A WORLD BIO-KINEMATIC MODEL TO EVALUATE ACHIEVEMENTS OF TRIPLE JUMP PLAYERS FOR THE ADVANCED IRAQI

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Abstract

The triple jump is one of the vital and important games in the program of track-and-field games. In addition, it is considered one of the technical games as, in performance; it depends on a lot of kinematic variables. Generally, it includes many consecutive technical phases which require research for the purpose of raising the level of technical performance and achieving new Iraqi records. The study aims to determine the values of kinematic values for the world champions and Iraq advanced category champions and put a model for each phase of triple jump performance phases (hop, stride and jump) with the significance of the kinematic variables proposed by the staff which consists of 18 researchers supported by the World Federation of Athletics in Berlin, 2009 and Daegu 2011 for track-and-field games. Population of the study was represented in jumpers and participants in Iraq's clubs and institutions championship held in the capital, Baghdad, on 22/10/2014. The sample of the study was chosen from the top eight. 26 attempts were analyzed of the total of six legal attempts for each jumper and comparing them with 16 attempts of world champions. 4 video cameras with frequency speed of 300 P/s were used and put on the left side of the approaching road on a distance of 7 m. the following variables: (speed and its decrease, touch and take-off angles, angles of knee and trunk, distance of each phase, touch times, etc) were used. The study reached three different models for each phase separately.

Among the most important conclusions, there are: the variable of support duration came at first place of importance in all extracted models and all technical phases, the Iraqi model for the advanced gives importance for not losing horizontal speed at the hopping phase. As for the world model, it does not give great importance for this variable as it does not tend to decrease horizontal speed, but keeping it, the model of Iraqi jumpers is more stable than the world model at both phases of hopping and stride and the reverse in jumping phase. There is an inverse relation in some variables between the world and Iraqi models which means that there is a difference in performance method.

KEYWORDS: Achievement. Triple jump.

1. INTRODUCTION & PROBLEM OF THE STUDY

The triple jump is one of the vital and important games in athletics programs. It is also considered a tactical sport because it depends in performance on many kinematic variables. In general, it includes a lot of consecutive technical phases that made it necessary to research and explore the basic variables through which technical performance level can be enhanced. Therefore, kinematic variables of any performance provide the right basis for teachers and trainers when it comes to teaching or training a certain sport skill. This is through finding suitable solutions for barriers standing before players to make optimal performance of the skill. In fact, there are some of kinematic variables which affect performance efficiency and quality such as approach angles, pushing at take of moments, touching times for each phase. According to these variables, distance of each phase can be determined and, as a result, total distance of each achievement. It is difficult to separate the overlapping variables of each phase as players need to perform these variables optimally to reach achievement. Due to the repetition of take-off phases in triple jump, there is a great importance for the nature of performing these variables to achieve the goal of this game.

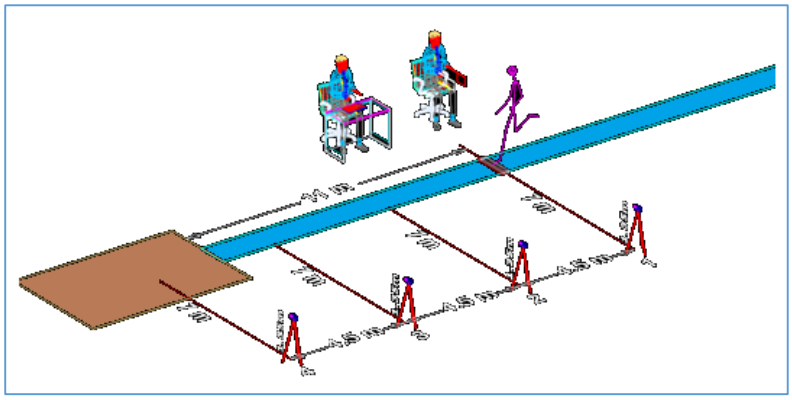
Poor achievement level is noticed in triple jump for Iraqi athletes through the comparison of past and current records. We found that the best Iraqi achievement was recorded at the level of 2015 applicants with the name of jumper Nezar Akram (15.05 m), while we find that the best record was in 1996 by the name of jumper Majed Abdelsada (16.50 m). This shows poor levels in Iraqi performance records. The Iraqi record is "(1.67 m) a way far behind the Arab record (for the youth) recorded by jumper, Mohamed Youssef (16.57) in 2004. This wide difference in numbers requires research for reasons of these results in the light of bio-kinematic results proposed by the assigned bio-kinematic team by the International Association for Athletics Federations (I.A.A.F). Methods proposed in this study are important to evaluate achievement according to models that will be designed through knowing the quantitative importance of each bio-kinematic variable in the designed models. The significance of the study comes from showing strength and weak points in performance appraisal after analyzing the most important bio-kinematic variables of world champions and Iraq advanced champions in addition to determine the order of variables in phase models according to their importance regarding the extracted values. The goal of the study is to:

1- Examine world and Iraqi models according to bio-kinematic variables for each of the technical phases in triple jump for world champions and Iraq's advanced champions.
2- Compare both models and determine the order of variables contributing in each model and percentage of contributing with increase or decrease in distance of each phase of the game (hopping, stride and jumping).

2. METHODOLOGY

Top eight advanced jumpers were selected according to final results of Iraq's Clubs and Institutions Championship held in Baghdad on 22/10/2014. Their anthropometric measurements are: (length: 179 cm 7.59±, weight: 72.37 kg 7.81±). Successful attempts were analyzed due to regulations of the game's international federation (26 attempts: 6 legal attempts for each jumper and 16 attempts for world champions.

Bio-kinematic analysis results were approved by the bio-kinematic team consisting of 18 researchers from six institutions in Germany in planning a great project about biomechanics and organizing it to be applied in international championships and with support of the German federation of athletics (DLV) and the International Association for Athletics Federations (I.A.A.F) (New Studies in Athletics, p. 195) including triple jump. The set of kinematic variables was divided according to technical phases of the game to reach a model for each phase. The sample of the study was pictured at three pm on Friday 24/10/2014 using 4 video cameras (300 pics/s) spreading along the technical phases and according to approved measurements from analysis of world champions. Camera (1) was put 7 meters to the left of the player at the edge near the approach path in a perpendicular position on the take-off panel. At a height of 1.35 m, cameras (2, 3 and 4) are put to the left in a distance of 4.50 m from each other as shown in table (1 – 2):



Form (1 – 2): Field of the main trial and dimensions of the used cameras in the study

3. RESULTS AND DISCUSSION

Analysis & Discussion of Models:

Analysis & Discussion of the Hopping Model:

Table (1 – 3): Bio-kinematic variables for the hopping phase for world and Iraqi champions:

No.	Variables	World Championships		Iraq Championships	
		Mean	Std.	Mean	Std.
1	**Stride Length** (2L)	2.545	0.152	2.151	0.273
2	**Horizontal velocity** (2L)	10.153	0.196	9.180	0.510
3	**Stride Length** (1L)	2.394	0.124	2.103	0.180
4	**Horizontal velocity** (1L)	10.239	0.248	9.128	0.462
5	**Inclination angle at touch-down**	18.938	2.720	20.615	3.371
6	**Trunk angle (touch-down)**	89.688	3.260	87.423	4.483
7	**Horizontal velocity**	9.387	0.389	8.858	0.527
8	**Vertical velocity**	2.256	0.280	2.859	0.619
9	**Loss of horizontal velocity**	0.851	0.294	0.468	0.359
10	**Minimal Knee angle**	138.375	9.373	134.846	6.851

11	**Average velocity of the lead leg**	652.750	90.676	691.058	54.975
12	**Duration of the support phase**	0.125	0.011	0.135	0.011
13	**Trunk angle (take-off)**	88.500	3.120	81.615	4.997
14	**Angle of take-off**	13.544	1.701	16.885	2.535
15	**Hop length**	6.351	0.230	4.976	0.370

Table (2 – 3): Results of teachers' values, importance and order of kinematic variables for the hopping phase according to teachers' values in both models (world and advanced Iraqi models):

No.	Variables	World Championships			Iraq Championships		
		Beta	VIF	Beta Rank	Beta	VIF	Beta Rank
	Constant	-1.45813			6.63517		
1	**Stride Length** (2L)	-0.277818	1.98	6	0.22242	3.84	2
2	**Horizontal velocity** (2L)	0.557564	4.08	2	0.158944	3.80	5
3	**Stride Length** (1L)	-0.43876	1.39	3	0.0516801	3.47	8
4	**Horizontal velocity** (1L)	0.282782	2.79	4	0.0519642	1.55	7
5	**Inclination angle at touch-down**	-0.00019618	2.77	14	0.0296937	1.84	9
6	**Trunk angle (touch-down)**	0.0361567	1.93	10	-0.00898384	2.24	11
7	**Horizontal velocity**	-0.0116736	0.76	11	0.200567	1.06	4
8	**Vertical velocity**	0.280823	2.31	5	-0.113211	1.74	6
9	**Loss of horizontal velocity**	0.203526	1.28	7	-0.219031	1.00	3
10	**Minimal Knee angle**	-0.00330952	2.94	12	-0.00712321	1.93	12
11	**Average velocity of the lead leg**	0.000429845	3.54	13	0.00004707	1.86	14
12	**Duration of the support phase**	5.47175	4.59	1	-20.4584	2.53	1
13	**Trunk angle (take-off)**	-0.0450521	2.42	8	-0.020026	1.82	10
14	**Angle of take-off**	0.0409345	2.82	9	-0.00477954	1.75	13
	R^2	76.6043			81.033		
	DW	2.25165			2.36631		
	MSE	0.151982			0.0505647		

Table (4 – 4) shows values of data inflation factor (VIF) that did not exceed the value (10) which means that independent variables do not include overlapping of lines and this contributes to accurate model building. On the other hand, from its big number, this factor shows that the value lies between (2.5 – 1.5) and multiple correlation coefficient square among independent variables and the dependent variable (hopping distance) (R^2) is accepted to show the importance of the model. The higher is the value, the more accurate the model is. The small MSE value shows close spread of values on regression line which means that the advanced model is more stable than the world athletes' model. It is also noticed through Beta order of variables according to teachers that supporting duration at the moment of touching in the front position came as primary importance, but there is an inverse relation in the advanced model compared with the world model. This means that reducing time in a single unit rate means reduction in 0.14 s instead of 0.15 s which leads to increase achievement in a value of 0.205 m (20 cm and 5 ml). In addition, supporting duration is inversely related to force that can be explained as ground pushing force and from the following rule: force = momentum / time. We can notice that force is inversely related to time (Hussein & Eiad, 2011). Moreover, the increase in touch duration affects the take-off angle which is the adopted method in the world model. The order of the maximum bending for knee angle was the same in both models as the less this angle is the more the distance will be. Through our information, this angle determines the amount of pushing through extension in order to lead body mass center towards a suitable direction with taking-off curve at this phase. One of the important variables between both models is the variable of horizontal velocity loss from 0.33 m/s to 0.32 m/s which means a change in a single unit leading to increase achievement in a value of (2 ml) at the hopping phase. As for the world model, this variable is not given great importance as it is not inclined to reduce horizontal velocity loss, but to maintain it as there are few parts that were changed in this independent variable compared with the supporting duration for example. As for the variable of horizontal velocity of the stride, it came second in terms of ordering variables due to teachers' values of the world model and came fifth in terms of the advanced model. When this variable increased with an amount of 1 cm/s for the world model, it will increase achievement distance with 6 ml. when this variable increases with the same amount for the advanced, achievement distance will increase with a value of 2 ml. we can notice that this slight increase in this variable will increase achievement distance, but this increase should be within suitable limits of the advanced jumpers. Therefore, we have to realize the great importance of this variable during training process to raise the level of achievement. As for the last stride distance length variable, it came at third place in terms of variable order according to teachers' values of the world model and came eighth in terms of the advanced model, but there is an inverse relation

in the world model compared with the advanced one. This shows that the 1 cm decrease in this variable's value found in the world champions will increase achievement distance in hopping (4 ml). As for this variable's 1 cm increase for the advanced jumpers will increase hopping distance (1 ml). The amount of increase for the world champions is bigger than the advanced, so we should work on developing the last stride distance length whose importance was explained in acquisition of horizontal velocity previously.

The variable of horizontal velocity of the last stride came fourth in terms of variables order according to teachers' values of the world model and came seventh in the advanced model. The increase of this variable's value (1 cm/s) for world champions will increase hopping achievement distance (3 ml) and its 1 cm increase for the advanced will increase hopping achievement distance (1 ml). As for the variable of vertical take-off velocity, it came at fifth place in terms of variables order according to teachers' values of the world model and sixth in terms of the advanced model, but there is an inverse relation in the latter compared to the former. The increase in this variable's value (1 cm/s) for the world model will increase hopping achievement distance (3 ml), but decreasing this value (1 cm) for the advanced will increase achievement distance (11.3 cm).

The variable of distance of stride before the last came at sixth place in variables order according to teachers' values of the world model and came second in the advanced model, but there is an inverse relation in the world model compared with the advanced which shows the (1 cm) decrease in this variable for the world model which will increase hopping achievement distance (3 ml). In case of increasing the value of this variable (1 cm) for the advanced, this will increase hopping achievement distance (3 ml). As for the increase of this variables' value (1 cm) for the advanced model, it will increase hopping achievement distance (2 ml). Concerning the variable of trunk angle at the release moment, it came at eighth place in terms of variables order according to teachers' values for the world model and at tenth place in terms of the advanced. It is noticed that teachers' values in both models hold negative sign which means that the decrease in the value of this variable (1 degree) for the world model will increase achievement distance (45 ml), but its decrease in value with the same previous variable will increase achievement of the advanced (20 ml). As for the variable of take-off angle, it came at ninth place in terms of variables order according to teachers' values for the world model and at thirteenth place in terms of the advanced model, but there is an inverse relation in the advanced model compared with the world model which shows that the increase of this variable's value (1 degrees) for the world model will increase hopping achievement distance (14 ml), but its decrease (1 degree) for the advanced will increase hopping achievement distance (5 ml). As for the variable of take-off touch trunk angle, it came at tenth place in terms of variables order according to teachers' values for the world model and at eleventh place in terms of the advanced model, but there is an inverse relation in the advanced model compared with the world model which shows that the increase of this variable's value (1 degrees) for the world model will increase hopping achievement distance (36 ml), but its decrease (1 degree) for the advanced will increase hopping achievement distance (9 ml). As for the variable of horizontal velocity for take-off, it came at eleventh place in terms of variables order according to teachers' values for the world model and at thirteenth place in terms of the advanced model, but there is an inverse relation in the advanced model compared with the world model which shows that the increase of this variable's value (1 cm/s) for the world model will increase hopping achievement distance (20 ml). As for the variable of trunk inclination angle at touch moment, it came at fourteenth place in terms of variables order according to teachers' values for the world model and at ninth place in terms of the advanced model, but there is an inverse relation in the advanced model compared with the world model which shows that the increase of this variable's value (1 degrees) for the world model will increase hopping achievement distance (30 ml).

Discussion & Analysis of Stride Model:

Table (3 – 3): Bio-kinematic variables for the stride phase for world champions and Iraqi champions:

No.	Variables	World Championships		Iraq Championships	
		Mean	Std.	Mean	Std.
1	**Inclination angle at touch-down**	20.687	2.182	19.115	3.603
2	**Trunk angle (touch-down)**	90.125	3.052	90.307	4.831
3	**Horizontal velocity**	8.293	0.187	8.217	0.666
4	**Vertical velocity**	1.998	0.171	2.282	0.677
5	**Loss of horizontal velocity**	1.091	0.297	0.641	0.515
6	**Minimal Knee angle**	132.687	7.542	132.692	9.268
7	**Average velocity of the lead leg**	574.25	70.180	618.758	81.889
8	**Duration of the support phase**	0.163	0.012	0.156	0.014
9	**Trunk angle (take-off)**	81.437	3.915	77.769	4.667
10	**Angle of take-off**	13.606	1.311	16.230	2.371
11	**Step length**	5.271	0.262	3.940	0.321

Table (3 – 4): Results of teachers' values and importance of ordering kinematic variables for the stride phase according to teachers' values in world and advanced models.

No.	Variables	World Championships			Iraq Championships		
		Beta	VIF	Beta Rank	Beta	VIF	Beta Rank
	Constant	2.01727			3.72243		
1	**Inclination angle at touch-down**	-0.0492	2.27	6	0.013757	3.43	7
2	**Trunk angle (touch-down)**	0.00605	1.06	9	-0.0135984	2.36	8
3	**Horizontal velocity**	0.17025	1.87	3	0.424545	4.88	2
4	**Vertical velocity**	0.10945	2.63	5	-0.0930085	3.85	4
5	**Loss of horizontal velocity**	0.17989	1.56	2	0.298491	2.59	3
6	**Minimal Knee angle**	-0.0142	2.17	8	-0.00478979	2.89	9
7	**Average velocity of the lead leg**	-0.0019	2.31	10	-0.00043763	4.75	10
8	**Duration of the support phase**	5.45335	3.89	1	-8.15337	5.01	1
9	**Trunk angle (take-off)**	0.02431	1.69	7	-0.0177973	1.64	6
10	**Angle of take-off**	0.14883	2.65	4	0.0789884	4.01	5
	R^2	62.8289				78.1683	
	Adjusted R^2	-			63.6139		
	DW	1.17065			1.94123		
	MSE	0.0678711			0.0376246		

It is noticed through Beta order of variables according to teachers that supporting duration at the moment of touching in the front position came as primary importance and the same order in both models, but there is an inverse relation in the advanced model compared with the world model. This means that increasing this model's value (0.01) of the second for the world model will increase achievement distance (55 ml) and when this variable's value decreases by the same previous variable for the advanced, it will increase achievement distance (82 ml). We can also notice that thigh angular velocity variable for the leading foot came at the same order in both models with negative sign. This shows the decreasing value of this variable for both models will increase stride achievement distance. As for loss of horizontal velocity, it came at second place in order according to teachers' values of the world model and at third place for the advanced model. It is also noticed that teachers' values for both models hold positive sign which means that increasing the value of this variable (1 cm/s) for the world model will increase stride achievement distance (2 ml). When this variable increases by the same previous amount for the advanced, it will increase stride achievement distance (3 ml). As for loss of horizontal release velocity, it came at third place in order according to teachers' values of the world model and at second place for the advanced model. It is also noticed that teachers' values for both models hold positive sign which means that increasing the value of this variable (1 cm/s) for the world model will increase stride achievement distance (2 ml). When this variable increases by the same previous amount for the advanced, it will increase stride achievement distance (4 ml). By this method, we are able to further explain other variables.

Discussion & Analysis of Jumping Model:

Table (5 – 3): Bio-kinematic variables for the jumping phase for the world and Iraqi champions:

No.	Variables	World Championships		Iraq Championships	
		Mean	Std.	Mean	Std.
1	**Inclination angle at touch-down**	21.25	2.435	19.5	2.319
2	**Trunk angle (touch-down)**	90.125	3.052	86.96154	5.134049
3	**Horizontal velocity**	7.014	0.299	6.215	0.726
4	**Vertical velocity**	2.501	0.295	2.551	0.632
5	**Loss of horizontal velocity**	1.281	0.260	2.001	0.894
6	**Minimal Knee angle**	138.375	5.389	133.384	7.526
7	**Average velocity of the lead leg**	519.5	55.480	549.035	70.134
8	**Duration of the support phase**	0.179	0.015	0.18	0.015
9	**Trunk angle (take-off)**	76.1875	5.833	75.730	6.508
10	**Angle of take-off**	19.762	2.615	17.346	2.841
11	**dist.**	0.456	0.120	0.316923	0.055192
12	**Knee angle (Landing)**	131.875	23.448	146.230	7.875
13	**Hip angle (Landing)**	75.0625	23.459	67.307	15.795
14	**Trunk angle (Landing)**	66.25	20.305	49.269	12.650
15	**Jump length**	5.922	0.290	4.565	0.374

Table (6 – 3): Results of teachers' values, significance and order of kinematic variables for the jumping phase according to teachers' values in world and advanced models.

No.	Variables	World Championships			Iraq Championships		
		Beta	VIF	Beta Rank	Beta	VIF	Beta Rank
	Constant	5.5505			6.49442		
1	**Inclination angle at touch-down**	-0.0741785	3.04	6	-0.00483234	2.15	10
2	**Trunk angle (touch-down)**	-0.00713303	1.53	10	-0.0148247	2.20	7
3	**Horizontal velocity**	0.950018	3.53	3	0.465669	3.62	2
4	**Vertical velocity**	0.463325	1.78	4	0.237051	2.36	4
5	**Loss of horizontal velocity**	0.3557	2.48	5	0.270208	3.08	3
6	**Minimal Knee angle**	-0.0136026	1.63	8	-0.0130624	1.94	8
7	**Average velocity of the lead leg**	-0.00118873	1.80	12	-0.00187573	3.39	14
8	**Duration of the support phase**	-4.5013	3.14	1	-12.1315	3.88	1
9	**Trunk angle (take-off)**	-0.0328051	3.99	7	-0.00686695	2.30	9
10	**Angle of take-off**	0.00437451	1.68	11	0.0155304	2.20	6
11	**dist.**	1.57894	3.58	2	-0.128724	2.38	5
12	**Knee angle (Landing)**	-0.00109365	2.28	14	0.00397018	2.30	12
13	**Hip angle (Landing)**	0.00112531	3.39	13	-0.0029912	3.87	13
14	**Trunk angle (Landing)**	-0.00976671	2.37	9	0.00419194	4.21	11
	R^2	86.631			75.4378		
	Adjusted R^2	-			44.1768		
	DW	2.20458			2.1891		
	MSE	0.0475969			0.0630864		

It is noticed through Beta order of variables according to teachers that supporting duration at the moment of touching in the front position came as primary importance and the same order in both models. It is noticed that teachers' signs hold negative signs which means that the decrease in this variable's value (0.01) of the second for the world model will increase achievement distance (45 ml) and when this variable's value decreases by the same previous variable for the advanced, it will increase achievement distance (12.1 cm). We can also notice that thigh vertical velocity variable for the release came at the same order in both models with positive sign. This shows the increasing value of this variable (1 cm/s) for the world model will increase achievement distance (4 ml). As for the increase of this variable's value (1 degree) for the advanced, it will increase achievement distance (13 ml). As for thigh angle at landing, it came at the same order in both models. It is also noticed that there is an inverse relation for the advanced model compared with the world model which means that increasing the value of this variable (1 degree) for the world model will increase jumping achievement distance (1 ml). When this variable increases by the same previous amount for the advanced, it will increase stride achievement distance (3 ml). As for the variable of distance of weight center to thigh edge, it came at second place in order according to teachers' values of the world model and at fifth place for the advanced model. It is also noticed that there is an inverse relation for the advanced model compared with the world model which means that decreasing the value of this variable (1 cm) for the advanced model will increase jumping achievement distance (1 ml). When this variable increases by the same previous amount for the advanced (1 ml), it will increase jumping achievement distance (1 ml). In case of this variable's increase (1 cm) for the world model, it will increase jumping achievement distance (16 ml) by this method, we are able to further explain other variables.

4. CONCLUSIONS

1- The variable of support duration came at primary importance at all models and for all technical phases for the world and Iraqi champions.
2- The advanced Iraqi model gives importance to the loss of horizontal velocity at hopping phase, but the world model does not give it great importance and does not tend to reduce the loss of horizontal velocity but to keep it.
3- The model of Iraqi jumpers is more stable than the world model at hopping and strides phases unlike the jumping phase.
4- There is a inverse relation at some variables between world and Iraqi models which means that there is a difference in performance method.
5- Order of bio-kinematic variables was not the same between both models in most cases.

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