MODEL TECHNIQUE ANALYSIS SHEET FOR THE HORIZONTAL JUMPS PART I - THE LONG JUMP

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1.1 The run-up

When developing **“**set values” for techniques in athletic events, the first task must be the identification of the “specific characteristics” of the respective technique. If one compares the long jump run-up, which consists of about 20 to 22 strides, with sprinting, the “techno-motor” differences do not seem to be very significant. At most, variations in three elements could be mentioned:

- The knee lift in the forward swinging phase is normally more marked.
- The subsequent extension of the knee joint and plant of the foot (support on the ball of the foot) should, according to the Soviet philosophy of long jumping (see Ter-Ovanesyan 1966) resemble slipping into slippers. (as an example, the world record holder Galina Chistyakova (URS) obviously tries to realize this “set value”.)
- During the last third of the run-up, many jumpers try to emphasize the stride rate.

A graphic presentation of the minimal deviations, however, does not seem to make sense. This is particularly true if one tries to find stylistic differences in either male or female athletes who compete in both the sprints and the long jump. Consequentially, it would be rather difficult to show these differences in the cases of Carl Lewis (USA), Larry Myricks (USA) or Jackie Joyner-Kersee (USA).

Thus, as far as run-up technique is concerned, the reader may be referred to the Analysis Sheet for “Sprints”. Therefore, if one follows the classical differentiation of the long jump into run-up, take-off, flight and landing, a treatise on long jump technique should begin with the take-off. In fact, this is done in almost all athletics manuals. However, most authors (see Krejor/Popov 1986; Popov 1982; Bauersfeld/Schroeter 1986; Schmolinsky 1980; Jonath et al. 1980) point out a “hardly noticeable” change in rhythm, a lowering of the centre of gravity (CG) and a corresponding change in stride length during the last three approach strides. On the other hand, a graphic presentation of “long jump preparation” is either missing altogether or follows classical sprint behavior to a great extent.

If one considers that, of all the field events, the long jump is the only one where there are considerable differences between the optimal and the actually realized angles of take-off - even with world class athletes these differences often amount to 50% (see Hay 1983, Hay 1981, Nigg et al. 1973 and Balireich 1970) — the necessity and significance of optimizing the take-off becomes obvious.

From the point of view of physics, the (long) jump itself is a "crooked throw". A shot putter, for example, can orientate the pre-acceleration path of the implement's CG toward the optimal angle of release. The flight distance in the long jump is very highly dependent on the horizontal velocity of the run-up, therefore, the long jumper must, first of all, achieve a maximally high horizontal velocity of his or her CG. The next objectives are to combine, at the moment of take-off, a maximally high vertical impulse with a minimal reduction of horizontal velocity, and to preserve the product through optimal flight behavior.

As run-up velocity increases, however, the relative span of time available for the process of redirecting the CG to a diagonally rising trajectory is reduced. Although the time of board contact (approximately 120 ms) is almost identical, the difference between a short run-up (consisting of only five steps with a velocity of about 6 m/sec) and a full run-up (with a velocity of 11 m/sec) is that the CG passes the support point (i.e. the take-off foot on the board) in the latter case with a velocity almost twice as great. Therefore, the technical and conditional requirements of the long jump become more demanding with increasing sprint capacity.

Furthermore, if one considers that the take-off alone is responsible for the quadrupling (!) of the flight distance of a run-up stride of 2.20 to 2.40m — the horizontal velocity and height of the CG remaining nearly identical — the quality of the redirection work which greatly influences the take-off angle becomes apparent. Thus, an abrupt stringing together of run-up and takeoff without transition or a neuromuscular innervation pattern in the take-off phase which resembles the sprint is not very probable.

The peculiarities mentioned, such as change of rhythm, lowering of the CG and change of the stride length, should leave "movement-morphological traces", which means that they should be visible. Observation of the world's best male and female long jumpers, however, seems to contradict this. Even with a closer look, except for a hardly perceivable change of the running rhythm, no considerable deviations from sprinting behavior can be detected. This seems to confirm the statement by Bauersfeld/Schroter (1986) that only "... minimal structural changes" can be seen. Things are completely different if one contrasts "synchronoptically" corresponding phases of the sprint with those of the long jump run-up. It is ideal if this is done with the same athlete (see Figure 1).

The unlimited direct comparison, as far as time is concerned, makes the detection of significant deviations and structural changes possible. Normally, these deviations and changes cannot be seen with the naked eye because of the very short duration of each stride 200 ms) and the very fast and diametrically opposed changes of the joint angle.

Since, in contrast to this, only very small differences — if any — can be detected in the third last stride, “ideal-typical” diagrams and descriptions relating to the relevant phases of long jump technique begin with the penultimate run-up stride.

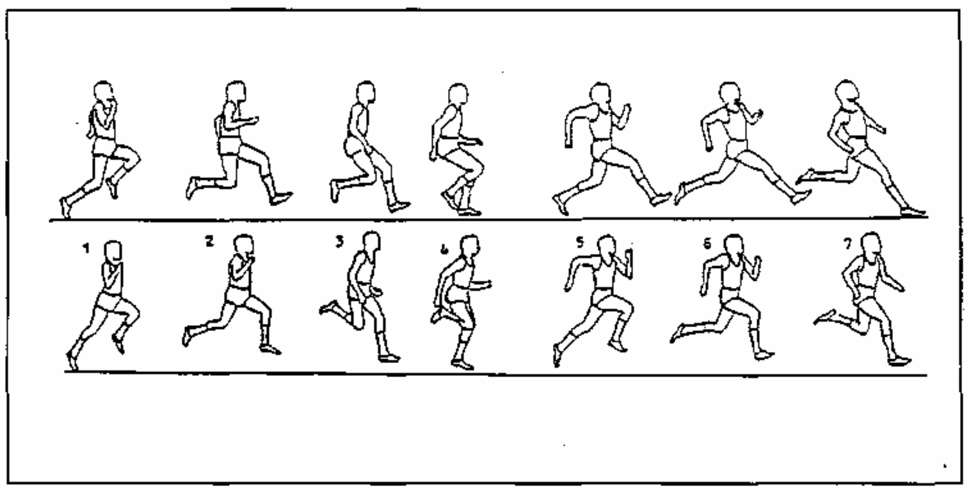


Figure 1: “Synchronoptical” comparison between the last two run-up strides (above) and fourth to last and third to last strides (athlete: Gary Honey, AUS)

1.2 Take-off preparation: the penultimate stride of the run-up

If one considers the movement behavior during the penultimate stride in run-up direction — that is from the left to the right — presented in Figure 2, the following differences from sprinting technique should receive attention or be mentioned:

- In contrast to sprinting, the rear support during the penultimate stride is performed with only an incomplete extension. This conserves energy in the take-off leg and introduces the lowering of the hip and **CG.** The trunk is also straightened.

- During the flight phase of the penultimate stride, which resembles a “floating stride”, the backward swinging phase is shortened by a premature bending of the hip and knee joints. A high heel kick, which is typical of sprinting, has been dropped since the premature flexing of the knee, for example during the horizontal position of the lower leg, is no longer continued.

- The lowering of the pelvis reaches its maximum at the yielding landing of the swing leg. The foot of the swing leg is planted heal first, resulting in a flat foot contact. This behavior, which is known from the straddle as “lowering”, leads to the “swing leg squat”.

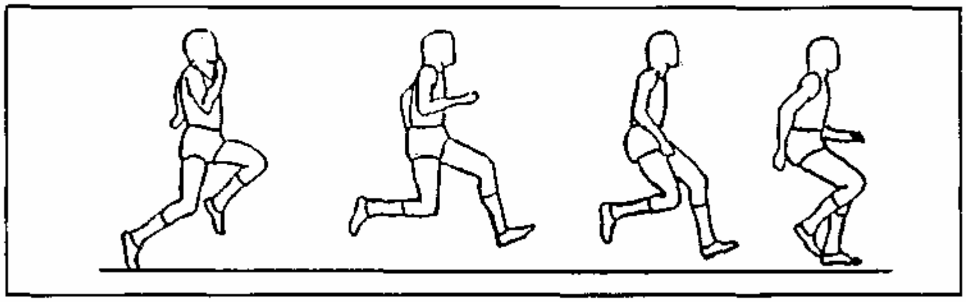


Figure 2: Phase structure of the penultimate run-up stride divided into: (from left to right) rear support, flight form, landing preparation and landing (= swing leg squat)

1.3 Take-off preparation: the last run-up stride

Even the last stride of the run-up, as shown in Figure 3, exhibits some considerable deviations from sprint behavior. The following points of observation are particularly worth mentioning:

- From the swing leg squat (whose main characteristic is the “sitting” on the swing leg while the trunk is straightened) the long jumper, through an incomplete extension of the knee of the swing leg during the support phase, applies a more horizontal impulse leading to a comparatively flat trajectory for the final stride. Since the take-off leg, whose heel is not kicked up at the back, prematurely and actively strides out, i.e. opens, the result are three phase elements which are considerably different from their respective movements in sprinting: the “push-off”, the “flight phase” (with straddled legs) and a slight “backward inclination of the trunk”. The take-off stride could also be called an “uphill step” or a “pawing step”.

- The result of these actions is that the long jumper hits the board with a slight backward inclination of the body. Here, the take-off foot is planted quickly with an active “pawing” motion. The take-off leg is extended, and the pre-tension of the muscles reaches down, even to the sole of the foot. The jumper’s heel makes first contact with the ground, but the front part of the foot is pressed down quickly and actively (see Klimmer 1986). The board contact, whose main characteristics are a marked front support, a slight backward inclination of the trunk and a slight twist towards the side of the takeoff leg, marks the finish of the take-off preparation phase.

- During the two last strides described, the trunk is passive, so that the dynamics of the strides leads to a slight backward inclination. This means that the jumper does not actively lean his body backwards, but his swinging leg presses his pelvis upward and forward, and the take-off leg, which strides out quickly and actively, overtakes the trunk.

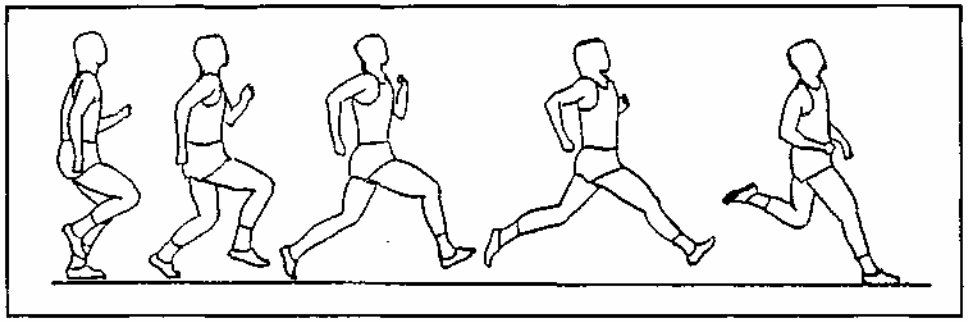


Figure 3: Final preparation for take-off during the last stride, shown from the swing leg squat up to the board contact phase (from left to right)

1.4 Take-off

The take-off is the most essential part of long jump technique. However, the take-off can only be successful if its preparation, as described above, is performed correctly, so that the loss of horizontal velocity is minimized. Correspondingly, the CG should reach its lowest point at the moment the takeoff foot hits the board and when the trunk has a slight backward inclination. (see Nixdorf and Bruggemann 1983)**.** If this is the case, the CG's path of acceleration, which is directed forward and upward, will be as long as possible. Consequentially, the action of redirection, mentioned above, begins immediately after the foot plant. Prerequisite for this are a pre-tension of the take-off leg, from the muscles of the sole of the foot up to the ischiocrural hip extensors, and an actively pawing foot plant.

The subsequent amortization, caused by the pressure of landing, is therefore not an active yielding of the ankle, knee and hip joint, but a passive "compulsive flexing". In other words, at the moment of board contact, the take-off leg functions as an (elastic) lever redirecting the pelvis and the CG to the diagonally ascending path of acceleration (see Figure 4).

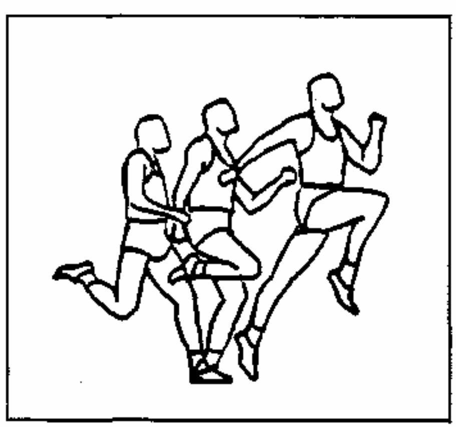
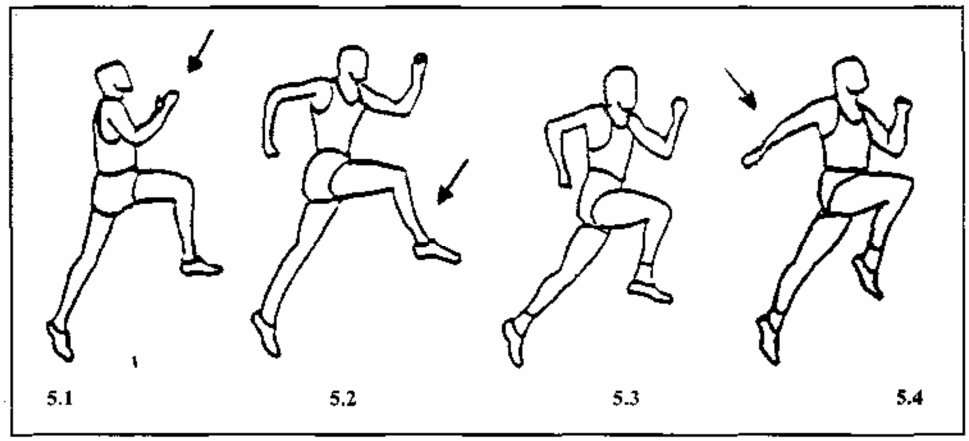


Figure 4: The take-off process (approximately 120 ms) presented in three phases (from left): heal strike, amortization and take-off posture

An explosive extension movement of the joints, which is supported by a synchronous, energetic swinging and a sudden stopping of both the arms and the swing leg for impulse transmission, leads to the “take-off posture”.

The variations observed in analysis of the take-offs of the world’s best long jumpers can be divided into four categories (see Figures *5.1-5.4).*



Figures 5.1; to 5.4: Four variations of the take-off posture.

The first category is characterized by the double arm swing (see Figure 5.1). In the last 30 years, Greg Bell (USA), Irv Roberon (USA), Igor TerOvanesyan (URS) and Robert Emmiyan (URS) have applied this arm swing technique. A direct relation to the hang-style does not exist, even though it would be a sensible anticipation as far as the parallel arm action in the flight phase of this technique is concerned. The effectiveness of the double arm swing itself is beyond doubt. In the high jump, it is a well established part of both the straddle and modern flop techniques. Referring to impulse, which for the long jump take-off should also be primarily vertical, the double arm swing would seem to be logically consistent.

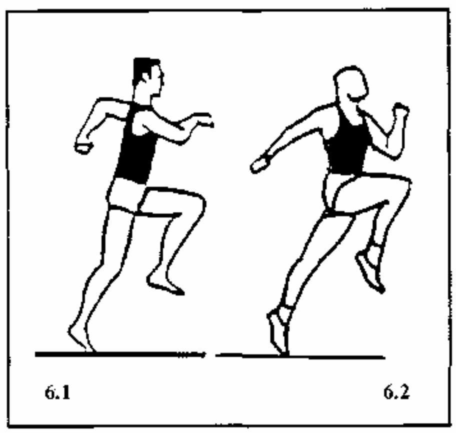
The reason for not choosing the double arm swing as an ideal-typical model is that, from the point of view of co-ordination at highest speed, it is very difficult to switch smoothly from the normal sprint arm action during the cyclic run-up to the double arm swing.

A second category is represented in Figure 5.2. This variation can be seen with all jumpers who apply the hitch-kick technique and anticipate the active forward kick of the lower part of the swing leg at the take-off. The advantages and disadvantages of this dynamic element, which is only possible through a premature release of the knee joint locking, will not be discussed further here. In any case, the take-off posture demonstrated in Figure *5.2* can only be attributed to those jumpers applying the hitch-kick technique.

A third category, the classical “counter arm swing”, is shown in Figure 5.3. As far as flight technique is concerned, this figure is “neutral”. This means that the take-off posture itself does not allow for any conclusions regarding the following movements. Thus, from the point of view of wishing to establish an “ideal-typical set value”, no more fitting drawing could actually have been found.

If one compares Figure *5.3* with Figure *5.4,* however, it should become clear why - in spite of certain reservations (the right arm is not clearly bent) the latter figure is chosen as “ideal- typical”. Although it is generally very difficult to get an impression of “dynamics” from (static) pictures, it should be possible in this case. It may be that this impression of dynamics is caused by the extreme dorsal flexion of the ankle which cannot be shown in the other figures in the same way because of the lack of pictures.

The erect posture of the trunk, (see figure 6.2), the slightly elevated head, the ‘‘high’’ shoulder girdle, the horizontally locked and bent swing leg and the completely extended take-off leg, including the hip joint, are, however, exemplary.



Figures 6.1 and 6.2: Take-off posture (6.1) (see Schmolinsky 1980) and the drawing chosen in direct comparison

The contrast between the take-off posture chosen as ideal-typical and the posture identified by Schmolinsky (1980) as having the corresponding function will possibly help to make clear the aspects of “dynamics” mentioned above.

Strictly speaking, the movement behavior of the right arm, is the running-in-the-air style’s analogy of the swinging arm to the hitch-kick swinging leg. In this case, the athlete also performs an anticipative extension of the arm, which prepares the contra-rotational movement of the arm during the flight phase.

Since the “flight-off” posture was planned to be chosen as ‘flight-neutral”, this phenomenon shows the limits of the generalization aimed at. In order to avoid an unnecessary amount of information, no alternative take-off posture is given here. The same principle will be considered when discussing the landing posture.

1.5 Flight

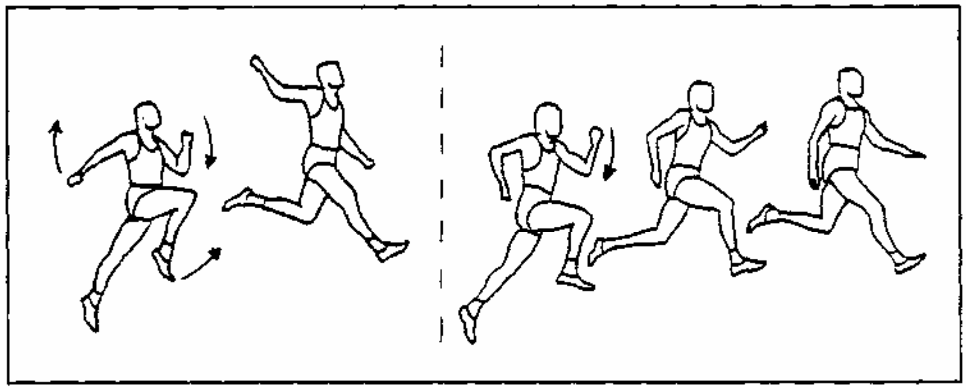
In the following the flight phase behavior for both the running-in-the-air style (without accentuated hitch-kick element) and the hang style are presented graphically and described. Primarily, in order not to over-stress the capacity of a one-page analysis sheet, the 2 1/2 step technique of the running-in-the-air style is chosen instead of the 3 1/2 step variation. (From the point of view of terminology it is interesting that, because of a different way of looking at things, in the English speaking countries one step less is counted in each case). Thus the 3 1/2 step technique, used by Carl Lewis and Larry Myricks becomes the 2 1/2 step running-in-the-air style, and the 2 1/2 step technique presented in the following becomes the 1 1/2 step running-in- the-air style.

The advantages and disadvantages of the individual flight techniques will not be discussed in detail here. The mere fact that both techniques are dealt with is an indication of their relative equality. Although, from the point of view of learning theory, there is a lot to be said for the running-in-the-air style (for example, this style indirectly influences the take-off posture in a positive way and it also allows a better balancing of the forward rotation produced at the take-off), hang style jumpers led, by Robert Emmiyan, are at least equally successful.

Fundamentally, a final assessment of the superiority of the one or the other flight technique does not seem to be possible without corresponding aerodynamic examinations of the accompanying values of air resistance which differ relative to the respective phase. Furthermore, the individually different rotation impulses (produced during take-off) could be an intuitive selection criterion. In other words, the athlete chooses his flight style because of the type of take-off impulses he produces.

When analyzing the flight behavior of the world’s best long jumpers, the number of variations on the basic techniques attracts one’s attention. No other athletic event has a similar wealth of variations. Without being able to discuss details in this text, this variability implies either a relative insignificance of the “flight action” or the current inability of experts to identify a single optimal technique.

In the following, an attempt is made at contrasting quasi “pure-blooded” elements of the running-in-the-air style with those of the hang style. Since the individual figure drawings shown are transition phases which can only be observed for a short period of time, the respective following phases are also presented as an optical aid.



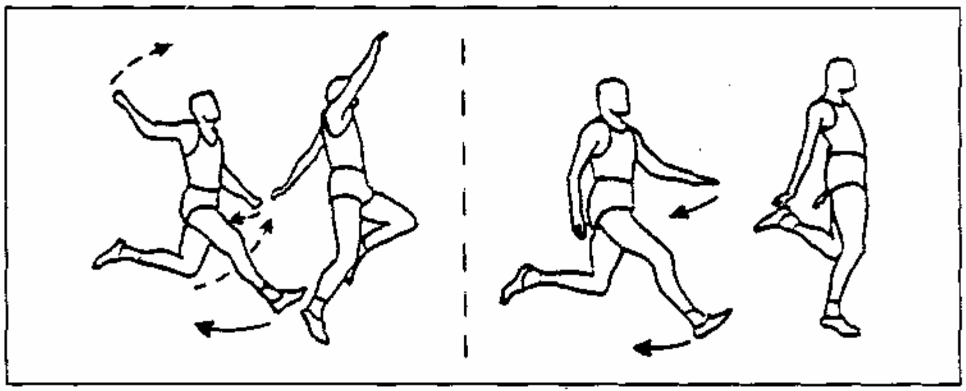
Figures 7 and 8: From the "take-off posture" to the "first step". On the left: running-in-the-air style, on the right: hang style

1.6 "First step"

After the take-off, both hang style and running-in-the-air style jumpers show a release of the take-off posture leading to the so-called "first step". This "first step" is characterized by an opening of the knee joint angle of the swing leg. While, in the case of the hitch-kick, this is done in a thrusting way, this movement is active in the running-in-the-air style and tends to be smoother and more passive in the hang style (unless the hang style jumper also applies the hitch-kick). It must be added here that there are variations of the hang style which show only an incomplete "first step. Due to the fact that the following "hang stage" is anticipated within the take-off posture, these jumpers cannot profit from the important swinging leg action.

The heel of the take-off leg (which is behind the body) is slightly kicked up at the back in a similar action to the backward swinging phase of sprinting. Though the leg posture is very similar, there are great differences as far as the arm action is concerned. In the running-in-the-air style, the arm on the side of the swing leg begins a forward "wind milling" movement. At the same time, the opposite arm performs a forward and downward movement parallel to the swinging leg (which is still in front of the body). Thus, consistent with the image of circling windmill wings, both arms rotate in the same direction, but the leading arm is 180 degrees ahead of the following arm.

In comparison, the arm action in the hang style is quite different (see Figure 8). Since here the jumper must perform a double arm swing, the counter-swinging arm movement realized in the take-off posture must, first of all, be "eliminated". Correspondingly, the opposite arm locked in front and above must be lowered towards the swinging leg. At the same time, the arm on the side of the swinging leg is moved towards the trunk where it virtually "waits'' for the opposite arm.



Figures 9 and 10: From the ''first step'' to the ''swing-leg stance''. On the left: running-in-the-air style, on the right: hang style

1.7 "The swing-leg stance"

It one considers the following figure drawings, which develop smoothly from the ''first step'', it becomes apparent that the jumper, for a very short time, reaches a "one-leg stand'' in the air, the longitudinal axis of the body being vertically aligned. In the running-in-the-air style, this one-leg stand is caused by the active backward movement of the extended, or almost extended, swing leg which is overtaken by the take-off leg as it is brought forward for compensation.

In the running-in-the-air style, this backward movement of the extended swinging leg and the forward movement of the bent take-off leg are very important. This is because the best way to balance the forward rotation mentioned above is by this "apparent" rotation. Thus, the running-in-the-air jumper utilizes the mechanical principle of counteraction: The leg which is actively moved backwards (in the forward sense of rotation) with a relatively high moment of mass inertia causes a corresponding re-action of the trunk. The forward movement of the other leg (in the backward sense of rotation), which is performed with relatively little torque, prevents a neutralization of the effect striven for. Parallel to this, the arms, which are as extended as possible, continue their forward wind-milling action.

In the hang-style, therefore, the "swing-leg stance" is achieved through a passive lowering of the swing leg and not through the use of the hip extension muscles, as is the case in the running-in-the-air style. Since the flexed take-off leg, which is still backward, performs no active forward movement, the lowering brings about a parallel position of the longitudinal axes of the thighs. The arm on the side of the take-off leg, which is simultaneously lowered or moved backwards, now also reaches a position parallel to the "waiting" opposite arm in the "one-leg stand". Thus, during the hang style, the one-leg stand is that phase starting from which legs and arms can be used "jointly" and parallel to one another.

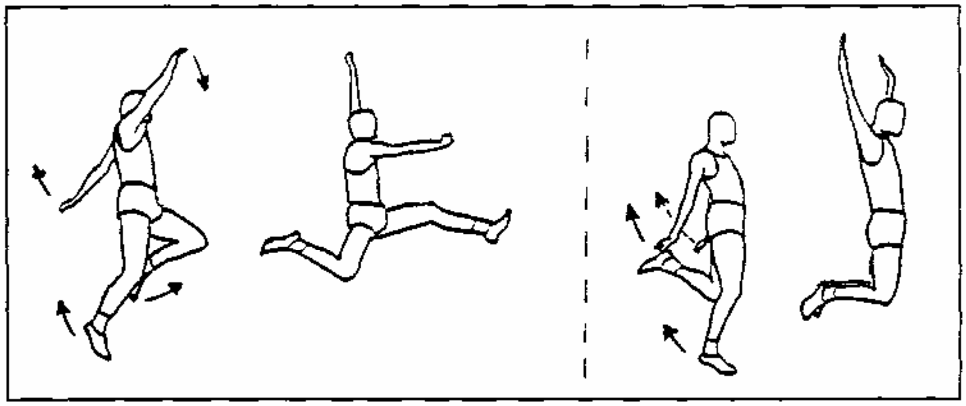
Correspondingly, this action could also be called the “bringing together phase” (in the case of the hang-style) contrary to the “overtaking phase” or “passing phase” in the case of the running-in-the-air style.

1.8 “Second step” and “hang phase”

When, in the running-in-the-air style, the “leading arm” as well as the (opposite) take-off leg, which has been brought forwards and is extended, again have reached an almost horizontal position, they are locked for a very short moment in a parallel position. Here, the 180° angle between the arms is reduced to approximately 90°, so that the “following” arm is directed vertically upwards (figure 11). Since the swinging leg moved backwards — similar to the backward swinging phase in the sprint — is flexed again behind the trunk in order to prepare the subsequent forward movement, the result is a sequence drawing that is very similar to the “hurdle seat”. This drawing is characteristic of the “second step”.

During the hang style, the synchronous and parallel rotation of both arms in the forward sense of rotation which after having reached the vertical position is delayed or even interrupted — a typical “hang-phase” is created, which is responsible for the name of this flight technique. While the arms perform their “double-arm circle”, which is directed backward and upward, the previously extended swing leg is flexed at the knee joint up to an approximately right-angled position. This results in a “knee-stand” in the air (figure 12). All the following leg and arm actions of the hang style are performed parallel and simultaneously.

The “C-like” over-extension of the spine during the hang-phase, which is demanded by some authors and demonstrated by some jumpers, has deliberately not been chosen as “ideal- typical”. Such a hyperlordosation, particularly in the case of very long jumps, would have to be maintained for a rather considerable time, and does not seem to increase performance. Independent of this, such an overextension would reduce again the moment of mass inertia, which is relatively high in the case of an erect trunk. This, however, would contribute to an increase in the angular velocity of the forward rotation around the latitudinal axis.



Figures 11 and 12: From the "swing-leg stance" to the "second step" in the case of the running-in-the-air style (left) and to the "hang phase" in the case of the hang-style

1.9 Landing preparation

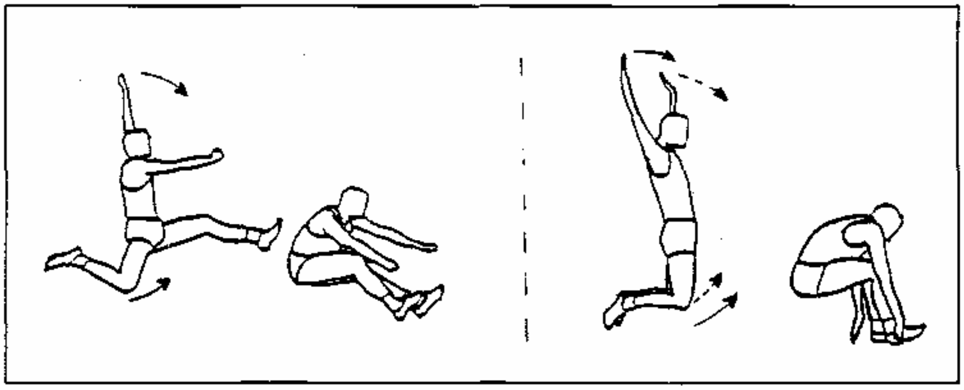
In the descending segment of the flight curve, the "second step" of the running-in-the-air style and the "hang phase" inevitably lead to the preparation for landing. In order to achieve this, in the running-in-the-air style, the rear arm catches up to the leading arm waiting in front of the body in a horizontal position. The flexed swing leg, which has been kept behind, also joins the take-off leg locked in front of the body. The results of these synchronous actions are a parallel position of both the arms and legs and a trunk that is pressed slightly forwards (figure 13).

To minimize landing loss, the legs should be kept approximately horizontal, which means that the feet should be a little higher than the flight curve. From the point of view of forward rotation it is then easier to achieve an optimal "diving into the sand angle" by a slight opening of the hip angle. In any case, the lifting of the already lowered legs or the closing of the hip joint, in order to achieve an identical optimal landing angle against the forward rotation, is disproportionately more difficult.

In the case of the hang style, the jumper forms a "bundle" by actively flexing at the hip joint, actively swinging through (or forward circling) both arms and bending the trunk forward. Here, the knee joints remain flexed. The position achieved during the preparation of landing, therefore, is very similar to the flight phase of the sail style (figure 14).

If one compares the resulting initial positions of both techniques, it becomes clear that, in the case of the running-in-the-air style, only a slight opening of the hip angle is necessary for a so-called "space-gaining" landing, whereas, in the case of the hang style, a relatively wider opening of the hip angle and an extension at the knee joints are needed.

Apart from this, the very different movement behavior of the arms determines what "landing position" is taken at last.



Figures 13 and 14: "Landing preparation", which is developed from the "second step" in the running-in-the-air style or from the "hang-phase".

1.10 Landing

Analogous to the "take-off posture" the type of landing, i.e. the "landing posture" resulting from the above, should also allow no conclusions regarding the flight technique. Analysis of landing behavior reveals (among long jump specialists) four categories of variations. These categories can be differentiated according to the behavior of the arms. Roughly speaking, at the moment of breaking the sand the arms are either parallel in front of the body (see figure 15.4), laterally beside the body (see figure 15.1) or behind the trunk (see figure 15.2). As a fourth variation, some athletes perform the "counter-arm landing" (see figure 15.3).

When considering the advantages and disadvantages of each category, difficulties are caused by the fact that the special literature (see Hoster/Dedier 1973; Ballreich/Kuhlow 1986; Krejor/Popov 1986; Teel 1981) disagrees as to what is the "best" landing posture.

According to biomechanics experts, an "economical landing" (Balireich 1970) is characterized by an optimal compromise between the maximization of the horizontal distance, which means the distance between the first contact of the feet with the sand and the CG, and the minimization of the vertical distance — which is the perpendicular distance between the CG and the sand surface at the analogous moment.

This means that the flight curve should be "utilized" to the greatest possible degree because this automatically results in a deep sinking of the CG. According to this, a landing with the arms held beside the trunk would be optimal. If the arms are held that way, their partial CG's are maximally low (see figure 15.1). The lateral position of the arms, however, means that — in comparison with the "arms- behind-position" — the horizontal distance to the point of breaking the sand is smaller. If this argument is considered, the landing posture favored for example by Carl Lewis, which is characterized by the arms being kept in front of and above the body, must be classified as less economical. In the case of this drawing (see figure 15.4), the horizontal distance between the CG and the point of breaking the sand is relatively the shortest. Furthermore, the sinking depth of the CG is principally reduced compared with the "lateral-arm landing".

Lastly, the counter-arm landing technique is a special case because, normally, this technique introduces or indicates a lateral fall (towards the side of the arm held in front). In this case, in comparison with the "lateral-arm landing", the CG is also significantly further above, which again results in a reduced falling depth on the descent of the flight curve.

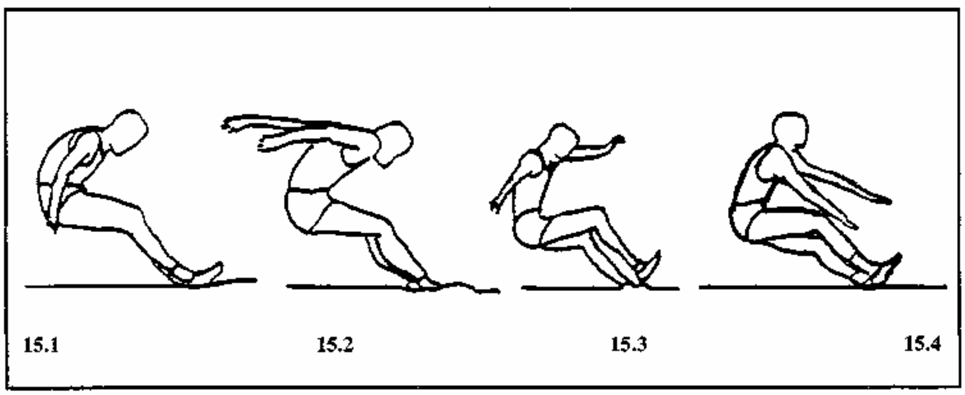


Figure 15

From this follows a relative equality of the landing postures with the arms kept beside or behind the trunk — unless one thinks that a lateral landing is principally more effective. The fact that the landing posture with the arm kept behind the trunk has been integrated into the "analysis sheet" which is a kind of synopsis of the details and criteria mentioned, has possibly been caused by a subjective preference.

However, it should not be overlooked that arms that are swung far backward have two advantages which have as yet not been mentioned: First, this counteracts a forward rotation that would increase the loss on landing until the last moment; second, an energetic, active and high amplitude forward swing of the arms at the moment the feet contact the sand can prevent the jumper from falling backwards (see figure 16 on the following page).

The following "Analysis Sheet - Long Jump" is an attempt at summing up the technique models and the attributed phase characteristics together with the individual points of observation and the corresponding criteria of evaluation for both the running-in-the-air style and hang style. Since only a single page is available for this, everything appears closely- packed, and some aspects could not be included. In spite of this, the remaining number of details is so high that the following procedures are recommended when using this analysis sheet:

1. Full consideration within the cognitive learning phases in order to acquire the “static”, “set value”, the phase structure, the specific terminology and the evaluation criteria.

2. Fault-centered, i.e. selective, identification and evaluation of individual items in technique training without the support of video or other monitoring systems.

3. Complete, successive assessment of the given points of observation during the video supported slow motion and single picture analysis. Here, primarily the respective (phase-adequate) degree of approaching the required optical values is checked.

In order to take into account the aspect of dynamics, within the flight phase of the running-in-the-air style (indicated on the analysis sheet by R.A.) and hang style (H.S.) the drawings subsequent to the positions being described have also been presented (in black). However, in each case, the points of observation and evaluation criteria refer to the white drawing. If the continuous tense is used (for example “opening”) then the black drawing, showing the end result of the process, is included. In order to avoid the “left-right-problem”, the terms “leading or front leg/arm” and “following or rear arm/leg” have been used.

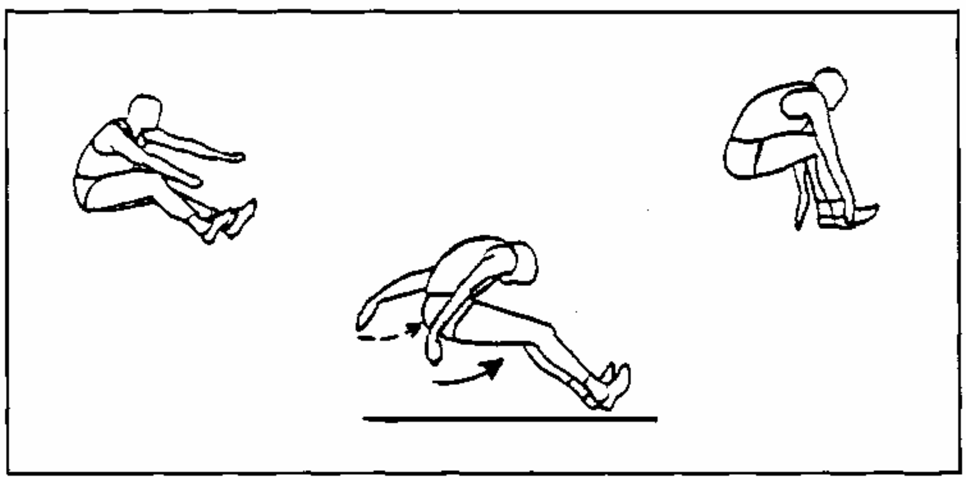
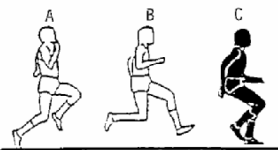
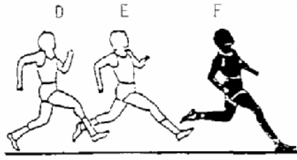
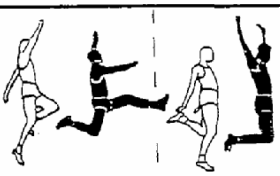
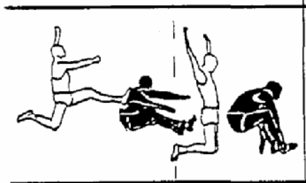
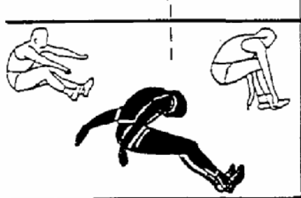


Figure 16: From the ‘‘preparation of landing’’ (left: running-in-the-air style, right: hang style) to the ‘‘landing posture’’

ANALYSIS SHEET OF THE LONG JUMP

LONG JUMP	PHASE	REFERENCE	CRITERION ASSESSMENT +/0/-
	APPROACH: Penultimate stride	A1 rear support 2 trunk B3 front leg B4 backward swing C5 support leg	incomplete knee extension upright heel lead reduced/constant knee angle B⟶C flat foot contact/yielding
	APPROACH: Last stride	D6 rear support D7 front leg E8 legs F9 support leg F10 trunk	horizontal push knee angle opening straddled/front leg: pawing pre-tension & extended at heel strike slight backward lean/slight twist
	TAKE-OFF POSTURE	11 take-off leg 12 swinging leg 13 trunk 14 shoulders 15 arms	complete extension (hip/knee/ankle) horizontal locking/bent upright lifted counter-arm swing/ locked
	FIRST STRIDE	16 swinging leg 17 take-off leg 18 arms	RA: backward drive/extended/active HS: lowering/passive RA: active bending/forward swing HS: relaxed bending/relaxed catching up RA: windmilling clockwise/counterbalance HS: front arm loweing/other arm: waiting
	SWINGING LEG STANCE	19 swinging leg 20 take-off leg 21 arms	RA: vertical/extended/backward swing HS: vertical position/knee: bending RA: passing/bent forward movement HS: 'waiting'/stationary/bent RA: continuing rotation HS: starting upward and forward rotation
	R.i.A.: SECOND STRIDE H.S.: HANG PHASE	22 front leg 23 rear leg 24 arms	RA: held in horizontal position HS: 'kneeling' (take-off leg) RA: behind trunk/bent forward movement HS: 'kneeling' (swinging leg) RA: 3 o'clock position/front arm waiting HS: hanging position/straight
	(PREPARATION OF) LANDING	25 arms 26 legs 27 trunk 28 arms 29 feet/legs	parallel to shanks parallel/HS: knee angle opening bent forward well behind trunk parallel/well ahead of CG

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