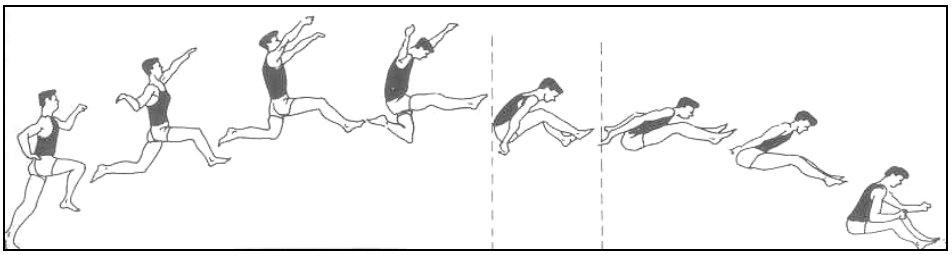


Figure 15.- Alternative "A" for the aerial phase (NATURAL or SAIL).

- ALTERNATIVE "B": HANG TECHNIQUE. Trunk movements dominate over the arms and legs ones. There is a "hip kick" (hip extension) compensated later with a simultaneous action of the arms and legs flexing forward (see Figure 16).

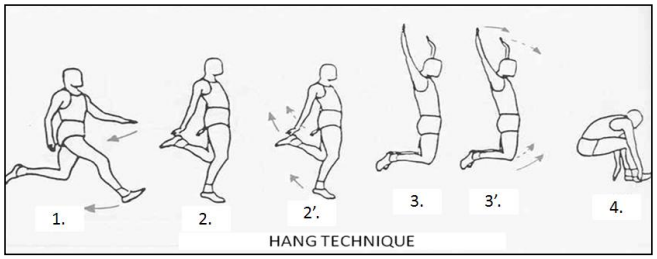


Figure 16.- Alternative "B" for the aerial phase (HANG TECHNIQUE).

- ALTERNATIVE "C": HITCH-KICK. Limbs movements are more important than those of the trunk. Legs perform movements simulating "steps" or "scissors" in the air, while arms perform compensatory movements (usually circular) (see Figure 17). There are variations depending on the number of steps done, like the one and a half, the two and half or the three and a half techniques. The three and a half hitch-kick technique is the one usually chosen by the best athletes nowadays.

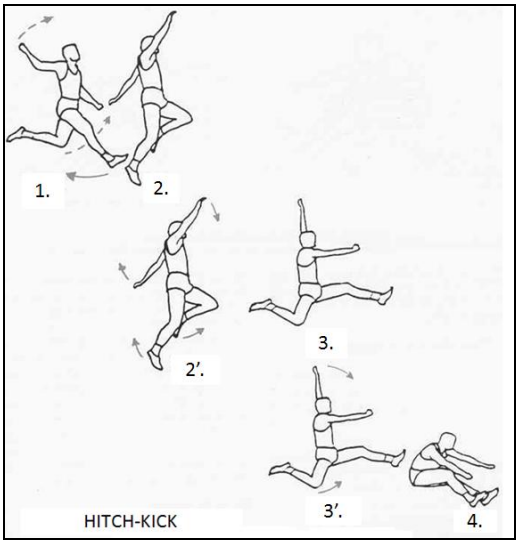


Figure 17.- Alternative "C" for the aerial phase (HITCH-KICK).

3ª) ADAPTATION: Series of movements at the end of the aerial phase, right when the CG goes under the take-off height. The jumper is "bent" and, usually moves the arms from front to back (see Figure 18). The arms move close to the sides of the legs. Throughout history, some great jumpers have changed this technique by putting their hands inside the legs.

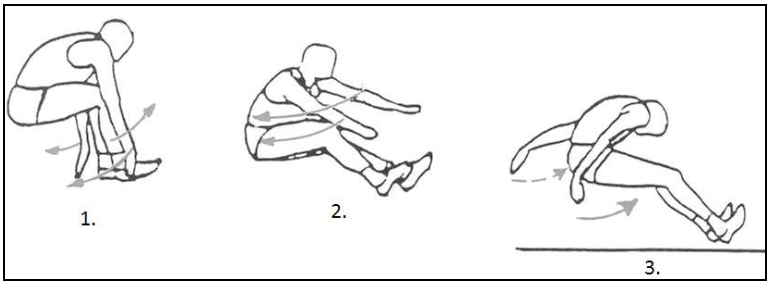


Figure 18.- Adaptation phase actions.

2.4.- LANDING.

When a jumper lands, the actual regulation indicates that the measurement should be done perpendicular to the take-off board, and until the closest contact with the sand pit. In Figure 19, we can appreciate the right way to measure a jump, when the jumper left his right arm behind his feet.

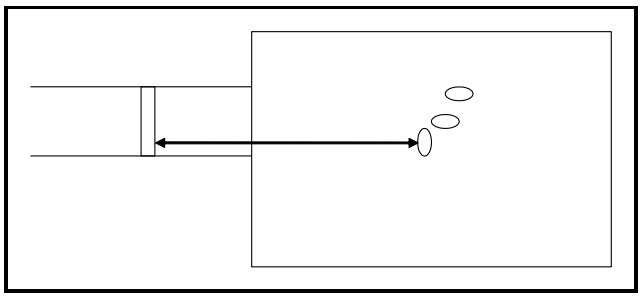


Figure 19.- Right measurement of a long jump.

While landing the jumper should try to contact the pit with the feet as far apart as possible. At the same time, jumpers should cushion to try to avoid injuries, and should try that, after landing the feet (usually the heel), the hips go forward and beyond the feet's support.

The jumper should try to move up and forward the feet as long as possible. The contact with the sand pit should be done simultaneously with both feet. The feet can be together or apart, depending on the landing technique.

If the jumper lands with the feet together, knees should be flexed, allowing the body to overcome the feet's support in one of the sides. Feet should rotate to facilitate the rotation of the whole body.

If the support is done with the feet apart, there are two options:

- The jumper place the hip between them
- The jumper moves the sand and makes a hole to place the hips into it (land on the footprint)

Anyway, once the feet touch the sand, legs should be flexed suddenly trying to move the hip forward, not to "sit" on the sand pit, to avoid losing several centimeters in the measurement of the jump.

Finally we need to remember that to perform a valid jump, we should jump from behind the line of the take-off board, without stepping on the plasticine board attached to it. When the jump is ended, the jumper should leave the sand pit in a balanced way and ahead of the print in the sand.

3.- BIBLIOGRAPHY.

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