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Model technique analysis sheets for the hurdles Part VII: high hurdles

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Translated from the original German by Jürgen Schiffer

7.1 Introduction

The fact that the height of the hurdles and the hurdle spacings have not been changed for 130 years tends to imply that the 110 metres Hurdles sprint has remained a 'compulsion' run (Misangy, 1956). Therefore the athlete who is best able to adapt himself to the 'set conditions', or who already fulfils the necessary requirements 'by nature', will be most successful in the event.

The hurdles race can be roughly divided into the following sections: start section or approach run; clearance stride(s) (including take-off, flight and landing phases); run between hurdles and run-in.

7.2 Approach to the first hurdle

The approach to the first hurdle is of decisive importance. This is due primarily to the fact that, if one allows 2.10 - 2.20m for the distance between the take-off spot and the first hurdle, the athlete is left with only about 11.50-11.60m in which to accelerate to the optimal take-off point. A limited acceleration distance applies to the whole race. Therefore, in order to attack the other 9 hurdles at the highest possible speed, a similar precision of approach behaviour must be the goal.

The speed curve in the 100 metres sprint (see Figure 1 on page 53) makes the very problematic nature of this constancy of stride pattern obvious: whereas world-class sprinters can increase or vary their stride rate and length freely over the whole distance, the hurdler's strides are 'standardized' with regard to their length. He can therefore only continue his positive acceleration from the first hurdle onwards by increasing his stride rate.

If the athlete chooses the 'normal' eight-stride approach to the first hurdle it is, strictly speaking, only the first seven strides which are 'unstandardized'. The 8th stride is used for the immediate take-off preparation and is always shortened by 10-15 cm as compared with the 7th stride.

Before dealing in detail with the reason for this shortening of the 8th stride, we must briefly reconsider the subject of acceleration in the approach run. This problem is clearly demonstrated if one records the stride pattern and the corresponding 'distance requirements' for eight strides from the crouch start without hurdles (Gralka, 1962; McInnis, 1982; Tidow, 1982). Compared with the eight-stride hurdle start the differences in distance covered are 1.93m (Gralka), 1.76m (Tidow) and 1.11m (McInnis). McInnis conducted the same experiment with women hurdlers. Whereas the women sprinters showed shorter strides in the 'flat sprint', a reverse tendency was observed in the men. Consequently Gralka draws the conclusion that it is only those high hurdlers who come as close as possible to the pre-set 11.50-11.60m distance from the 'natural start' in the flat sprint who have prospects of success.

Although such considerations are certainly useful for future specialists, they are not very helpful for decathletes. Regardless of the fact that there are 'adaptation reserves' if the athlete changes to a seven-stride approach, as could happen in the case of particularly great 'plus' differences in the flat sprint, or if he chooses a different starting block position or start pattern (for example the front foot breaking contact first), the main difficulty for all athletes is that the stride pattern must always be orientated to the optimal hitting of the ten take-off points. This principle must be adhered to as much as possible regardless of the athlete's velocity.

Correspondingly, the hurdler should always make allowances for possible variations in daily form, changing weather conditions (for example the presence or absence of wind) and rates of acceleration (to the 1st hurdle as well as within the following nine rhythmic units).

Therefore one cannot agree with the opinion that the hurdler should adapt his velocity to the distance between the hurdles (Gambetta and Hill, 1981). It might rather be the case that the ability to regulate the stride rate, i.e. frequency variation, while maintaining a consistent stride pattern is the real key to success.

The term 'frequency variation' is used here because in the 110 metres Hurdles the positive acceleration achieved in the approach can be continued at best only to the 5th hurdle (Susanka et al., 1988; Letzelter, 1977; Artyschenko, 1977). From then on - depending on the athlete's physical and motor preparation - there is a more or less pronounced reduction in velocity up to the 10th hurdle.

However, the velocity curve described here is only partially valid for the top world-class specialists (13.40 sec.). If one considers the characteristic curve of a 13.20 sec. run as presented in Figure 1, it becomes obvious that the reduction in time within the first five rhythmic units is only 40 ms (from the 1st to the 2nd unit). Then a plateau follows which is characterized by a constant and maximum velocity (3rd to 5th unit). This is followed by a very slight velocity reduction up to the 9th and final unit, which takes only 50 ms more than the fastest unit. Such a high consistency could be seen in all medallists at the II World Championships in Athletics in Rome, 1987 (Susanka et al.) and was also shown by Milburn, the 1972 Olympic champion (Letzelter, 1977). Such small time variations could certainly not be measured using manual time-keeping methods.

However, for all hurdlers of less than elite international level - for example decathletes of the 14.50 to 15.50 sec. performance level - the negative acceleration section begins at the 1st or 2nd hurdle, and its path is much more pronounced (Letzelter, 1977; Schmolinsky, 1959).

This demonstrates the essential importance of the start section and the velocity already achieved up to the take-off for the 1st hurdle.

On comparing the starting techniques used for the flat sprint with that used for the sprint hurdle events, it is clear, ignoring variations between individuals, that there is a fairly close 'starting angle' (the angle between the longitudinal axis of the body and the ground) right up to the 4th-5th stride. This is almost identical with that shown in a flat race. Then the hurdler's angle opens out, thus tending to reduce the possible rate of acceleration. Considering the importance of this section of the race, this would appear to be a matter of some concern.

The main reason for the early release of the sprint-specific forward lean of the

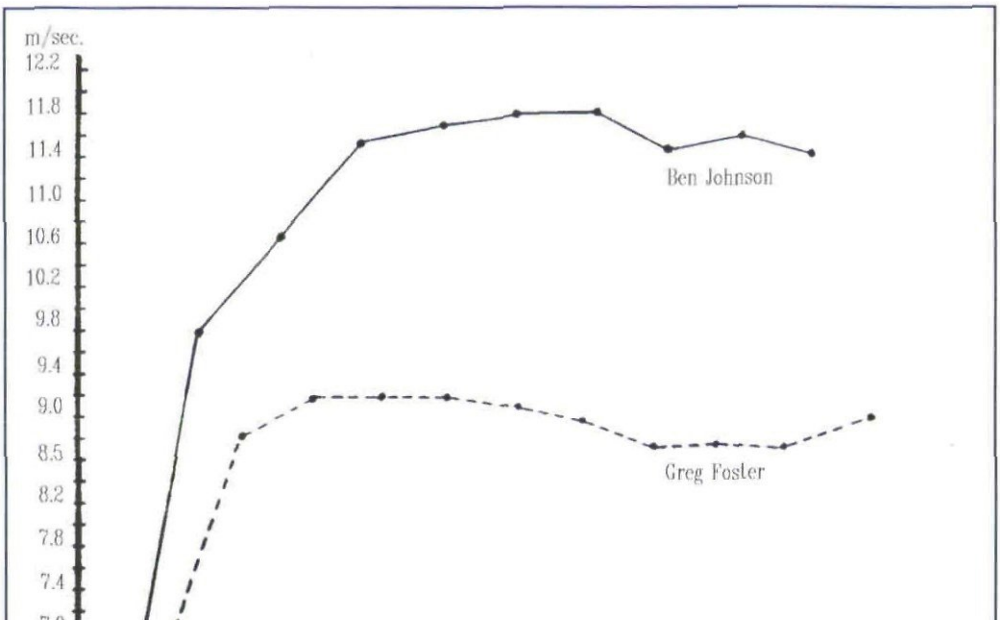

Figure 1: Velocity curves of the 1987 world champions over 100 metres (Ben Johnson, CAN) and 110 metres Hurdles (Greg Foster, USA). The mean velocity for each section of the race has been calculated on the basis of the intermediate times published by Susanka (110 metres Hurdles) and Moravec et al. (100 metres).

body is that the centre of gravity must be brought to a maximally high 'launching level'. Correspondingly, only a slight vertical impulse is needed. Thus the displacement of the horizontally-accelerated centre of gravity over the hurdle can be minimized. As this straightening of the body must not take place too abruptly, which means not within one or two strides, it should begin early in the race. However, it would certainly be possible to use the 6th to 8th stride for this.

Such a late opening of the body can however be observed only very rarely, because the ability to vary the stride pattern mentioned above depends very much on visual information. As visual behaviour and head movements are closely connected, the focusing of one's eyes on the hurdle influences the position of one's head and thus the trunk position and the starting angle. Nevertheless, a later visual focusing on the obstacle could be postulated. If one considers that the perception process and particularly its translation into motor signals also takes time, and that furthermore the clearance stride itself cannot be used as a movement segment for corrections, a straightening of the body is only possible between the 4th and 5th stride. Gambetta and Hill (1981) even demand that the adjustment be already made between the 4th to 6th stride, and that the first three and last two strides should remain 'constant'. (If one followed this idea, the visual contact with the 1st obstacle should be made even sooner, i.e. at the moment of starting out of the blocks.)

The necessity even for specialists to have available visual information during the hurdles event, despite standardized conditions, as are to be found in indoor stadia, can be demonstrated by the following experiment. The subjects were blindfolded and thus prevented from looking at the obstacles. All broke off the race at the second hurdle or cleared it with a 'safety jump'. Without visual feedback, none of the athletes managed to perform even highly automatized movements without disturbance (Schnell, 1982).

A further aspect, which is an additional reason for the premature straightening of the body in the starting section, is that a pronounced forward lean of the body, typical of the flat sprint, would impair the movement of the lead leg directly in front of the hurdle. This will be dealt with in detail in the next section. Finally attention should be drawn to the fact that an acute starting angle would also have a negative influence on the curve of the centre of gravity during the clearance stride. Given the conditions of the event, the desired shift of the centre of gravity, which should be in a direction as nearly parallel to the ground as possible, would be unattainable with such a forward lean of the body.

It must, however, be mentioned that, during hurdle clearance, this minimal lift of the centre of gravity, which can be called optimal, is also dependent on body height and leg length. Thus the data published by Mero and Luhtanen (1986), according to which the centre of gravity curve of Foster in the I World Championships in Athletics, 1983 was rather flat during hurdle clearance and only 20 cm above the hurdle at its peak point, can certainly not be achieved by shorter athletes. Corresponding studies (Dick, 1982; Lewis, 1981; Pereversjov et al., 1984; Michno, 1983) clearly emphasize that a relatively large body height is required: only one of the hurdlers with times in the world's top 50 all-time performance list is below 1.80m tall. The range is between 1.78 and 1.94m, and the mean value is 1.87m (Michno, 1983).

Keeping in mind all that has been said so far and that, during the hurdle clearance stride itself, positive acceleration is not possible, the task set in the 110 metres Hurdles event can be optimally solved as follows:

- maximal acceleration up to the 1st hurdle with visual control from the 5th stride onwards;

- continuation of the increase in velocity over as many rhythmic units as possible;
- hitting of the optimal take-off point for each hurdle;
- vertical orientation of the longitudinal axis of the body at the 8th stride or in front of the barriers;
- minimization of the vertical velocity during take-off;
- early ground contact after hurdle clearance in a well-balanced sprinting posture.

7.3 Clearance stride

The most important segment of the hurdle technique, the clearance stride, can be roughly divided into three movement phases: take-off, flight and landing.

7.3.1 Take-off phase

As mentioned above, it is essential for an optimal clearance of the hurdle that the runner 'make himself tall'. In English-speaking countries this is generally called 'running tall' (Bush, 1985). Apart from releasing the sprint-like forward lean of the body it is therefore absolutely necessary to run on the balls of one's feet and prevent the centre of gravity from sinking during the support contact.

This requirement is fulfilled by the world's best hurdlers. A detailed analysis of the leading specialists' take-off shows either a constant height of the centre of gravity or a lowering of only one centimetre (Mero and Luhtanen, 1986). The calf muscles, which are excentrically loaded during the front support phase, here reach the limit of their performance ability. This is indicated by the behaviour of the ankle joint which yields passively in spite of the fact that it is locked. If one considers the dynamics of take-off, which takes place between 99 and 135 ms (Willimczik, 1972; Artyshenko, 1977; Ward and India, 1982; Mero and Luhtanen, 1986) and results in a 'jump' of approximately 3.50m in length, it becomes clear that the heel of the support leg comes close to the ground. However, a complete locking of the corresponding ankle would not be sensible, since this would reduce the movement amplitude for the final active plantar flexion.

The contact with only the ball of the foot can therefore be identified as an essential technical criterion of the take-off phase. This movement behaviour also guarantees that the take-off leg cannot be used as an effective lever and that there is hardly any braking effect with a corresponding reduction in horizontal velocity. The key to a correct execution of take-off, without heel contact, is to shorten the front support phase by a quick placement of the take-off foot as well as an almost vertical alignment of the lower leg (see Figure 2). Jones (1964) over-emphasizes this process by postulating that one should shorten the last stride in front of the hurdle so that the centre of gravity is in front of the take-off foot. Biomechanical studies show that in reality the hurdle is never attacked without front support. Researchers agree, however, that there is a negative relationship between performance and the horizontal distance between the centre of gravity and the support foot. This means that with an increase in performance level the centre of gravity gets closer to the support point. For world-class athletes, for example, distances of as little as 20 cm were measured (Mero and Luhtanen, 1986). These findings are supported by research results concerning the duration of the braking and the acceleration impulses as reported by Willimiczik (1972). According to these results, performance deteriorates as the time of the front support is lengthened.

Thus a low clearance of the hurdle without an unnecessary loss of horizontal velocity is possible if, during the take-off preparation, the trunk is straightened and the behaviour of the support leg is correct. Within the medium support and rear support movement phases, a corresponding shifting of the lead leg, the arms and the trunk must be performed simultaneously.

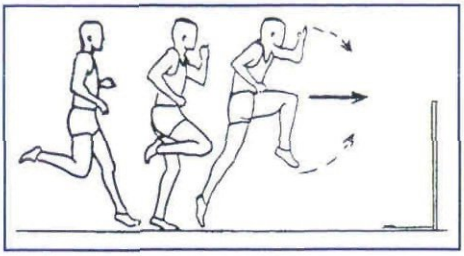

Figure 2: Take-off preparation and opposite arm movement behaviour

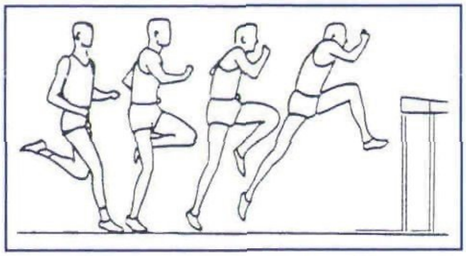

Figure 3: Take-off phase and take-off form with 'knee lead' and shift of body weight

As can be seen in Figure 3, the 'back-flipped' lead leg (led by the knee) and the opposite arm are actively swung forward and subsequently extended horizontally in time with this shifting movement. The terms fling out or stab, which are used in this context (see analysis sheet) stress the dynamics of the behaviour of the lower leg and the movement of the opposite arm. It is important that the lead leg is brought forward fast and in a straight line. This is best done if the movement is led by the knee. This means that the action of the lead leg is prepared by a back-flipped lower leg. Thus the knee, which is actively swung forwards and upwards as precisely as possible in the standard running direction with a reduced moment of inertia, leads this movement. The criterion 'back-flipped' is also important because the lower leg can only execute a dynamic flinging movement towards the front - i.e. in the direction of the top bar of the hurdle - if beforehand it is kept back.

Of course the trunk also takes part in this active forwards movement. The trunk is actively pressed forwards while the spine is kept straight and the athlete's gaze is directed along a line parallel to the ground. One could assume that the trunk follows the actions of the opposite arm and the shank of the lead leg. On closer observation, however, one realizes that the shift of weight directed to the top rail of the hurdle first causes a tilting of the whole body. Here the toe of the actively plantar-flexed take-off foot is the turning point. The synchronous extension of both the elbow joint of the opposite arm and the knee joint of the lead leg, as well as the 'dipping' or active pushing of the trunk towards the front and on to the hurdle begin at the moment of take-off. This process is also called hurdle attack.

Here it is very important that the shoulder axis does not follow the stabbing movement of the leading arm but is rather constantly held square to the running direction. Thus a rotational movement of the trunk is avoided, which makes it easier to maintain balance during the hurdle clearance and landing.

Even amongst world-class athletes, the technique of this process, which is called folding up (Hommel and Keydel, 1975), is not standardized. This might, amongst other things, be caused by the anthropometrically predetermined take-off height of the centre of gravity, which is different in every athlete. In any case, a further shift of the trunk to the front, after contact with the ground is broken, makes the following movement of the trail leg easier and enables the athlete to *choose* a flat path of flight when clearing the hurdle. This is because, after take-off, an optimal positioning of mass elements (here the shifting of the trunk forwards and downwards) brings about a 'reactive' lifting of the rest of the body (here the lead leg, as well as the pelvis), although the path of the centre of gravity cannot be influenced at all. It is thus possible to achieve a relatively flat flight over the hurdle, without the lead leg or the buttocks contacting the hurdle.

A further advantage of this trunk lean is that a 'straightening reserve' is available which can be utilized during the landing preparation in order to support the fast landing of the lead leg.

It should be mentioned, in this context, that the primarily horizontally-directed shifting work, which has already taken place during the take-off phase, could additionally bring about a slight forward rotational impulse about the transversal axis of the body (Nett, 1966). This would apply if, as postulated, the resulting line of thrust really ran slightly behind the centre of gravity. According to the principle of the conservation of momentum, such a rotational movement would overlap the whole flight action and cause a faster landing of the lead leg with the flight curve remaining identical. Furthermore, the reactive straightening effect of the trunk which is triggered by the action of the lead leg would be minimized in this way. The result would then be the desired slight forward lean of the trunk in the landing phase, which would enable the athlete to continue his sprint without pause. This aspect of an assumed forwards rotation about the transverse axis, which is mentioned here as a hypothesis, will be dealt with again in the framework of the landing preparation phase.

7.3.2 Flight phase

When trying to structure the supportless movement segment of the clearance stride, it is useful to divide it into three parts. As regards the hurdle, one could speak of a flight towards the top rail, clearance and landing preparation. The phase of flight towards the top rail begins when the take-off foot breaks contact with the ground, and ends when either the toe or the heel of the lead foot, depending on foot posture, reaches the top rail of the hurdle (in the vertical plane). The clearance phase lasts from this moment until the trail foot has crossed the hurdle.

The clearance phase leads into the landing preparation phase, which ends when the lead foot contacts the ground. (Ward and India published a similar structural approach in 1982, characterized by the respective knee being used as a criterion for differentiation.)

If one realizes that the complete clearance stride lasts for only 280-359 ms (Artyschenko, 1977; Mero and Luhtanen, 1986; Schlüter, 1981; Susanka et al., 1988; Willimczik, 1972), it does not seem sensible from the point of view of perception psychology to subdivide these three phases again, either linguistically or graphically. Correspondingly, for the presentation of the segments of the flight phase, three figurations, which are typical and immediately interlink with each other, are chosen and linguistically labelled.

7.3.2.1 Flight: splitting phase

As shown in Figure 4, the hurdler assumes a split position at the end of the flight towards the hurdle. By doing so, the prerequisites for a flat and collision-free sprint across the barrier are observed. The opposite arm and the lead leg are parallel and, to a large extent, horizontally directed. The upper body is pressed forwards, while the take-off leg is clearly left behind.

A criterion of this delayed bringing forward of the trail leg is that, during this phase, the knee of this leg is still held behind the hip joint on the same side. It is obvious that assuming the split position makes high demands on the flexibility of various joints.

The 'leaving behind' of the take-off leg is important because, on the one hand, it ensures at least indirectly an active and flat

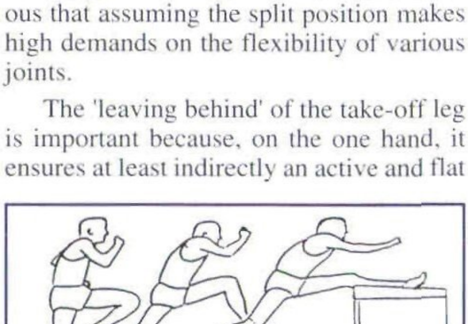

Figure 4: From the take-off to the splitting phase

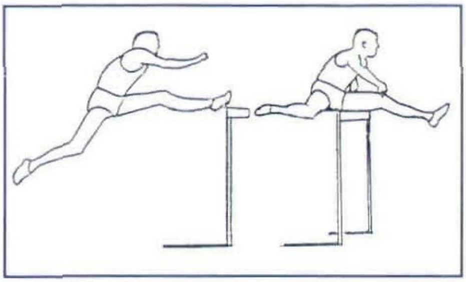

Figure 5: From the splitting phase to the hurdle sitting phase

take-off, and, on the other, it creates the best conditions for the fast and smooth bringing forwards of the take-off leg in the subsequent clearing phase.

7.3.2.2 Flight: clearance phase

As the peak point of the flight parabola is *in front* of the barrier, if the segments of the clearance stride are organized in an optimal way (Mero and Luhtanen, 1986), an active abduction of the trail leg up to the horizontal is indispensable for clearance of the hurdle without contact with the top rail. By a simultaneous external rotation of the foot the toe of this foot is also moved out of the danger area. To reduce the moment of inertia of the take-off leg, it is brought forwards from the split phase in a flexed position and is simultaneously lifted towards the side. This movement behaviour results in a figuration resembling the gymnastic element 'hurdle sitting' (see Figure 5).

However, at closer sight it becomes clear that here the extended (or at least almost extended) lead leg is already directed slightly downwards. This is the first indication of the action which immediately follows the clearance of the hurdle.

The arm on the side of the lead leg can only be seen at this moment (between the thigh of the lead leg and the trunk) because, until then, the trunk blocked it from sight. This variation of arm behaviour, which is also called '1-and-a-half lead arm technique' (Miller, 1982), has meanwhile gained dominance over the 'opposite arm lead' or the 'double arm lead' of earlier times. The 1-and-a-half lead arm technique can be regarded as the optimal compromise between the shifting work which must be done in the take-off phase and the technique-determining aim of disturbing the natural smoothness of the sprinting style as little as possible.

As far as the arm shift is concerned, the opposite arm technique is neutral. The double-arm shift technique, however, anticipates a position of the arm on the side of the lead leg which actually should be demonstrated only during the landing preparation. So it is not possible, after the double arm lead, to bring forwards the arm on the side of the lead leg simultaneously with the opposite trail leg, since this arm is already at the front when the take-off position is assumed (see Figure 6).

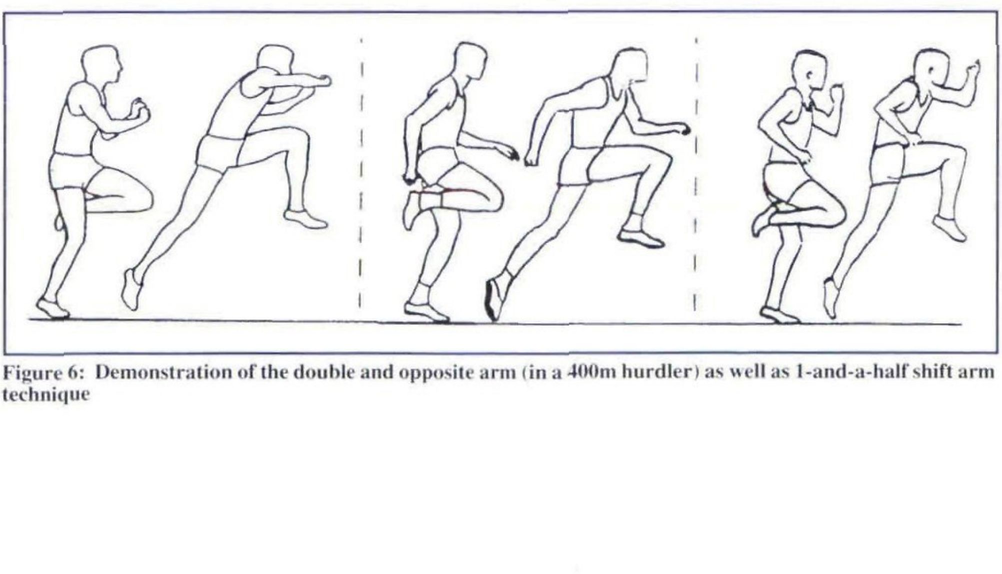

Figure 6: Demonstration of the double and opposite arm (in a 400m hurdler) as well as 1-and-a-half shift arm technique

7.3.2.3 Flight: landing preparation

The hurdle sitting position which is assumed only for a very short period or, better expressed, dynamically, leads smoothly into the landing preparation. The main characteristic of this movement phase is the opposed movement behaviour of the trail and lead leg. While the trail leg is still flexed, executing a forwards and upwards movement, the lead leg is extended and actively pressed downwards. The longitudinal axes of the thighs of both legs thus show an opening scissors movement. This leg action is overlapped by opposed arm movements taking place synchronously. While the arm on the side of the trail leg continues its compensating, almost horizontal backwards movement, the other arm is brought forward together with the trail leg.

It is remarkable that the trunk maintains its slight forward lean. This is not self-evident, because the action of the lead leg should cause an upwards movement of the rest of the body. The fact that this does not take place, or at least cannot be observed, is caused on the one hand by the upwards movement of the trail leg, and on the other by the forwards rotation about the transverse axis which has been postulated for the take-off. Although the trunk is straightened by way of compensation, since the flexed take-off leg cannot compensate for the whole counter-movement, this rotation overlaps the whole flight phase and conceals the straightening effect which might be expected.

It should also be noted in this context that the dynamic lead-leg action, which has been described and recommended above as the ideal model, is interpreted in a completely different way by other authors. For example, Wilt (1981), Costello (1984) and Gambetta and Hill (1981) are of the opinion that the lead leg should not be snapped down actively, but that the upwards-directed trail-leg action and the straightening of the trunk themselves lead to a fast ground contact. In this respect, Miller (1982) holds the middle ground, recommending an active 'standing up' which automatically leads to the desired effect of an immediate landing.

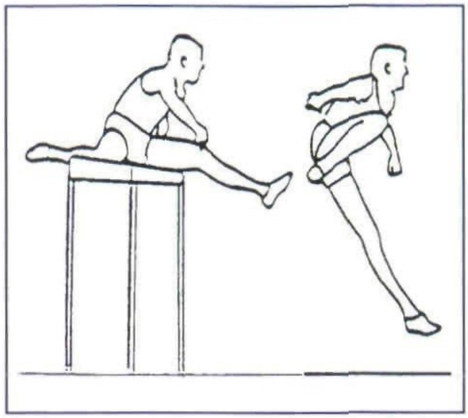

Figure 7: From the hurdle-sitting phase to the landing preparation

However, most authors favour an active downwards movement. An individually varying degree of forward lean of the trunk may possibly also be responsible for these contradictory standpoints. Those authors who interpret the lead leg movement as being 'reactive' recommend an accentuated forward lean of the trunk. During the landing preparation, this lean must be released in a natural way. Correspondingly, it is at least optically very difficult to differentiate precisely between cause and effect.

In any case, the 'leading leg reaction thesis' cannot be maintained if the athlete, in spite of only a moderate forward lean, is still able to perform an optimally fast grounding of his leg. This, for example, was demonstrated by the 1976 Olympic champion Guy Drut (FRA), who even maintained this moderate forward lean in the landing preparation. This does not exclude a combination of active and trunk-induced reactive lowering of the lead leg, which would certainly be the quickest variant.

7.3.3 Landing phase

The active pressing down of the lead leg is additionally supported by the demand that this leg, as is generally accepted, should be grounded in an extended and vertical posture. The corresponding point of contact is normally 1.30-1.40m behind the hurdle, and must be as close as possible to the normal line of the running direction. This pre-set direction guarantees that the complete movement of the lead leg is executed in the vertical plane, as is already implied by the term 'knee-lead' within the take-off phase.

Even in the further course of the support phase, the lead leg must not yield to the landing pressure to which it is submitted after the completion of the 3.50m clearance stride. As a result, there is no visible amortization, either in the knee joint or in the locked ankle joint, which means that the heel does not contact the ground. Consequently, a positive acceleration can only be achieved by using the hip extensors, i.e. the ichiocrural and the gluteus maximus muscle, in synergy.

However, the activation of these kinetors with the establishment of lead leg contact would not alone permit a smooth movement. For this reason, the active pressing down of the extended and pretensioned lead leg and the continuation of the straightening of the hip joint are absolutely necessary for the immediate resumption of acceleration work.

In this context it should be noted that the athlete cannot 'step down' from the flight parabola of the clearance stride (Nett, 1966). This means that during the landing preparation the lead leg cannot be moved backwards and downwards as fast as one would like. This activity must be timed in such a way that the lead leg makes full use of the 'natural' radius and that the toes and the ball of the foot really make firm contact with the ground. If the athlete succeeds in establishing ground contact with an almost vertical positioning of the leg when standing on the ball of the foot, the distance loss on landing reaches a maximum (with a constant slight forwards lean of the trunk). Thus the goal of minimizing the duration of the flight phase can be attained. (This is in contrast to the Long Jump landing behaviour: maximizing flight time and minimizing loss of landing.)

The fact that the lateral lift of the take-off leg causes the pelvis to be tilted to the opposite side, thus 'lengthening' the lead leg, proves to be helpful in the sense of getting into contact with the ground again as soon as possible. Furthermore, the tilted position produces a buffer which helps to reduce the unavoidable shock when grounding the lead leg.

The description of the landing process presented so far, according to which no compensatory action can be used by the knee joint, leads to the conclusion that there is a very high excentric strain on the calf muscles in this phase. Consequently, all the world's best hurdlers show a 'passive amortization' with a corresponding reduction in plantar flexion. The increase in range of movement resulting from this enables the athlete to use his ankle joint plantar flexors to contribute to positive acceleration in the subsequent rear support.

If one analyses the contact phase, which lasts for only 78-110 ms (Artyschenko, 1977; Mero and Luhtanen, 1986; Ward and India, 1982; Willimczik, 1972), it becomes clear that the duration of its front support as well as its total duration has a negative influence on performance. So, in the front support - i.e. immediately when the landing figuration has been achieved - the horizontal distance between the landing foot and the centre of gravity is, in the case of the world's best athletes, only 3-11 cm (Mero and Luhtanen, 1986). In good hurdlers it is approximately 19 cm, and in non-specialists (around 16 sec.) it is approximately 29 cm (Willimiczik, 1972). The aforementioned 78 ms for the whole duration of the landing or support phase - which is in the lower border area of world-class sprinters!

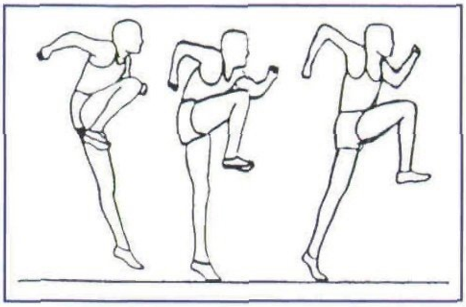

Figure 8: From the landing phase to the rear support

- was recorded in the former World Record holder Renaldo Nehemiah (USA) (Ward and India, 1982), whereas the 90 ms were recorded in Greg Foster in 1983 (Mero and Luhtanen, 1986).

Such a short duration of the landing/ support phase is only possible if the flight parabola is optimally flat. It can be achieved if the 'free' extremities - i.e. both arms and the trail leg, as well as the trunk - are brought into an optimal sprinting position even before the landing. Here the high knee movement of the trail leg is of particular importance. Only if this leg is lifted as high as possible and brought into the running direction with its knee leading can the braking distance be minimized and the contact time be limited to a short moment. By this means the athlete succeeds in preventing his centre of gravity from lowering more than 4-11 cm during the landing phase (Mero and Luhtanen, 1986) and in continuing his sprint 'on a high level'.

If one considers the transition from the landing to the rear support position (see Figure 8), the intention of 'staying tall' can be clearly observed.

The arms show an accentuated range of movement in an upward direction; the trail leg has now assumed the function of a lead leg, and is also directed upwards as far as the horizontal axis of the thigh is concerned. In addition, in the rear support, there is an extension of the total body. In this way it is possible to connect the first stride of the run between the hurdles smoothly with the preceding clearance stride and the subsequent 2 strides, the extension of the knee joint being maintained and the range of movement in the ankle joint being very small. The conservation of smooth propulsion is the result of a two-fold pulling action at the pelvis; the support leg pulls through a straightening of the hip joint while the free leg pulls through a swinging movement.

The comparison illustrated in Figure 9 proves that even world-class runners show a certain variation in the landing or rear support phase.

Ottoz (ITA) here demonstrates an extreme variation with his arms and legs,

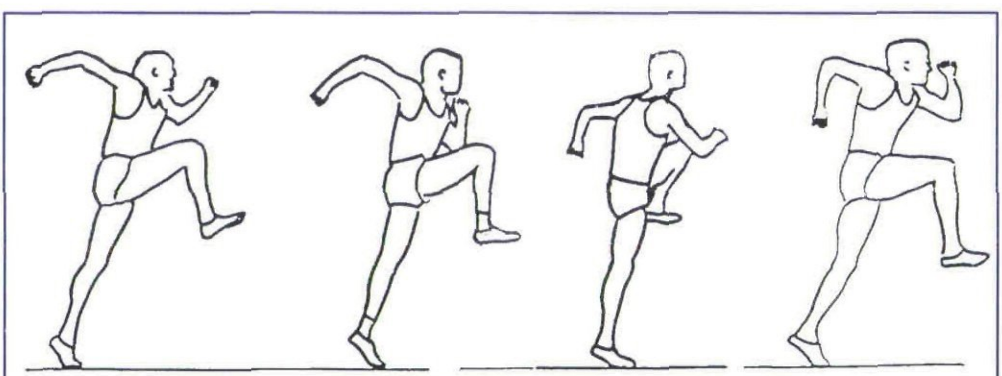

Figure 9: Rear support phase in four world-class athletes in direct comparison: (from left to right) Ottoz (ITA), Nehemiah (USA), Drut (FRA) and Milburn (USA)

which is almost a caricature of the aim to run tall. The movement patterns, particularly as far as the arms are concerned, of Nehemiah and Drut appear to be more moderate. However, these three athletes all demonstrate a considerably more pronounced knee lift than Milburn. This is significant as far as the individual variations of form of the first stride within the respective rhythmic unit(s) are concerned.

The run between the hurdles, which, in the case of a clearance stride of 3.50m is 5.64m in length, has this peculiarity: that only the second of the three strides can be used fully for the resumption or continuation of acceleration. This is because the last stride is used for take-off preparation and should be correspondingly short and performed with an upright trunk. However, this shortening does not so much affect the intensity of the support phase as rather the modification of the front swing phase. In any case, what has been said makes it clear that the art of the sprint hurdler really consists in attaining or maintaining a high level of velocity within the rhythmic units. This is achieved primarily, or even exclusively, by the variation of stride rate, with the position of the trunk only changing very slightly. This applies equally to every race the hurdler runs, and to his career from 15 sec. advanced beginner to 13 sec. specialist

In contrast, after the clearance of the 10th hurdle, the hurdler can accelerate sharply by assuming a sprinting forward lean and with no regard for stride length. Here world-class hurdlers achieve almost the maximal level of velocity demonstrated between the 4th and 5th unit. Some hurdlers even achieve their highest velocity when crossing the finish line. Thus only here the hurdler can sprint freely for the last five of the ttotal 50 strides)including the ten clearance strides).

Andrea Cassinis/ ITA

7.4 Summary

In the analysis sheet presented at the end of this article, the most important characteristics of the ideal movement patterns, described and discussed here, and the corresponding assessment criteria are summed up.

In the case of very frequent and significant deviations from the target technique, a tip given by Schnier should always be considered when analysing their causes. If one follows this author, '...almost all technical faults are caused by a lack of flexibility' (1982). Although this is certainly an extreme opinion, the experience particularly of decathletes (Kunz, 1980) shows that it is indeed advisable to test first of all the athlete's specific flexibility (Tidow, 1990) before drawing up a strategy for correction.

A further cause of deviation from the ideal model could be that the athlete lacks sprinting ability (Hommel and Keydel, 1975). This ability appears to be obligatory because without sufficient acceleration, which is built up primarily in the starting section, no optimally flat flight parabola can be achieved. This is a result of the following interdependencies:

In the case of a low horizontal velocity a relatively close take-off position to the hurdle is necessary in order for clearance to occur without running the risk of collision. This solution, however, is only feasible to a limited extent, because of the necessary freedom of movement of the lead leg.

□

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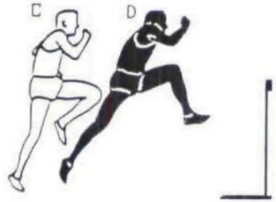
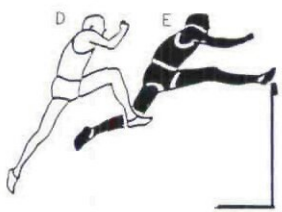
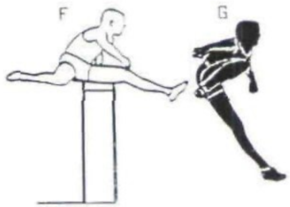
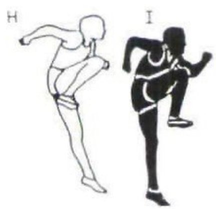
Analysis sheet for the 110 metres Hurdles

High Hurdles	*Phase*	*Reference*	*Criteria Assessment*
	I TAKE-OFF PREPARATION	A 1 Take-off point A 2 Take-off foot A 3 Take-off leg AB 4 Swinging leg AB 5 Take-off leg AB 6 Trunk AB 7 Head	Optimal distance to hurdle Contact with the ball of the foot only Short forward support 'Back-flipped' forward swing/led by knee Minimal amortization Straight/'tall' Gaze: horizontal
	II TAKE-OFF	CD 8 Swinging leg CD 9 Trunk CD 10 Opposite arm CD 11 Head D 12 Take-off leg D 13 Trunk	Knee lead/fast opening of knee angle Active pushing forward Active opening simultaneous with swinging leg Gaze: constantly horizontal Completely extended up to tip of the foot Integrated into shift
	III SPLITTING PHASE	DE 14 Opposite arm DE 15 Swinging leg DE 16 Trunk E 17 Opposite arm E 18 Swinging leg E 19 Arm on the side of swinging leg (ASSL) E 20 Take-off leg	Stabbed horizontally forward Shank is swung forward (explosively) Increasing forward lean/spine: straight Horizontal/long Horizontal/long Close to trunk/passive Long/relaxed/hip over-extended
	IV HURDLE SITTING	EF 21 Head posture EF 22 Opposite arm EF 23 Take-off leg [illegible]	Unchanged Brought backward for compensation/long Brought forward in an abducted & flexed manner [illegible]

		F 25 CG F 26 Take-off leg F 27 Take-off foot F 28 Swinging leg	Vertical distance to hurdle: minimal Horizontal/flexed/abducted at 90 degrees Lifted sideways/in a horizontal plane Moving downward/long
	V LANDING PREPARATION	FG 29 Trunk FG 30 Take-off leg FG 31 Opposite arm FG 32 Swinging leg FG 33 ASSL G 34 Shank of take-off leg	Forward position unchanged Forward and upward movement/knee angle: constant Brought backward for compensation/long Active movement backward and downward/long Moving forward/flexed Directed upward and parallel to the trunk
	VI LANDING	H 35 Opposite arm H 36 Swinging leg HI 37 Take-off leg HI 38 Head/trunk I 39 Landing point I 40 Support leg I 41 Trunk I 42 Arms	Reverse of backward movement Extended/led by ball of the foot/pre-tensioned/ankle: locked Flexed/lifted high/being adducted Unchanged Optimal distance from hurdle Vertical/extended/excentric load on the calf/ no heel contact Forward lean Sprint-like counter-arm swing
	VII REAR SUPPORT	IK 43 Support leg IK 44 Backward arm K 45 Knee of swinging leg K 46 Body	Extended/hip and ankle impulse Reverse of upward swing 'High' aimed in running direction/opening Sprint-like forward lean/Chest: frontal/'tall'

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