THE INFLUENCE OF MOTOR ABILITIES AND SOME SPECIFIC KINEMATIC PARAMETERS ON THE RESULTS IN 60 - METRE HURDLE-RACES

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Abstract

The purpose of this paper is to based on measuring, determine the influences of some motor abilities and specific kinematic parameters on the result of 60m hurdle-races. For this purpose, on the sample of 9 athletes aged 13 – 14, every athlete runs twice in the same conditions, and we treat every result as an entity, summary of 18 entities. In this paper athletes are competing in hurdle running, the authors of this paper, applied a set of three motor tests and two sets of specific kinematic parameters. The set of motor tests was used to assess basic motor abilities. The first set of specific kinematic parameters depicts start and start acceleration. The second set of specific kinematic parameters depicts crossing over the first hurdle. We applied regression analysis which, from the set of motor abilities, isolated standing long jump variable in addition to flying start on 20m run as significant variables, while in kinematic parameters from the first set of variables we isolated the running time from the start to the first hurdle as a variable with a significant influence, while from the second set, we isolated horizontal speed variable and body mass centre height over the hurdle. Based on the obtained results, we may draw a conclusion that the obtained results are influenced by basic motor abilities and some kinematic parameters specific in hurdle running.

Key words*: athletes, hurdles, kinematics, cadets*

Introduction

Hurdles are one of the most complex athletics disciplines regarding motor abilities and technical skills and it is characterised by cyclical, fast and strong moving. The main problem in hurdle running is crossing over a hurdle which requires high technical skills. Elite hurdle runners must have good flexibility, speed, power, mental stability, and highly - developed technical preparedness.

Top results in this discipline necessarily involve high technique level, coordination, rhythm, speed, equilibrium, and power (Babić et al, 2015) in addition to flexibility which is crucial, particularly in the hip area. Running involves ten or five hurdles depending on the discipline (60m, 100m, 110m, 400 m). Hurdles are crossed over by hurdle steps. Acquiring the technique is one of the main preconditions to achieve top results in this discipline. The movement speed and explosive power have a dominant role in hurdle running.

The main goal of hurdle running is economy in moving with the minimum loss of speed. This form of running has been known for more hurdles being placed on the running track at different distances, depending on the discipline. Hurdle runners must regularly be observed from different angles in order to discover mistakes which cannot be seen when an athlete is seen from one side only (Przednowek et al., 2017). A hurdle runner must reach the finish line as fast as possible. Each athlete has his own hurdle running style which can be developed further on, but not by losing speed.

In order to introduce hurdle running technique and for the purpose of easier analysis, we may observe the following segments in a hurdle run: start, running to the first hurdle (starting acceleration), jumping over the first hurdle (starting acceleration), running between hurdles (running on the track), and finish (crossing the finish line).

In hurdle running, low start is performed in more difficult conditions than in sprint disciplines. An athlete must achieve maximum speed over a limited distance from the start to the first hurdle. These are the characteristics of hurdle running. In a hurdle start, at the command "set", hips are raised a bit more than in a 100m run start. After the start – earlier stretching and lifting up the upper trunk in vertical raising in order to take a favourable position before attacking the first hurdle. Earlier transition to a full swing stepping (Babić and Đelalija, 2009).

Running to the first hurdle is performed in 7 or 8 steps. The eighth or the ninth step is already jumping over the hurdle. The last step before the hurdle must be shorter than the previous one. It is a mistake to make this step longer since it makes it

more difficult to perform the take - off, attack and jumping over correctly.

Efficient running to the first hurdle involves optimum rhythm, body opening as soon as possible, the last step being shorter than the previous one, efficient hurdle start progression, setting the take - off leg on the optimum spot before attacking the hurdle (Krzeszowski et al., 2014).

After the take - off and hurdle attack, an athlete reaches the flying stage - moving over the hurdle. At this stage, the swinging leg is completely straight in the knee and directed forward, and it's straightening starts at the moment when the knee reaches the height of the hurdle bar. At the same time, the body is even more lifted. The flected feet of the swinging leg towards the lower leg, straightened knee, and the most favourable body lifting enable to jump over the hurdle with minimum body OCT and good conditions to quickly lower the swinging leg on the track. When the take - off is done, the take - off leg lags far behind the swinging leg, however, when the straightening of the swinging leg is done, the take - off leg begins to accelerate at high speed.

The crossover of the take - off leg over the hurdles is the most difficult part of the hurdles running techniques due to its unnatural moving. The leg crosses over the hurdle aside, bent in the knee, and the foot, the knee and the upper leg are on the same height, almost parallel to the ground. This position is called hurdling sit, and demands extraordinary flexibility of the pelvis belt. At this stage, the angle between the upper leg and the take - off lower leg is small in order to the take - off leg could be transmitted faster over the hurdle and further on in front of the body. The foot is flexed towards the lower leg.

Most of the previous researches have dealt with kinematics in senior population and a small number of researches in hurdle running was conducted among young athletes population. Many studies focused on the problem of influence of various factors on the hurdle run result (Pietrzak and Iskra, 2016; Krzeszowski et al., 2016; Gudelj et al., 2013; Hamlin et al., 2015)

These and other significant studies have shown that success in hurdle running asks for a number of different anthropological characteristics and technical skills. Thus Gonzales, Mallo, Veiga and Navarro (2008) tried to determine the significance of the step length in 60m run over hurdles on different competition levels. All the races at the 44th Spanish Indoor championship have been analysed as well as those at the 12th IAAF World Indoor championship in Valencia in 2008.

All the races have been analysed by using 2-D video system. The results of this research have shown that the best male group used a shorter distance in the first 8 steps, the distance between the take - off and the hurdle was longer (0.11 m), the distance from the hurdle to the descending point was shorter (0.17 m) and the step length between the hurdles was longer. The best female group used a longer step between the hurdles. While in male groups, statistically significant differences were presented.

Iskra and Čoh (2006) conducted a biomechanical study of the quality of crossing - over a hurdle technique in an 110 m run with hurdles to determine and analyse kinematic and dynamic parameters which to the greatest extent generate efficient running over hurdles techniques. The research was done by observing performance from a starting block with following 5 hurdles set according to the competition rules on the sample of 4 athletes. Kinematic analysis was conducted by using Apas video system. The research led to a conclusion that efficient crossing - over hurdles technique depends on the following factors: the contact time of take - off leg, optimum relation of the skidding phase towards the propulsion of take - off time, the relation of the take - off point towards the landing point relatively in relation to the hurdle, the time of flying, short skidding at landing, high position of the mass centre (CG) at landing, and minimum reduction of the horizontal force in landing (CG).

The hurdle discipline is complex and difficult to be studied due to its structure and specificity. Previously published data of biomechanical analysis of certain athletic disciplines published in scientific research projects by IAAF (1988, 1997, 2009 and 2011) focused on the importance of a stable model of competition activity, particularly in achieving the greatest results. The purpose of this study was to establish influences of some motor abilities and kinematic parameters (start and crossing - over the first hurdle) on the result efficiency in 60m run over hurdles in young athletes population. To obtain as relevant results as possible, the study was conducted in older athlete (named cadet) competitive population of hurdle runners.

Methods

The sample of subjects

The sample of subjects in this study included the population of 9 athletes, competitors from the older (cadet) category (aged 13-14) who run twice in the same conditions. Every result threats as an entity, summary of 18 entities. All cadets participate in hurdle running competitions. The sample in this research is a representative one.

The sample of variables

The sample of variables is presented by motor abilities and some specific kinematic parameters of hurdle running which present start and starting acceleration to the first hurdle, crossing over the first hurdle, while the 60m hurdle run result was taken as a criterion variable.

Variables to assess specific motor abilities are standing long jump (RSL), 20m run with a flying

start (R20MFS), and 20m run from a low start (R20MLS). The result for standing long jump (RSL) represents distance from the subject's top of the toes to the distance set by the back part of the foot. The jump is performed from the surface slightly tilted and the respondent one lands with both feet (RSL). The result for 20m run from a flying start (R20MFS) represents the time of subject by crossing 20 metres in the shortest time period as possible. The respondent crosses a 20 - metre distance in full sprint before the starting line, and time is measured by two sets of photo cells positioned at the starting and the finishing line too. The result for 20m run from a starting block (R20MLS) represents the time that the subject achieved after leaving the electronic starting block, and crossing the finish line. The result is measured so that the athlete crosses the distance from the electronic starting block after the audio signal to the finishing line in the shortest time period as possible. Two sets of time measuring photocells are positioned at the starting and the finishing line.

Start and starting acceleration variables are running time from the start to the first hurdle (R601H), reaction time (R60T), the number of steps to the first hurdle (NS1H), the length (LLS1H), and the speed (SLS1H) of the last step before crossing over the first hurdle. Time lapse at the first hurdle is the time that the subject crosses from the starting sign to the first hurdle (R601H). The reaction time is the time between the starting sign and the subject's pressure reaction on the starting block (R60T). The number of steps to the first hurdle is the number of steps that the subject makes to the first hurdle (NS1H). The length of the last step before a hurdle is the length of the last step before a take - off and an attack on the hurdle (LLS1H). The speed of the last step before the take - off is the speed of the last step before the take - off and the attack on the hurdle (SLS1H).

Kinematic variables that are observed on the first hurdle are the mass centre height at the moment of take-off from the ground, in front of the hurdle (CM1), and the mass centre height on the hurdle (CMH1). The next variable observed is the body tilting on the hurdle (BTH1), flying speed horizontal component at the moment of jumping over the hurdle (HS1), and total flying distance from take - off before the hurdle toward the contact to ground with the swinging leg after descending behind the hurdle (TFD1). The body mass centre height before the first hurdle is a vertical distance from the horizontal surface to the top of iliac crest at the moment of take - off from the ground before jumping over the first hurdle (CM1). Body mass centre height on the first hurdle is vertical distance from the horizontal surface to the top of iliac crest at the moment of crossing over the first hurdle when the body reaches maximum vertical height (CMH1). The body tilting on the first hurdle represents minimum body tilting while jumping over the first hurdle is the angle forming the direction set by two points (the mass centre and the clavicula), and the horizontal direction parallel to the running surface (BTH1). The horizontal speed on the first hurdle is the speed of jumping over the first hurdle, measured at the moment of reaching the highest point at the subject's moving course towards a certain flying trajectory in the position when the body reaches the maximum vertical body mass centre height on the first hurdle (HS1). The total distance of jumping over the first hurdle is the distance crossed from the moment of separating the take - off leg from the horizontal surface while attacking the hurdle before the first one up to the moment of the contact of the swinging leg and horizontal surface while descending behind the first hurdle (TFD1).

In order to assess specific motor abilities, we have used the following equipment: the surface with marked lines for every 10 centimetres to determine the subject's standing long jump length, two sets of photocells at the starting and the finishing line for measuring the subjects' results in 20m run tests and the electronic starting block.

To assess kinematic parameters, we have used the following equipment: six sets of photocells for measuring movement dynamics on the competition track, Opto jump is an optical measurement system for determining kinematic parameters in running, the electronic starting block measures the start reaction time and the lowest quality of SVHS 100HZ camcorders. We conducted at least 2D analysis by Kinovea movement structure analysis software. The camcorder was positioned vertically onto the first hurdle from a 5 metre distance on a tripod 1.20m tall. The analysed space was calibrated by a referent framework (180x180x180 cm).

DATA PROCESSING METHODS

To process the obtained data, we used Statistica ver. 12 programme package (Stat Soft, Inc. TULSA, USA). According to the objectives of this research, we have been using the following methods: the calculation of basic descriptive parameters for all the variables, normality distribution variables have been tested by Kolmogorov-Smirnov test. To determine the influence between motor abilities and kinematic parameters in 60m run with hurdles, we have used multiple regression.

Results and discussion

Table 1. presents basic descriptive parameters for all the studied variables, arithmetic means (AM), the lowest (MIN) and the best (MAX) result, standard deviation (SD). Kolmogorov-Smirnov test has shown normal distribution in all the variables.

Table 1. Results of basic descriptive parameters for all studied variables

	AM	MIN	MAX	SD
R601H	2.63	2.46	2.99	0.15
R60T	0.18	0.13	0.33	0.06
NS1H	8.00	7.00	9.00	0.69
LLS1H	162.89	124.00	193.00	21.21
SLS1H	7.52	6.71	8.05	0.52
CM1	104.75	97.43	112.64	5.42
CMH1	125.12	118.78	131.91	5.03
BTH1	43.89	26.00	64.00	9.91
HS1	5.47	4.64	6.85	0.73
TFD1	328.33	292.00	362.00	25.32
RSL	258.22	236.00	292.00	16.41
R20MFS	2.48	2.27	2.74	0.15
R20MLS	3.61	3.34	4.05	0.20

AM (arithmetic mean), MIN (lowest result), MAX (best result), SD (standard deviation)

The table 1. evidently shows the best and the worst results in addition to the medium values as well, however due to the lack of previous researches focusing on this issue, the values cannot be compared.

The influence of kinematic parameters on result in 60 meters hurdles race between the start and the first hurdle were observed in this research. The results of regression analysis are shown in table 2.

Table 2. Results of regression analysis between the start and the first hurdle on the criterion variable 60 meter hurdle race

	b*	t	p-value
R601H	0.98	2.66	0.021
R60T	-0.26	-1.04	0.321
NS1H	-0.30	-1.09	0.298
LLS1H	-0.68	-2.05	0.063
SLS1H	0.17	0.57	0.579

R = 0.91; R^2 = 0.83; Adjusted R2= 0.76; F(5,12) = 12.13; p < 0.00024
Std.Error of estimate: 0.40; b*-un standardised regression coefficient
t – value of testing the significance of regression coefficients, p – significance level

The results obtained by regression analysis reveal a considerable quantity of joint set information including 5 predictor variables and 60m run over hurdles results. We isolated 76% of the explained variance with multiple correlation coefficient R=0.83 (table 2).

In the predictor set of variables, the variable with the greatest influence on the criterion variable is the running time to the first hurdle (R601H) with coefficient b=0.98. The obtained results are similar to the results from previous researches conducted on senior subjects. This seems logical since the time of reaching the first hurdle also determines the dynamics of the run, i.e. the jumping over the other hurdles. The research conducted on female Olympic medal winners have revealed that the result efficiency in hurdle running asks for the most balanced rhythm possible, with the smallest possible loss of speed. Since the sample of subjects in this study involved cadets not included in many other researches, comparing them to the one on the seniors, we obtained the running time to the first hurdle as a variable with a significant influence, while we obtained no other important parameters such as speed or the length of the last step or the actual number of steps to the first hurdle, which was revealed as the significant one in senior subjects (Krzeszowsk et al. 2016; Babić et al. 2015; Smajlović and Likić 2011).These results can be explained by the subjects' age and the fact that they have not still fully acquired the hurdle running technique in the best way and have not reached their maximum development neither in morphological characteristics, nor in motor abilities.

Also, the set of five kinematic variables observed on the first hurdle show influence in table 3. on the result in 60 metre hurdles running.

Table 3. Results of regression analysis on the first hurdle on criterion variable 60 metre hurdle race

	b*	t	p-value
CM1	-0.08	-0.43	0.678
CMH1	0.41	2.48	0.029
BTH1	-0.12	-0.66	0.524
HS1	-0.77	-4.42	0.001
TFD1	-0.08	-0.55	0.592

R = 0.96; R^2 = 0.92; Adjusted R2= 0.89; F(5,12) = 28.78; p < 0.000
Std.Error of estimate: 0.27; b*-un standardised regression coefficient
t – value of testing the significance of regression coefficients,p – significance level

Further result analysis reveals there is a significant influence by the set of 5 predictor variables and results on 60m run over hurdles. We isolated 89% of the explained variance with the multiple correlation coefficient R=0.92 (table 3).

In the predictor variables set, the greatest influence on the criterion variable is horizontal speed variable (HS1) at the moment of crossing over the first hurdle with b=0.77, followed by body mass centre variable (CMH1) on the hurdle with b=0.41. While crossing over a hurdle, the crucial parameters are horizontal speed and body mass centre height on the first hurdle, both in accordance to the previous researches on older subjects, which were revealed by this analysis as well. The obtained results of the regression analysis reveal that during this phase, the subjects should work on their technique to achieve better results, while in seniors the significance of these variables may be explained by the best performance they can achieve and by reaching a constant, i.e. by losing as little time as possible while jumping over the hurdle and making flying optimum regarding the take-off distance before the hurdle and the distance between the leg and the crossed-over hurdle. This variable reveals that cadets with a higher horizontal speed and lower body mass centre achieve better results when crossing over the hurdles, i.e. they do not lose a lot of speed while jumping over the hurdles.

The motor tests which have the biggest influence are indicated by motor abilities test on result in 60 meters hurdles race are shown in table 4.

Table 4. Results of regression analysis on of motor tests on criterion variable 60 meter hurdle race

	b*	t	p-value
RSL	0.31	2.61	0.021
R20MFS	0.80	4.39	0.001
R20MLS	0.35	2.03	0.062

R = 0.95; R^2 = 0.89; Adjusted R2= 0.87; F(3,14) = 39.98; p < 0.000
Std.Error of estimate: 0.30; b*-un standardised regression coefficient
t – value of testing the significance of regression coefficients, p – significance level

The set of motor variables reveals there is a significant influence of the predictor set of variables on the results of 60m run over hurdles. We have isolated 87% of the explained variance with multiple correlation coefficient R=0.89 (table 4).

In the set of predictor variables, 20m run with flying start (R20MFS) has the greatest influence on the criterion variable with b=0.80 in addition to standing long jump (RSL) with b=0.31. These results are expected and logical so 20m run test with flying start is a motor test for assessing maximum running speed and the basis for its realization is the mechanism responsible for maximum fast involvement of agonists, antagonists and synergists which is essential for the one. The same mechanisms and musculature are responsible for efficiency in hurdle running. Standing long jump motor test measures explosive power, i.e. additionally measures maximum fast generating of extension muscle force in the ankles, as well as in the knees and the hips. At the moment of take-off and hurdle attack, the same musculature is engaged as in the previous test. The stated motor abilities are extremely important for the running part between the start and the first hurdle and for running between hurdles. Similar information was obtained in running and jumping researches(Pavlović at al.2016; Radulović et al. 2016; Blažević et al).

CONCLUSION

The aim of this research was to establish the influence of specific kinematic parameters on the result in 60m run over hurdles in athletes age 13-14 cadets category. The researchers applied a set of three motor tests and 10 kinematic parameters grouped into the groups of a set of parameters depicting the start and the starting acceleration and the set of parameters depicting the crossing over the first hurdle. For the criterion variable, the parameter was the 60m run over hurdles result. We measured results in 9 best cadets in the Republic of Croatia. The results were processed by regression analysis which revealed that there is a connection between the predictor set of variables and the criterion. Regression analysis of the first set of kinematic variables (running time to the first hurdle, reaction time, the number of steps to the first hurdle, the length of the last step, and the speed of the last step) showed that the greatest influence has the variable of running time from the very start to the first hurdle. Regression analysis of the second set of kinematic parameters (mass centre height at the moment of take-off from the ground, mass centre height on the first hurdle, horizontal speed at the moment body reaches maximum height, body tilting on the hurdle, and total flying distance over the first hurdle from the moment of take-off to the moment of descending over the hurdle).The results revealed two parameters essential for efficiency in 60m run over hurdles are horizontal speed variable and body mass centre height variable while crossing over the first hurdle. In the set of motor variables, the significant variables were standing long jump and 20m flying start.

The results are in accordance to the results obtained in older subjects athletes research. The results will enable to get the insight into the movement structure of older cadet athletes. These results can serve as guidelines for planning and programming training and for a better selection of younger athletes.

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UTJECAJ MOTORIČKIH SPOSOBNOSTI I NEKI SPECIFIČNIH KINEMATSKIH PARAMETRA NA REZULTATE U TRČANJU 60 METARA PREPONE

Sažetak

Cilj ovog rada je da se na temelju mjerenja utvrde utjecaji nekih motoričkih sposobnosti i specifičnih kinematičkih parametara na rezultat u trčanju 60 metara prepone. U tu svrhu na uzorku od 9 atletičara u dobi od 13-14 godina, kategorija starijih kadeta (atletičari su trčali dva puta u istim uvjetima i svaka trka se tretira kao entitet te je ukupno 18 entiteta) koji se natječu u disciplini preponskog trčanja primijenjen je skup od tri motorička testa te dvaju skupova specifičnih kinematičkih parametara. Skupom motoričkih testova procjenjivali smo bazičnu motoriku. Prvi skup specifičnih kinematičkih parametara opisuje start i startno ubrzanje. Drugi skup specifičnih kinematičkih parametara opisuje prelazak preko prve prepone. Primijenjena je regresijska analiza koja je iz skupa motoričkih sposobnosti izolirala varijable skoka u dalj s mjesta te letećeg starta na 20 metara kao varijable značaja, dok se kod kinematičkih parametara iz prvog skupa varijabli izoliralo vrijeme trčanja od starta do prve prepone kao varijablu s bitnim utjecajem, a iz drugog skupa varijable horizontalna brzina te visina centra mase tijela na preponi. Na temelju dobivenih rezultata možemo zaključiti da su dobiveni rezultati pod utjecajem bazičnih motoričkih sposobnosti i nekih kinematičkih parametara koji su specifični za preponsko trčanje.

Ključne riječi: atletičari, prepone, kinematika, kadeti

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