KINEMATICAL ANALYSIS OF HURDLE CLEARANCE TECHNIQUE IN 110M HURDLE RACE

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ABSTRACT

The 110 meter high hurdles race is one of the most exciting races in the sport of track and field. The goal for the hurdler is to sprint as fast as he can and get to the finish line in the least amount of time as possible, remembering that "they are sprinters first and hurdlers second" (Bowerman, 1991). Hurdle clearance can be delineated into three phases: the take-off phase, flight phase, and the landing phase (Tidow, 1989). The objective of this pilot study was to establish and analyze those kinematic and dynamic parameters that define an efficient hurdle clearance technique. Test runs from starting blocks with the clearance of five hurdles, set in accordance with the competition rules, were carried out on a sample of two male hurdlers both are junior national athletes. Kinematic analysis was performed with quintic system. .It was found that efficient hurdle clearance technique is generated by the following factors: The contact time of take-off, an optimal ratio of the braking phase to propulsion phase of take-off, the ratio of the point of take-off to landing, flight time, short braking phase in landing, high position of the centre of gravity (CG) at landing and minimal reduction in the horizontal force of the CG at landing.

KEYWORDS: hurdles, technique and kinematics.

INTRODUCTION:

The 110 meter high hurdles race is one of the most exciting races in the sport of track and field. The goal for the hurdler is to sprint as fast as he can and get to the finish line in the least amount of time as possible, remembering that "they are sprinters first and hurdlers second" (Bowerman, 1991)Technically, the high hurdles are among the most demanding track and field events. According to some of the research carried out to date (Schluter, 1981; Mero and Luhtanen, 1986; La Fortune, 1988; McDonald and Dapena, 1991; Dapena, 1991; McLean, 1994; Kampmiller, Slamka and Vanderka, 1999), the hurdle clearance technique is one of the key elements defining the competitive result. From the aspect of biomechanics, hurdles are a combination of cyclic sprinting and acyclic clearance of ten 1.067m hurdles. Therefore, the athlete must possess a high level of sprinting abilities, special flexibility at the hip joint, fast strength, and a high level of technical knowledge. While clearing the hurdle, the loss of horizontal velocity must be as small as possible. However, this depends on numerous factors, especially those, that define the take-off before hurdle clearance, the trajectory of the movement of the CG, and the landing after hurdle clearance. For efficient hurdle clearance, the point of the take-off and the point of landing of hurdle clearance are important. The correct position of these two points is a prerequisite for an optimal CG flight trajectory and reflects in the flight time, which must be as short as possible (Schluter, 1981; Dapena, 1991). In addition to the correct position, the kinematic-dynamic structure of take-off and landing, which directly affects the velocity of hurdle clearance (La Fortune, 1988; McLean, 1994) is also important. Therefore, the objective of the present study was to determine which parameters generate the most efficient hurdle clearance technique, by combining a 3D kinematic analysis.

METHODS:

Biomechanical analysis was performed on a sample of two male athletes, junior level of India, with an age of 20years and 19 years, body height 183.4cm and 188.1cm , and with an weight 80.4kg and 82 kg simultaneously . The result in the 110m hurdles was 13.90s. and 14.63s was best performance. The measurements were carried out on war hero stadium sangrur stadium with a synthetic surface. According to the protocol, each athlete performed three runs from starting blocks with the clearance of five hurdles, set at standard race distances from the start. The kinematic analysis of the technique was performed at the fifth hurdle. A 3D kinematic system quntic with two mutually synchronized digital cameras SONY, operating at a frequency of 50 Hz and placed at an angle of 90° with respect to the object filmed, were used to establish the kinematic parameters. The stride before hurdle clearance, the hurdle clearance, and the stride after hurdle clearance were analyzed.

RESULTS AND DISCUSSION:

The results in Table 1 show the basic kinematic characteristics of hurdle clearance. The speed of the athletes in the zone of hurdle clearance was 7.61 $m.s^{-1}$.

Table 1: Kinematic and dynamic parameters of hurdle clearance

Parameter	Unit	Subject A	Subject B	Mean
Rhythmic units (hurdle)	$m.s^{-1}$	7.87	7.35	7.61
Take – off (breaking phase)				
Horizontal velocity of CG	$m.s^{-1}$	78.25	7.45	7.85
Vertical velocity of CG	$m.s^{-1}$	0.05	-0.02	.015
Centre of gravity to foot distance	M	0.43	0.44	0.435
Breaking time	S	0.079	0.078	0.0785
Breaking time %	%	59.8	58.2	59
Take –off (propulsion phase)				
Horizontal velocity of CG	$m.s^{-1}$	7.88	6.88	7.38
Vertical velocity of CG	$m.s^{-1}$	2.26	2.14	2.2
Centre of gravity to foot distance	M	0.50	0.42	0.46
Push-off angle	0^0	71.0	72.3	71.65
Foot to hurdle distance	M	2.36	2.27	2.315

Contact time	S	.132	.134	.133
Propulsion time	S	0.053	0.056	0.054
Propulsion %	%	40.2	41.8	41
Flight				
Flight time	S	0.38	0.40	0.39
Height of CG above the hurdle	M	0.33	0.33	0.33
Maximal height CG	M	1.42	1.41	1.415
Landing (breaking phase)				
Horizontal velocity of CG	$m.s^{-1}$	7.65	7.21	7.43
Vertical velocity of CG	$m.s^{-1}$	-1.72	-1.81	-1.765
Height of CG	M	1.25	1.19	1.22
Centre of gravity to foot distance	M	0.18	0.14	0.16
Foot to hurdle distance	M	1.28	1.39	.1335
Breaking time	S	0.017	0.048	0.0325
Breaking time %	%	17.4	39.1	28.25
Landing (propulsion phase)				
Horizontal velocity of CG	$m.s^{-1}$	7.97	7.32	7.645
Vertical velocity of CG	m.s-1	-1.31	-0.51	-.91
Contact time	S	0.098	0.123	.110
Propulsion time	S	0.081	0.075	0.078
Propulsion time %	%	82.6	60.9	71.75

During take-off, the horizontal velocity of the CG decreased in the braking phase by 0.23 $m.s^{-1}$, while at the same time the vertical velocity in the propulsion phase increased to 2.15 $m.s^{-1}$, which is the consequence of the need to raise the centre of gravity over the hurdle. The change in the relationship between the horizontal and vertical velocity is associated with the dynamic parameters of take-off. The braking phase lasts 59 %, and the propulsion phase 41 % of the total contact time. The total time of the contact phase of hurdlers in front of the hurdle is 0.133 s. similar values of take-off parameters were established in the study by McLean (1994). In the braking phase, defined with the centre of gravity to foot distance 0.43 m, an efficient execution of take-off in front of the hurdle has also a direct effect on the efficient trajectory of the movement of the CG, which is expressed in the height and time of the flight of the hurdler. For athletes in the study sample, the flight phase lasts 0.39 s. The fastest athlete, (subject A), also has the shortest flight time of 0.38s. This distance is an individual trait and is associated with the morphological characteristics of the hurdler and with the take-off angle 71.6°. For these hurdlers, the total length of the stride over one hurdle was 3.65 m. The landing occurs at 1.33 m from the hurdle. In other studies (La Fortune, 1991; McLean, 1994; Kampmiller, Slamka and Vanderka, 1999), the optimal ratio of the take-off to landing point was 65 % : 35 %. In this study, almost the same result was obtained. The ratio of the take-off to landing was 63.45 % : 36.55 %. For subject B, who had the poor result, this ratio was 62.0 % : 38.0 %. The data determined that the fastest hurdler (subject A), had the largest foot to hurdle distance of 2.36 m (64.9 %). This athlete also had the shortest landing to hurdle distance of 1.28 m (35.1 %), and the smallest take-off angle = 71.0°, the consequence of which is a low position of the centre of gravity over the hurdle (0.33 m) and thus a short duration of the flight phase (0.38 s).

For efficient hurdle clearance technique, the landing phase is equally important. A poor technique in performing this component, characterized by a long contact time and a large percentage of braking time, results in a large loss in horizontal velocity of the hurdler (La Fortune 1988, Dapena, 1991). The landing technique differs significantly from the take-off technique. The braking phase lasts only 20 % of the total contact time, which amounts to 0.110 s. This means that the athlete must place the foot directly beneath the body's centre of gravity at landing. For top hurdlers, the braking phase lasts only 9 - 10 % of the contact time (Schluter, 1981; McLean, 1994). The fastest hurdler in the present experiment (subject A) had also the shortest contact time of 0.098 sec and used only 17 % of this time for braking. In the remaining propulsive part of the contact time, the athlete increased the horizontal velocity of the centre of gravity by 0.32 $m.s^{-1}$, which is the highest value among athletes who participated in the experiment. The hurdler who had the poor time in the zone of hurdle clearance (subject B) had the longest contact time of 0.123 s. and used as much as 39 % of this time for braking.

In addition to the correct technique, the ability of the muscular system to resist fast stretching and stiffness as a consequence is important in this case. Stiffness as a neural mechanism of muscle action, depends above all on the pre-activation of the muscles and action of the following reflexes, namely the Miotatic reflex and Golgi tendon reflex (Gollhofer and Kyrolainen, 1991). Short-range elastic stiffness is a biomechanical characteristic of landing, in which an immediate mechanical response of the activated muscle to the eccentric contraction in the braking phase of landing is involved. The criterion of efficiency of the execution of this phase, is the height of the CG in the braking phase, which in this case, is 1.23 m. Without question, the height of the CG in the landing phase, depends on the morphological characteristics of the athletes, especially their body height. The best athlete (subject A) , managed to maintain the highest position of the centre of gravity after landing and the largest horizontal velocity of 7.97 $m.s^{-1}$. This was achieved, despite the fact that he is the smallest subject in the experimental sample (BH = 183.4 cm) - The landing phase is the most important factor, as it affects the transition from hurdle clearance into sprinting to the next hurdle. For the athletes in the present sample, the horizontal velocity in the braking phase of landing was 7.43 $m.s^{-1}$. This indicates that in the phase of hurdle clearance, the horizontal velocity decreased only by 0.18 $m.s^{-1}$, from which it can be concluded that the efficiency of hurdle clearance technique is high.

CONCLUSION:

On the basis of the results of this study, it can be established that the execution of take-off and landing defines the degree of efficiency of hurdle clearance. Undoubtedly, this is an important factor, which determines the competition results of athletes in the 110m hurdles event. The time relationship between the braking phase and propulsion phase is completely different in take-off and landing. The function of take-off is to ensure a suitable transformation of the horizontal velocity of the CG into vertical velocity. The horizontal velocity decreases and the vertical velocity increases, due to the change in the direction of the movement of the CG. In the landing phase, which is one of the most important components of technique, the contact time and the braking phase of the contact time must be as short as possible, in order to maintain the horizontal velocity of the CG while clearing the hurdle. The efficiency of hurdle clearance is also defined by the take-off angle, the correct ratio of the foot to hurdle distance in take-off and landing, flight-time, and the height of the centre of gravity over the hurdle. The results of the pilot study can be utilized for good and objective assessment of hurdling technique, diagnosis of shortcomings, and for the control and modeling of the technical preparation of the athletes.

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