From start to finish: The women's 100m hurdles

Canadian Master Coach, Brent McFarlane takes a step by step look at the sprint hurdles event for women

THE NATURE OF THE EVENT

The purpose of the women's 100m hurdle race is to generate as much speed as possible over the distance while clearing 10 equally spaced hurdles, set 8.5 metres apart, which are 84cm in height. The distance between the start line and the first hurdle is 13 metres and the distance from the last hurdle to the finish line is 10.5 metres. The athlete's centre of gravity (centre of mass) is kept as close to its normal sprinting path as possible while clearing the hurdles in order to minimise the length of time in the air.

The 100m hurdles is typical of all hurdle races in having identifiable elements which must be blended into one unified effort. The seven elements, expressed in time sequence are:

i. start;
ii. sprint approach to the first hurdle;
iii. hurdle clearance (takeoff, layout, descent);
iv. landing;
v. follow-up stride;
vi. reacceleration to the next hurdle;
vii. sprint to the finish line.

Combined together, these elements give, in effect, eleven different 'races'; from the blocks to the first hurdle, nine other clearances and the run-in to the finish line.

THE START AND THE SPRINT APPROACH TO THE FIRST HURDLE

The 100m hurdles is a sprint event. A good start and maximum acceleration to the first hurdle are necessary in order to maintain the fastest possible rhythm between hurdles. Sprint hurdlers cannot attain their maximum velocity because there are normally only eight strides from the start to the first hurdle. This means that the lead leg is in the back block, except for a few of the tallest, strongest hurdlers who are able to take seven strides with a fast rhythm.

Optimal acceleration is achieved when *the greatest amount of force is applied to the track in the shortest amount of time.* (This product is known biomechanically as 'impulse'). Force is applied through the foot but it is generated by the summation of forces in other joints working in unified sequence, principally the ankle, knee and hip. The need for *a big force in a short time* is an idea of fundamental importance which results in speed: the product of stride length and stride frequency. Since stride length is predetermined, the development of stride frequency is the most important factor in a hurdler's preparation. In this pure acceleration phase, the free leg swing, when the leg is not in contact with the ground, is also a dynamic action. It is brought about by flexion in the same hip, knee and ankle joints which are extended to provide the driving force in the previous stride. The flexed joints shorten the whole lower limb complex. This enables the hip joint to rotate forward faster by reducing the biomechanical resistance to the rotation, known as the moment of inertia.

For these biomechanical reasons, eight shorter strides from the blocks normally permit greater acceleration than seven longer strides. The distance covered is the same but there is one more opportunity to exert force to the ground.

The speed of movement of the joints, that is, their angular velocity, is likely to be greater. Assuming a faultless hurdle clearance in both cases, the eight stride hurdler is likely to be carrying a quicker rhythm over the hurdles. The pure acceleration action of the lower leg is characterised by a low shin angle between the shin and the ground, a cocked or dorsiflexed foot and a casting motion which is often described as 'stepping forward' below the opposite knee.

HURDLE CLEARANCE – TAKE-OFF

The distance from the hurdle on take-off depends on several factors – speed of the approach run, length and speed of the lead leg, height of the athlete, height of the hurdle and the flexibility of the hip, knee and ankle joints. There are three clearly identified strides between hurdles, but hurdling should not be considered 'three strides and a jump'. It is rather a continuous four stride pattern with the last stride merely longer and accentuated in its action. The take-off distance for women before the hurdle will vary between 1.95m to 2.10m on the take-off before the hurdle and between .80m and 1.0m on the landing after it. The female hurdler touches down closer to the hurdle than her male counterpart because the hurdle is lower.

Four actions need attention in this phase of hurdling:

i. lead leg;
ii. trail leg;
iii. arm action;
iv. body lean.

HURDLE CLEARANCE – LEAD LEG

The lead leg attacks the hurdle beginning with a high knee action generated from the hip flexor muscles (ilio-psoas, rectus femoris) and the supporting muscles of the upper leg. The foot is always 'cocked' by dorsiflexing the foot, or 'pulling the toe up'. These actions decrease the moment of inertia about the hip and therefore permit a high angular velocity in the subsequent movements of the lead leg. The lead leg action is supported and enhanced by plantar flexion, or foot drive, of the trail leg to lift the body and keep the hips tall as the lead leg attacks the hurdle. The raised centre of gravity enables the trajectory over the hurdle, a parabolic curve, to be as flat as possible. This keeps the path of the centre of gravity as close as possible to a normal sprinting action. The rotational force, or torque, of the plantar flexion is generated by the gastrocnemius and soleus and other supporting muscles in the calf. The hurdler should concentrate on 'thigh up, knee up, toe up, heel up' to facilitate a quick take-off and to reduce braking forces upon landing. Leading with the foot not cocked has a tendency to lock the knee prior to the heel reaching the hurdle. If this continues throughout the clearance, a delayed landing and greater braking forces will result. The lead knee should cross the hurdle in a slightly flexed position. This allows an efficient, fast 'step down' and landing and facilitates re-acceleration of the hip towards the next hurdle. The lead leg must be lifted straight up and down in the saggital plane, that is, in the direction of running. If not, the hurdler will land off balance and with a braking action.

HURDLE CLEARANCE – TRAIL LEG

The ankle plantar flexors of the trail leg must be allowed to complete their full drive. This is shown by full extension of the trail knee joint at take off and is achieved by the contraction of the hip extensors (gluteus maximus and hamstrings) and the knee extensors and stabilisers (the group of three 'vastus' muscles in the front of the thigh) in conjunction with the plantar flexor muscles at the ankle. The knee of the trail leg will be locked momentarily prior to the lead leg reaching the hurdle. This should be part of the natural running stride rather than being a forced action.

HURDLE CLEARANCE – ARM ACTION

As the lead leg is lifted, the opposite (lead) arm attacks the hurdle with an extension across the chest at shoulder level to the body's midline. It should not be thrust forward towards the hurdle, *nor cross over the midline.* This would tend to

exaggerate the lateral rotation of the upper body resulting in a loss of balance and timing. Synchronisation of the actions of this lead arm with the lead leg is critical since they serve to keep the shoulders square towards the hurdle and counteract any lateral movement in the hip. The other, off-side (trail) arm simply moves close to the trail hip in as close a movement to the normal sprinting action as possible.

HURDLE CLEARANCE – BODY LEAN

Once in flight, the body's centre of gravity describes a parabolic curve which cannot be altered. The elements of effective lift, attack and take-off must therefore start while the hurdler is in contact with the ground. The effect of the driving forces described above is enhanced by a forward rotation caused by a forward body lean or 'forward falling' at take-off. This helps to keep the centre of gravity as close to the normal sprinting path as the hurdle technique allows. To aid this position, the take-off stride is slightly shorter than the others. The strength necessary for body lean is produced in the abdominal muscles (rectus abdominus and supporters) while strength in the back (erector spinae and supporters) provides for a quick recovery from the lean into the upright sprinting position.

In the take-off phase, the errors to watch for are:

i. **sinking the hips on take-off** will cause the centre of gravity to lower and thereby increase its parabolic curve across the hurdle;
ii. jumping **the hurdle** occurs when the take-off is too close;
iii. **low lift of the lead leg** causes either a locked lead knee or an incomplete trail leg drive;
iv. **poor hip mobility** slows the entire action.

All of the above factors can also result in increased breaking forces upon landing.

HURDLE CLEARANCE – LAYOUT

Hurdling is a continuous action. At no time do the legs or arms stop moving. Any deceleration or hesitation often observed in the layout is detrimental. The trunk is forward over the lead leg, the trail leg starts its first stages of the hip circle, the shoulders remain square, the lead arm is almost fully extended and the lead leg is flexed slightly as it crosses the hurdle. A clearly flexed knee over the hurdle allows for a quicker descent by decreasing the moment of inertia of the lower limb complex. If the knee is locked, there will be a jumping effect and a loss of speed. The trail arm moves downwards in a circular motion at the hip to maintain timing and balance in the upper body.

HURDLE CLEARANCE – DESCENT

When the foot of the lead leg advances over the hurdle and begins to move downward, the descent phase begins. At this point, the trail leg is advancing forward with an everted (turned out) toe, shoulders are still square, the trunk is still forward but the upper body is beginning to rotate upwards slightly as the lead leg drops. The knee flexor muscles (hamstrings and gastrocnemius) are essential for a fast 'cut down' of the lead leg. If body lean or trail leg drive is insufficient, the hurdler will tend to land on her heel. Consequently, braking forces are considerable, speed will be lost and there is even a risk of injury.

The correct leg split in the take-off and layout gives rise to the hip circle which continues with the thigh crossing parallel to the hurdle. If the angle at the trail knee is kept at 90 degrees or less, then once again angular velocity is increased in the clearance action of the hip. The trail leg is raised above the hurdle to a position which is almost at a right angle to the body. This requires abduction of the thigh at the hip joint by the gluteus medius muscle. The ankle of the trail leg is everted by the peroneus longus and brevis muscles of the calf. Pulling the thigh through its complete action should be emphasised at this point. This pull through of the trail leg to the landing step is initiated by the hip flexor muscles (ilio-psoas and supporters) and the adductors of the thigh.

As the trail leg comes forward an equal and opposite reaction is produced. This is the backward 'pawing' of the lead arm. If the shoulders are to remain square throughout the flight then these

two actions must be equal. Since the leg has more mass than the arm, the arm must swing wider than the leg to counteract its action. Therefore, the lower arm and hand complex actually goes 'down and around' the trail knee. A useful cue is to 'cut off' the knee. This action increases the moment of inertia of the upper body and thus provides a more solid reaction to, or absorption of, the action of the lower body in the same plane. The arm action occurs mostly in front of the body and does not go behind the hip. The overall importance of actions in front of the body gives rise to the term 'front-side mechanics'.

The arm movement in hurdling has a three stroke action:

i. at take-off: lead leg and lead arm attack;
ii. on clearance: the lead arm 'cuts off' the trail leg. The off-side hand races the knee of the trail leg to 'be tall';
iii. on landing: both hands drive tall for re-acceleration.

The pawing action terminates as soon as the lead leg hits the ground. Body lean is held, although rising slightly, as the body advances into the landing position of the trail leg.

LANDING, FOLLOW-UP STRIDE AND RE-ACCELERATION

Hurdling involves a 'falling' and 'recovery' action on each stride. After landing, the hurdler concentrates on immediate recovery to a normal sprinting stride. A good follow-up stride will place the centre of gravity just slightly ahead of the body. It will land her on the ball of the foot and be moving strongly backwards to pull the centre of gravity forward and enable immediate application of *impulse* into the track once more – 'A Big Force in a Short Time' – displacing the hip forward quickly. A landing too far ahead of the body will slow or prevent this backward movement and set up undesirable braking forces.

The trail arm must not be so fast or erratic as to upset shoulder alignment, since this will result in undesirable upper body rotation. The primary purpose of this arm is therefore to balance the upper and lower body, allowing the lead arm to drive backwards as the body resumes its normal sprinting action in the re-acceleration towards the next hurdle.

Any mechanical errors during clearance can result in the common problems of braking upon landing, running flat-footed, low hips and centre of gravity, over-striding and, most obvious, the loss of speed.

The three strides between hurdles are shorter than normal. The follow-up stride is always the shortest since its driving force is reduced by the preceding hurdle clearance. The second stride is the longest. The third and last stride is always slightly shorter than the previous stride. As we have discussed, it prepares the body for the next hurdle attack and once more assists the trajectory of the centre of gravity on its parabolic curve during clearance.

FINISHING SPRINT

Having cleared the last hurdle, all attention is directed immediately towards the remaining 10.5m to the finishing line. Athletes should know exactly how many strides they need (generally about 6.5 strides) and regularly practise the dip on the last stride so that it becomes a normal part of their race.

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Until his retirement from active coaching in 2006 through ill-health, Brent McFarlane was National Hurdles Coach for Canada for almost thirty years and coached at Olympics, World Championships, Commonwealth and Pan-American Games and, in 2000, was Canada's head track and field coach for the Sydney Olympics. He is the author of the definitive 'Science of Hurdling and Speed', from which this excerpt is taken, has studied and visited coaches in more than 50 countries and published over 500 articles in athletics journals throughout the world.