Kinematic Analysis of Ultimate Stride Length and Take-Off of Fosbury Flop High Jumpers

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Abstract— **INTRODUCTION: The Fosbury Flop high jump technique consists of a run up, take-off, flight and landing. Among these four phases the take-off is the key to performance. The run up will influence take-off technique and body movements in flight. Therefore the final stride of the run up is the transitional phases connecting the run up and take-off. Many studies have measured the take-off parameters of high jumpers in competition situations. These measurements will provide useful feed back to the coach as well as high jumpers. The purpose of this study was to analyze kinematic variables of take-off i.e. the movement time of different phases of take off and knee and approach angles of final stride of the run up of three top junior state level athletes of Andhra Pradesh using the Fosbury Flop technique. METHOD: Three male high jumpers were filmed through two Panasonic-AG-DVX-102B,F11 sensitivity, high image quality, camcorders during their competitive performance in the Andhra Pradesh inter district junior athletics championship from 6th July to 8th july,2012 held at GMC Balayogi athletics stadium, Hyderabad, India. The best valid and failed jumps were taken from each fosbury flop athlete for the analysis used by the quintic biomechanics 9.03 V 17 (motion analysis). The kinematic variables which were selected in the study were 1) Reaction and movement time of last stride and the instant the take-off 2) Knee and approach angles of last stride and the instant take-off. Collected data were analyzed by t test for comparison of the kinematic parameters between successful and unsuccessful jump. A level of significance was set at 0.05.RESULTS: This study indicated that all the three jumpers who have used the fosbury flop technique have shown insignificant differences on the variables tested. CONCLUSION: In this study data was collected only on two variables of take off. i.e. speed and angles. The standing height and leg lengths were also collected. However, to establish the relationship between the anthropometric measurements of the athletes and the performance, there is a need to obtain more data of the athletes participating at different levels of competitions.**

Index Terms— **Kinematic, Approach angle, Quintic biomechanics, Anthropometric**

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I. INTRODUCTION

The fosbury flop high jump technique consists of a run up, take-off, flight and landing. Among these four phases the take-off is the key to performance. The run up will influence take-off technique and body movements in flight. Therefore the final stride of the run up is the transitional phases connecting the run up and take-off. Many studies have measured the take-off parameters of high jumpers in competition situations.

The take-off plays an important role on the high jump performance. The literature has presented several studies using kinematic parameters, there are very few studies using dynamic parameters to evaluate the take-off (Coh &Supej, 2008).In contrast to other jumps, the high jump presents an increased complexity due to the curvilinear approach-run pathway imposing a three dimensional analysis of the movement. On the other hand, the point where the jumpers perform the take-off differs considerably for different subjects. For those reasons research presented in the literature is fundamentally based in the kinematics of the approach run and take-off. The purpose of this study was to analyze kinematic variables of take-off i.e. the movement time and knee and approach angles of final stride of the run up of three top junior state level athletes of Andhra Pradesh using the Fosbury Flop technique.

Athletes taking off for a high jump set a foot down on the ground well in front of the body with the leg almost straight. The knee flexes and then extends before the foot leaves the ground for the jump.

The foot remained in contact with the ground for a time of only about 120 ms for our typical male athletes but the real athletes maintained contact with the ground for 155ms(Aura&Viitasalo 1989) or 185ms (Dapena & Chung 1988). The discrepancy must be due at least in part to the athlete's length of a foot. The toes of high jumpers remain on the ground for some time after the heel has left it. Also the force exerted by the athlete rises rapidly to its initial peak because no account is taken of the elastic properties of the foot and shoe. These measurements will provide useful feed back to the coach as well as high jumpers. The results from this work may help to improve performance of high jumpers in Andhra Pradesh.

II. METHODOLOGY

Subjects:

Three male high jumpers were filmed during their competitive performance in the Andhra Pradesh inter district junior athletics championship from 6th July to 8th july,2012 held at GMC Bal yogi athletics stadium, Hyderabad, India.

The best valid and failed jumps were taken from each fosbury flop athlete for the further analysis.

Tools and equipments:

Biomechanical analysis requires specific tools and equipment to capture and analyze the data. The experimental apparatus used in this research work were two Panasonic-AG-DVX-102B,F11 sensitivity, high image quality, camcorders, measuring tape and the Quintic Biomechanics 9.03 v17 motion analysis software.

Collection of data and filming protocol:

For the collection of kinematic data two Panasonic camcorders was mounted. One camcorder was mounted at left standard line and another camcorder was mounted in front of the crossbar. Two camcorders captured the video clippings of left leg take-off fosbury flop jumper's last two strides. All the attempts of the selected subjects were recorded during the competition. When they cleared the bar on a particular height was taken as successful jump and when they were unable to clear the bar at a particular height was taken as unsuccessful jump. Analysis were conducted using the quintic biomechanics 9.03 V 17 (motion analysis). The kinematic variables which were selected in the study were 1) movement time of last stride and the instant the take-off 2) Knee and approach angles of last stride and the instant take-off.

1) Movement time of last stride and the instant the take-off. Technique variables were free leg touchdown(FT),take-off foot touchdown(TD),take off foot set down(TS),take off foot toe off(TO) and from touchdown to toe off(TD-TO).
2) Knee angels of last stride and the instant the take-off and Approach angle of take-off. Technique variables were touchdown knee angle(TD), knee lowest(KL),toe off(TO).take off foot approach angle(AA)

Acquired data were subjected to statistical analysis by't' test for comparison of the kinematic parameters between successful and unsuccessful jump. All statistical procedures were conducted using the SPSS 16.0 software. A level of significance was set at 0.05.

Table 1: Anthropometrical data of junior fosbury flop high jump athletes.

Athletes	Age	Height (cm)	Leg length (cm)	Knee to toe length(cm)	Weight (kg)	Hip centre to 5cms above	Best performance (cm)
A. R. Kumar	18	177	94	53	68	99	175
Y. Yeshwanth	16	170	90	50	60	95	178
D. laxmikanth	16	165	87	49	50	92	170
MEAN	16.67	170.67	90.33	50.67	59.33	95.33	
SD	0.82	4.26	2.48	1.47	6.38	2.48	

The data indicates that the averages age of the junior athletes was 16.67±0.82 years with an average height of 170.67±4.26cm, average leg length was 50.67±1.47 cm and average weight was 59.33±6.38 kg. Among the three subjects Y.Yeshanth has shown the highest performance of 178 cm. The location of centre of mass of a athlete was calculated while standing erect with the arms by the side, is about 5 cm above the centers of the hip joints (Dyson 1973)

Table 2: Movement Timings of three subjects during takeoff phase.

Variable		A.R. KUMAR		Y.YESHWANT		D.LAXMIKANTH	
		Successful	Unsuccessful	Successful	Unsuccessful	Successful	Unsuccessful
FT	Mean	133.00	123.33	100.00	122.00	122.00	124.33
	SD	0.00	14.36	0.00	13.47	13.47	13.06
TD	Mean	167.00	168.67	211.33	155.67	234.00	113.33
	SD	0.00	2.04	13.88	54.30	0.00	56.75
TS	Mean	33.00	33.33	33.00	33.00	33.00	33.33
	SD	0.00	0.41	0.00	0.00	0.00	0.37
TO	Mean	211.33	224.67	167.00	167.00	211.33	202.00
	SD	13.88	11.43	0.00	0.00	13.38	2.45
TD-TO	Mean	245.00	236.00	200.00	211.30	245.00	247.00
	SD	13.47	2.45	0.00	13.88	13.47	12.43

Note: Unit of measurement: mille seconds

Table 3: Knee and approach angles in degrees of three subjects during takeoff phase.

Variable		A.R.KUMAR		Y.YESHWANTH		D.LAXMIKANTH	
		Successful	Unsuccessful	Successful	Unsuccessful	Successful	Unsuccessful
TD	Mean	158.18^0	156.05^0	147.80^0	154.34^0	157.99^0	162.20^0
	SD	2.78	4.75	5.41	1.48	3.77	3.79
KL	Mean	131.03^0	126.75^0	134.85^0	138.91^0	130.67^0	137.94^0
	SD	3.37	3.08	1.90	7.21	5.58	3.52
TO	Mean	169.14^0	169.13^0	176.06^0	170.94^0	161.49^0	171.78^0
	SD	2.94	7.22	3.61	3.81	2.34	2.81
AA	Mean	45.29^0	44.77^0	42.44^0	44.41^0	50.29^0	49.18^0
	SD	1.06	2.12	2.64	1.45	2.42	2.49

The researcher reached at the results of this empirical investigation which is presented by the respective tables and graphs. Through this study the scholar found that FT took less time than TD because jumper's centre of mass

should be kept low by keeping free leg knee low and both arms swing back and take off leg extended forward ahead of the body for favorable condition to take-off that is why TD took higher time than FT.

In TS the time taken for foot (heel to toe) set down on the ground was very low than TO. After foot set down the position of the body leans back for mechanical advantages of forward rotation and double swing (arms bring forward and upward) as well as free leg knee bring high at waist level so naturally TO takes more time than TS.

Table 4: Difference of movement time (Unit:ms) and knee and approach angles between successful and unsuccessful jumps.

Movement Time					Knee And Approach Angles			
Variable		Successful (msec)	Unsuccessful (msec)	t value	Variable	Successful	Unsuccessful	t value
FT	Mean	118.33	123.22	**0.55**	TD	154.66^0	157.53^0	0.36
	SD	15.56	14.97			6.45	5.09	
TD	Mean	204.11	145.89	**0.02**	KL	132.18^0	134.53^0	0.49
	SD	27.82	54.51			4.65	7.54	
TS	Mean	33.00	33.22	**0.15**	TO	168.90^0	170.62^0	0.6
	SD	0.00	0.39			6.54	5.56	
TO	Mean	196.56	197.89	**0.92**	AA	46.01^0	46.12^0	0.95
	SD	23.39	23.69			3.88	3.06	
TD-TO	Mean	230.00	231.44	**0.9**				
	SD	23.46	18.48					

*Significant at 0.05 level of significance t 0.05,07=2.306

These results found that the mean differences of each variable of movement time of FT, TS, TO and TD-TO was not much difference between successful and unsuccessful jumps. The difference between means was not significantly different at 0.05. . In case of TD (take-off foot touchdown) was showed variation in means between successful and unsuccessful jumps and the difference between means was statistically significant at the 0.05 level and higher. This was showed in the figure: 1 bar diagram.

The scholar also found that the mean differences of each variable of knee angles at TD, KL and TO as well as approach angle of AA were not much difference between successful and unsuccessful jumps. The difference between means was not significantly different at 0.05 level.

Figure 1. Comparison of movement time between successful and unsuccessful jumps.

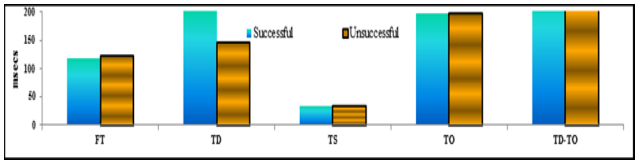
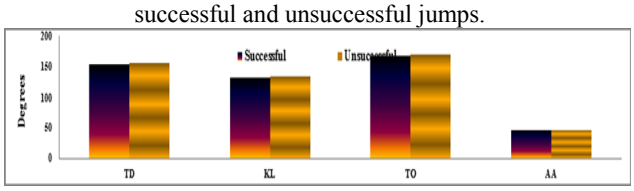


Figure 2. Comparison of knee and approach angles between successful and unsuccessful jumps.



Above first graph in figure 1 shows the movement time difference between successful and unsuccessful jumps. At all phases the there is not much difference between successful and unsuccessful jumps except at touchdown. In figure no.2 the graph shows the knee angle and approach angle difference between successful and unsuccessful jumps but no difference was found.

III.SUMMARY AND CONCLUSION

As documented from the results of this study it was concluded that insignificance differences were found between successful and unsuccessful fosbury flop high jump technique of Andhra Pradesh junior level high jumpers in their movement time variables except take off foot touchdown (TD) and in angles part insignificant difference were found between successful and unsuccessful jumps because all the calculated t values were lower than tabulated t value. It is not necessary for every player to have the same movement time and knee and approach angles at various stages. In high jump the performance depended on many factors. The prime factors are individual strength, standing height and take-off technique. The muscle strength of the legs is an important component contributing to the successful performance of high jump. Therefore, it is of important theoretical and practical value to evaluate the difference in muscle strength of legs between the different levels of athlete.

We can also conclude that cross bar may falls off in different ways and the way the crossbar falls off clearly indicate the possibilities of what the jumper has committed fault. Unsuccessful jump has to be analyzed by the coach as well as the athlete for improving performance. According to Dapena that the entire take-off phases from the instant the take-off foot touches the ground (touchdown) to the instant it loses contact with the ground (toe-off) lasts from 140 to 180ms. In this study the subjects took more time than elite athletes. The mean approach angle of three subjects was below 47^0 degrees than the range from 47^0 to 54^0 degrees for optimum jump reported by Dapena.

RECOMMENDAIONS

1) These observations suggest that, athletes would be improved their strength of the legs so that they can improve their movement time as quickly as possible as well as optimum knee angle may be maintained during takeoff phase.

2) Coaches and athletes should be concentrated on weak points for perfection in training sessions to improve performance.

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