Biomechanical Analysis of Centre of Mass Height during the Takeoff Phase In Fosbury Flop High Jump of National Level Participants

Ch. Raja Rao, Prof. Y. Kishore, Dr. J.Ramamohan Rao

***Abstract*— The high jump is one of the most technical and complex proof of the athletics this proof can be divided into four phases: the approach run, the takeoff, the flight or bar clearance and landing. To clear a high jump bar it is necessary to drive the centre of mass of the athlete to the largest height possible. The purpose of the present study was Biomechanical analysis of the centre of mass height during takeoff phase of Indian national fosbury flop high jumpers during their competitive performance**

***Methodology*: Thirteen male national high jumpers were selected for this study and get videotaped with three high speed video cameras during their competitive performance in the men's high jump final during the 52nd National open athletics championship. Thirty three valid attempts of the thirteen finalists were recorded during the competition. . Conclusion: The variations in CoM height may be attributed that in fosbury flop high jump depends on anthropometric factors which are linked to centre of mass Amuscular plyometric qualities to jump high and ability to clear the bar.**

***Index Terms*— Biomechanics, Fosbury flop, Quintic,**

I. INTRODUCTION

The high jump is one of the most technical and complex proof of the athletics; this proof can be divided into four phases: the approach run, the takeoff, the flight or bar clearance and landing. The most important and critical phases of the jump are the approach run and takeoff, the bar clearance is a direct consequence from previous phases.

The peak height of the mass centre during the flight over the bar is dependent on the height and vertical velocity of the mass centre at toe-off. The mass centre height at toe-off is largely dependent on the standing height of the athlete and so the high jumper should therefore strive to maximize the vertical mass centre velocity at toe-off. In order to maximize the mass centre vertical velocity at toe-off the approach parameters must be optimized. Alexander (1990) used a two segment simulation model with a single muscle to show that jump height was maximized at intermediate values of approach speed and plant angle.

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Ch. Raja rao, Lecturer in Physical Education, GDC,Mahabubabad, Wgl,Telangana**.**

Prof. Y. Kishore, Dean faculty of Education, Head&Director Dept. of Phycical Education,Achary Nagarjuna University

Dr.J.Ramamohan Rao, Faculty of Physical Education, Acharya Nagarjuna University, Guntur, A.P.

To clear a high jump bar it is necessary to drive the centre of mass of the athlete to the largest height possible. Despite the considerable research into high jumping, investigations into optimal takeoff technique are very limited. The purpose of the present study was Biomechanical analysis of the centre of mass height during takeoff phase of Indian national fosbury flop high jumpers during their competitive performance.

II. METHODOLOGY

Selection of Subjects:

Thirteen male national high jumpers were selected for this study and get videotaped with three high speed video cameras during their competitive performance in the men's high jump final during the 52nd National open athletics championship in outdoor with the informed consent of the athletes.

Tools and equipments:

The experimental apparatus used in this research work were three Panasonic-AG-DVX-102B, F11 sensitivity, high image quality, camcorders, Quintic Biomechanics v21 motion analysis software.

Collection of data and filming protocol:

For quantitative video analysis certain procedures must be followed carefully, at both the video recording and digitizing stages, to minimize the systematic and random errors in the digitized co-ordinates. For the collection of data three Panasonic camcorders were used. First camcorder was fixed at left standard line with a distance of 9.90 meters from the left upright for left foot takeoff jumpers, the second camcorder was fixed perpendicular to the bar with a distance of 15.25 meters from the bar and third camcorder mounted at right standard line with distance of 9.90 meters from the right upright for right foot takeoff jumpers. . Three camcorders captured the video clippings of Fosbury flop jumper's last stride. Each jump image analysis started prior to the end of the penultimate stride of the approach run and continued until the flight path of the centre of mass had reached its peak. Prior to digitizing the jump sequences, 18 landmarks on the image (top of the head, neck, left shoulder, left hip, right hip, right shoulder, left elbow, left wrist, left hand, right elbow, right wrist, right hand, left knee, left ankle, left toe, right knee, right ankle, right toe) were digitized manually (minimum twelve frames). The variables selected for this study during takeoff phase were **1)** ***the height of the centre of mass at touchdown (HTD)***

2) ***The height of the centre of mass at toe off(HTO)***

Analysis

The raw data were arranged separately, tabulated and subjected for the descriptive statistical analysis, followed by

coefficient of correlation by using SPSS to distinguish if there any deviation. The researcher reached at the results of this empirical investigation which is presented by the respective tables and graphs. Table 1: Physical characteristics of the thirteen subjects and their best performance

Sl.No	BIB No	Name of the Athlete	Age	Ht	Wt	Leg length	BMI	Training age	Best jump
1	190	Amarnath Ojha	21	187	64	102	18.30	2	195
2	728	Arun Kumar	22	183	66	98	19.71	8	200
3	819	Ashok.M	27	180	66	95	20.37	8	200
4	750	Ch.Nikhil	23	188	76	98	21.50	7	216
5	343	Harishankar Rai	29	177	72	87	22.98	13	216
6	591	Harshith .S	18	189	62	99	17.36	2	216
7	593	Jagdeep singh	20	187	71	97	20.30	5	205
8	827	Jithin thomas	22	175	61	95	19.92	8	222
9	488	K.Gotham	22	180	65	93	20.06	5	205
10	345	K.S.R.Singh	22	179	62	94	19.35	4	205
11	532	Navin.S	23	180	73	92	22.53	8	195
12	495	Rithesh kumar	22	180	62	90	19.38	5	195
13	860	Shaiju.A	26	185	70	95	20.45	3	200
		Mean	**22.85**	**182.31**	**66.92**	**95.00**	**20.17**	**6.00**	**205.38**
		Sd	**2.72**	**4.16**	**4.57**	**3.68**	**1.42**	**2.85**	**8.56**

Age unit: Years, Height/length unit: centimeters, Weight unit: Kilo grams

The data indicates that the average age of thirteen fosbury flop high jumpers is 22.85±2.7 years with an average height of 182.31± 4.12; average weight is 66.92±4.6 kg average leg length was 95.00±3.7 cm, average BMI is 20.17±1.4 and training age is 6±2.9 years. The best performance was 222c

Table 2: The height of CoM of best performance at touchdown and toe off.

Sl.No	Name of the Athlete	Standing Height (cm)	Bar Height (cm)	HTD (m)	HTO (m)	% HTD	% HTO
1	Amarnath Ojha	187	195	0.76	1.14	41	61
2	Arun Kumar	183	200	0.7	1.11	38	61
3	Ashok.M	180	200	0.71	1.05	39	58
4	Ch.Nikhil	188	216	0.81	1.27	43	68
5	Harishankar Rai	177	216	0.7	1.12	40	63
6	Harshith .S	189	216	0.81	1.22	43	65
7	Jagdeep singh	187	205	0.71	1.16	38	62
8	Jithin thomas	175	222	0.85	1.32	49	75
9	K.Gotham	180	205	0.73	1.11	41	62
10	K.S.R.Singh	179	205	0.73	1.16	41	65
11	Navin.S	180	195	0.74	1.15	41	64
12	Rithesh kumar	180	195	0.71	1.12	39	62
13	Shaiju.A	185	200	0.73	1.77	39	96
	Mean	182.31	205.38	0.75	1.21	40.92	66.31
	Sd	4.32	8.88	0.05	0.18	2.81	9.45

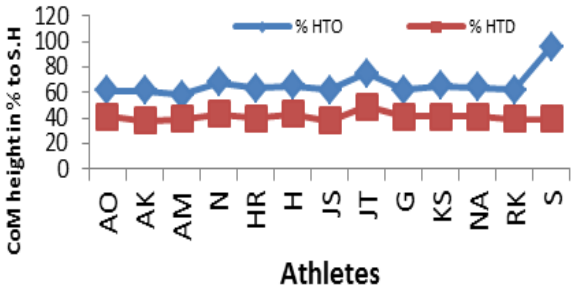
*HTD centre of mass height at touchdown,*HTO centre of mass height at toe off , %HTD,%HTO CoM values are presented as a percentage of the standing height.

The mean values of the partial heights during the takeoff phase i.e. at the instant TD and at the instant TO were 0.75±0.05 m and 1.21±0.18m, respectively. These partial height values are often presented as a percentage values compared to the athletes standing height. The mean value of HTD% was 40.92%. which was lower than the previous studies of 49% reported by Dapena (1980a), and HTO%

66% which was lower than the rate of 71% reported by Dapena(1980a). Hay (1985) calculated the ratio of the CoM height to the jumping height and obtained 63%. However since the ratio is affected by the standing height and the flight height after takeoff. The deviation among percentage related to S. height at TO was more than TD.

The height of CoM at touchdown the results of thirteen finalists the fourth, sixth and eighth subjects were had good centre of mass height at touchdown in relation to percentage of standing height than others. The sixth subject has the chance of improvement in this technique so that his performance may be improved because he has good standing height and his training age was only 2 years than others. At the end of takeoff phase the eighth subject performed optimum technique than others.

Graph: centre of mass height at touchdown and toe off of best jumps.



Among thirteen subjects the Jithin Thomas showed good technique than others. Hence those who are below 40% may be advised to improve this technique so that their performance can be improved. About CoM height at TO. Jithin Thomas showed correct technique than others. According previous studies HTO% was 71% reported by Dapena(1980a). Hence those who are below 71% may be advised to improve this technique so that their performance can be improved.

III. SUMMARY AND CONCLUSION

. Through this study those who are good standing height and less training age especially the sixth subject has the chance of improvement in technique as well as performance because he has good

standing height of 189cm and his training age was only 2 years than others. At the end of takeoff phase the Jithin thomas showed perfect technique than others. Higher percentage of athletes' percentage with reference to their standing height not effective. To increase the performance i.e to clear a high jump bar, it is necessary to drive the centre of mass of the athlete to the largest possible by keeping CoM heights at favorable position during takeoff phase. Hence, who are poor in generation of more lift may be advised to try for good take off position so that performance may be improved.

The variations in CoM height may be attributed that in fosbury flop high jump depends on anthropometric factors which are linked to centre of mass height at the start of the takeoff phase the muscular plyometric qualities to jump high and ability to clear the bar. Considering that the position of the centre of mass height depends on the position of all the body segments a jumper could raise their centre of mass by elevating their arms and their free leg or clear the bar with a CoM under the bar. Therefore being tall could be an advantage but a good position at takeoff could enhance this anthropometric parameter.

IV. RECOMMENDATIONS

1) This study would recommend that the athletes whose CoM height was low in relation to their standing height at start of the takeoff phase to learn and adopt how to run fast and lower and experiment with jumps in training session.

2) This study also recommend that If the desired change in centre of mass height is very large it would be advised to make it gradually over a period of time it would depend on current leg strength capability.
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3) We would recommend that research study can be done on velocities through video analysis so that we understand clearly about its impact on CoM heights.

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