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THE KINEMATICAL ANALYSIS OF INDIAN ELITE FEMALE LONG JUMPERS DURING TAKE-OFF PHASE

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Abstract:

Background: The Purpose of the study was to identify kinematical factors analysis of the take-off phase in Indian elite female long jumpers during the 62nd national interstate senior athletics championship 2023, Bhubaneswar, India.

Methods: 8 female Indian national-level long jumpers Were selected as subjects from the 62nd national interstate senior athletics championship 2023, Bhubaneswar, India. The ages of the subjects were ranged from 22 to 31 years. The study was determined to select the biomechanical variables namely take-off time (compression phase and extension phase), take-off parameters (projection velocity, height of the CM and angle of projection of the CM) and knee angle of take-off leg (knee angle of the touchdown (T2) and maximum knee flexion (T3). The data was analysed using two Sony high-speed cameras, which have frequencies from 60 to 300 frames per second (f/s). The data were recorded from the sagittal plane and frontal plane. Camera-1 was placed perpendicularly at a distance of 8.20 m from the subject and at a height of 1.35 m. Camera-2 was placed perpendicularly in front of Camera-1 and was at a distance of 11 m from the subject's take-off ground and at a height of 1.35 m. Data were collected by analyzing the video recording of each jump. Data processing was performed using the Kinovea motion analysis software.

Result: In this study, each long jumper maintains an individual jumping pattern in relation to timing and the different kinematic parameters.

Keywords: Kinematics, female jumper, take-off, knee angle, projection angle, effective distance, touchdown, projection velocity

I. INTRODUCTION

The take-off of the long jump is to create a vertical impulse through the athlete's centre of gravity while maintaining balance and control. This phase is one of the most technical parts of the long jump. While concentrating on foot placement, the athlete must also work to maintain proper body position, keeping the torso upright and moving the hips forward and up to achieve the maximum distance from board contact to foot release. There are four main styles of take-off: the kick style, double-arm style, sprint take-off, and bounding take-off. We will focus on the sprint take-off (TO).

Several studies have shown that performance in the long jump is directly related to different mechanical and muscular mechanisms that occur from the touchdown of the take-off foot through the take-off itself. Basically, the jumper's goal is to generate vertical velocity of his/her centre of mass (CM) at take-off without losing too much horizontal velocity of the CM. It is well known that the greatest gain in vertical velocity takes place during the compression phase, which is associated with a loss in horizontal velocity.

Different models have described the mechanical and technical features of the long jump. The deterministic model by Hay, Miller & Canterna lays down a hierarchical structure with the factors that determine the jump distance, stressing the participation of the changes in the horizontal and vertical velocities of the jumper's CM during the take-off. An alternative approach is used by Alexander3, whose model shows that the jump distance is a function of a) the approach velocity; b) the angle of the take-off leg with respect to the ground at touchdown; c) the knee angle and, d) the muscular torque acting about the knee.

A description of the technique used by elite jumpers gives insight into individual forms of organisation used to obtain high performance. These models eventually become references that help coaches and athletes to design their own strategies to achieve maximum mechanical efficiency.

This study describes the technical models used by a group of athletes who were finalists in the 62nd National Interstate Senior Athletics Championship 2023, Bhubaneswar, India. The aim of the study is to compare the jumpers' individual models in the light of the available documented biomechanical data on the long jump**.**

II. OBJECTIVE OF THE STUDY

The objective of the study was to the kinematical parameters analysis of Indian female long jumpers during the take-off phase.

III. MATERIALS AND METHODS

To determine various kinematical factors of long jumpers were studied through two-dimensional kinematical analysis.

Participants

The study sample consisted of 8 female long jumpers competing during the 62nd national interstate senior athletics championship 2023, Bhubaneswar, India. The ages of the subjects were ranged from 22 to 31 years. All the participants provided informed consent approved by the Department of Physical Education, Banaras Hindu

University. The official permission for video recording were provided by the Athletics Federation of India (AFI) and 62nd National Interstate Senior Athletics Championship Committee.

Design and procedures

To analyse the kinematic of the take-off phase in the long jump 2D video camera technique was used two Sony Digital Camera (model: HDR-XR55OE) was used to analyse the long jump performance. The camera was mounted on the Sony tripod. Two digital cameras were taken with one placed in the sagittal plane and the other in the frontal plane. Camera-1 was placed at a height of 1.35 m above the ground and the distance between the take-off board and the camera was 8.20 m and vertically above the take-off board. Camera-2 was placed perpendicular to Camera-1 at a height of 1.35m and performed take-off phases above it at a distance of 11m from the ground in front of the subject. For each jumper, the best jump was selected on the final score. The study was determined to select the biomechanical variables namely take-off time (compression phase and extension phase), take-off parameters (projection velocity, height of the CM and angle of projection of the CM) and knee angle of take-off leg (knee angle of the touchdown (T2) and maximum knee flexion (T3). The data was analysed using two Sony high-speed cameras, which have frequencies from 60 to 300 frames per second (f/s). Data were collected by analyzing the video recording of each jump. Data processing was performed using the Kinovea 0.9.5 and Silicon Coach Pro motion analysis software.

Collection Data

To facilitate study the recorded videos were uploaded into Kinovea Motion analysis software for the collection of data. The measurement of 1 m was calibrated and the variable stride length was calculated from the distance between the rear leg toe to the take-off leg toe and it was measured in meters. The take-off leg angle was calculated from the angle between the take-off leg and the ground take-off. Unit is degree. Knee angle was calculated from the angle between the femur and tibia in the take-off leg during take-off time, the unit is Degree.

Statistical Analysis

The statistical methods used for the data analysis are documented below-

A. Descriptive statistics were used to calculate the mean, standard deviation and coefficient variation
B. Coefficient correlation used to between velocity and angle of projection of the CM

IV. RESULT & DISCUSSION

The biomechanical analysis for each athlete focused on the period of the last stride and the take-off phase. The most important factors for long jump performance occur during these decisive periods, which offer the best conditions for comparing athletes' techniques.

The main time periods were:

T1: Instant of the take-off of the last stride.

T2: Instant of touchdown (TD). Take-off foot lands on the ground.

T3: Instant of maximum knee flexion of the take-off leg (MKF).

T4: Instant of the take-off (TO). The foot leaves the ground (Instant of projection). Three sub-phases in the reference instants mentioned above (T1, T2, T3 and T4) were considered.

Last stride (Ls): period between instants T1 and T2.

Compression phase (td-mkf): period between instants T2 and T3.

Extension phase (mkf-to): period between instants T3 and T4.

Figure 1: Representative instant of T1, T2, T3 and T4.

Table 1 shows the results of Indian long jumpers with official and functional distances. Each athlete's best jump was analyzed. As seen here, the effective distance (6.46±0.15m) is 10cm more than the official result (6.34±0.15m), which means that the actual value changed the result of the competition.

Table 1: Basic data of sample for official and effective distance of the long jump

Jumper Name	Official distance (m)	Effective distance (m)
Ancy Sojane	6.51	6.63
Shaili Singh	6.49	6.60
Bhavani Yadav Bhagavati	6.44	6.56

Nayana James	6.41	6.51
Sherina	6.41	6.50
Karthika Gothandapani	6.20	6.30
Priya Rathore	6.14	6.32
Neenav	6.14	6.23
Mean	6.34	6.46
SD	0.15	0.15

All jumpers performed the take-off on the board, though at different distances from the statutory foul line. The jumpers with the greatest gaps between official and effective distances were Priya Rathore with 18cm 11 and 11cm, while the athletes who best adjusted their take-off to the foul line were Sherina and Neenav with 9cm.

Results

Phase timing

The results show that the compression phase (T2-T3) lasts between 38 and 56 milliseconds, while the duration of the extension phase (T3-T4) goes from 50 to 66 ms, the phase timing model used by all jumpers being fairly similar (Table 3). On average, the total take-off time for all of the jumpers is 105 ms, the time used in the compression phase being shorter than that of the extension (45.75±6.63ms and 59.25±5.31 ms, respectively). This means that jumpers use 43.57% of the total take-off time in the phase in which the knee extensor muscles work eccentrically, and 56.43% in the phase in which they work concentrically. Note that the winner's phase timing has the smallest inter-phase difference. In other words, he used 56 and 58 ms for compression and extension, which accounts for 49.12% and 50.88% of the total time, respectively.

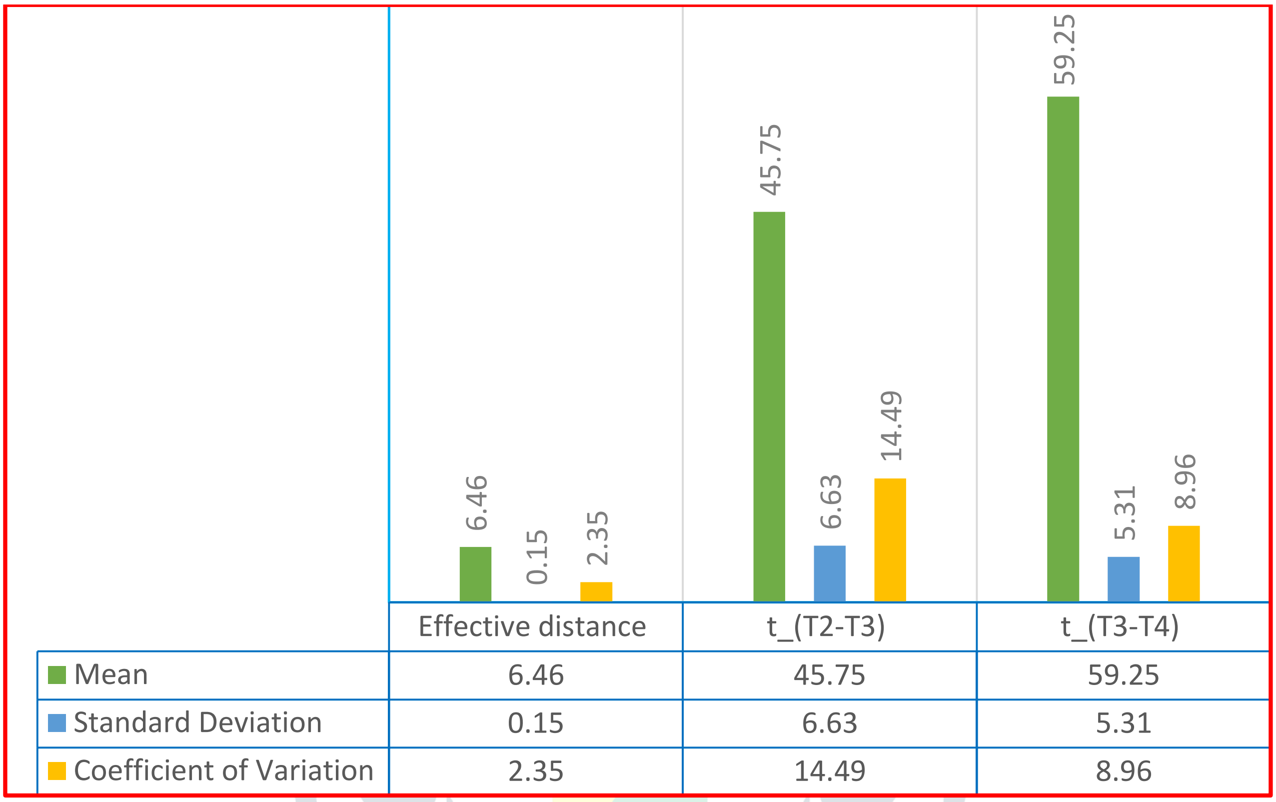
Table 2: Effective distance and phase timing during compression phase (T2-T3) and extension phase (T3-T4)

Jumper Name	Effective distance (m	t_(T2-T3) (ms)	t_(T3-T4) (ms)
Ancy Sojane	6.63	56	58
Shaili Singh	6.60	52	66
Bhavani Yadav Bhagavati	6.56	52	60
Nayana James	6.51	44	54
Sherina	6.50	42	65
Karthika Gothandapani	6.30	40	50
Priya Rathore	6.32	42	60
Neenav	6.23	38	61
Mean	6.46	45.75	59.25
SD	0.15	6.63	5.31

CV (%)	2.35	14.49	8.96

The compression phase is decisive for achieving the required braking so that the horizontal velocity built up in the approach run can be transformed into vertical impulse. In this phase the jumper accumulates elastic energy; the fact that it is so short proves the jumper's extraordinary ability to complete such a transformation.

Figure 2: Graphical representation of Effective distance and phase timing during compression phase (T2-T3) and extension phase (T3-T4)



Take-off parameters

In accordance with the projective nature of the jump, the parameters that condition the jumpers' trajectory in the flight phase are Velocity, Height and Angle of Projection of CM at the instant of projection (T4). Table 3 shows the result with mean values of 8.07 m/s, 1m and 21.72 for velocity, height and angle of projection of the CM, respectively. (Note that the value for the height of the CM is not standardised with respect to the athlete's height. The three parameters are within a reasonably low variability range, with an 8% variation coefficient maximum. The angle of projection seems the most variable one, with a value of 7.8%.

Table 3: Velocity, height and angle of projection of the CM at take-off (T4)

Jumper	Effective distance (m)	Vcg T4 (ms)	Height CG–T4 (m)	Projection Angle CG–T4 (˚)
ANCY SOJANE	6.63	7.90	0.98	22.90
SHAILI SINGH	6.60	8.25	1.03	21.50

BHAVANI YADAV BHAGAVATI	6.56	8.02	0.97	24.10
NAYANA JAMES	6.51	8.48	1.05	19.40
SHERINA	6.50	8.05	1.00	21.80
KARTHIKA GOTHANDAPANI	6.30	8.24	1.02	20.00
PRIYA RATHORE	6.32	7.78	0.99	21.30
NEENAV	6.23	7.80	0.98	22.80
Mean	6.46	8.07	1.00	21.72
SD	0.15	0.24	0.03	1.55
CV (%)	2.35	3.03	2.81	7.13

Projection velocity is 8.07 ±0.24 m/s. Nayana James reaches the highest projection velocity, 8.48 m/s, while Priya Rathore has the lowest, 7.78 m/s.

As for the angle of projection, a value of 21.72º ±1.55º has been calculated. Differentiated patterns can be seen in this case. The jumper with the greatest angle is Bhavani Yadav Bhagavati, 24.10º, while Priya Rathore has the lowest, 19.40º. The correlation coefficient between velocity and angle of projection of the CM is negative; the greater the projection velocity, the smaller the angle and vice versa, although it is not statistically significant reached (r: -0.669; p: 0.069).

Figure 3: Graphical representation of Velocity, height and angle of projection of the CM at take-off (T4)

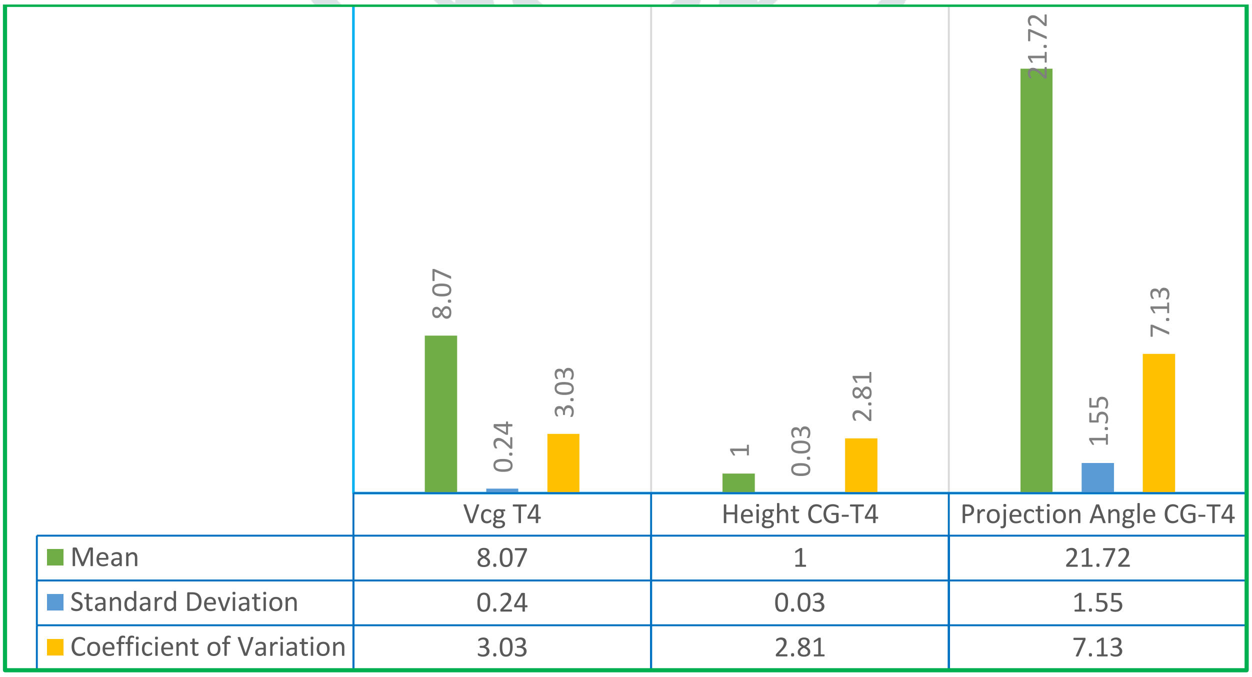
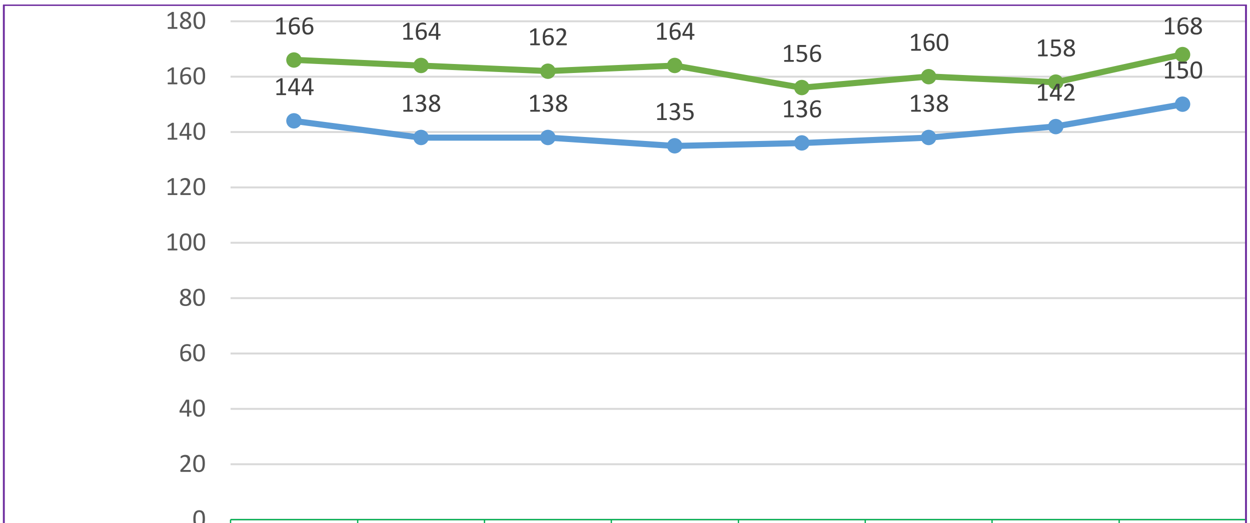


Figure 4 shows take-off leg knee angle values at touchdown (T2), and maximum knee flexion (T3). As shown, the compression phase is similar in all jumpers as regards the degree of flexion. In general terms, jumpers flex their knee between 16º and 26º during the compression phase, their behaviour being very similar. The athletes whose knee were more stretched at the touchdown instant are Ancy Sojane (166º) and Neenav (168º). Contrarily, Nayana James reached that point with his knee being more flexed (135º). The rest have a similar behaviour, with about 162º knee flexion.

Figure 4: Graphical representation of take-off leg knee angle values at touchdown (T2), and maximum knee flexion (T3)



	Ancy Sojane	Shaili Singh	Bhavani Yadav Bhagavati	Nayana James	Sherina	Karthika Gothanda pani	Priya Rathore	Neenav
Knee-TD	166	164	162	164	156	160	158	168
Knee-MKF	144	138	138	135	136	138	142	150

V. CONCLUSIONS

As noted in the results, it has been observed that each jumper maintains an individual jumping pattern in relation to timing and the different kinematic parameters under study. Nevertheless, these individual patterns are conditioned by some minimum requirements needed to jump a long distance related to the position of the kinetic chain and the change of the velocity components of the athlete's CM during the take-off phase. Athletes' individual models exemplify motor complexity, and numerous methodologies are required to analyse them. Descriptive studies such as the present work help to understand the dimensions involved in achieving performance in the long jump and to compare with jumpers with different performance levels.

We hope the information presented herein will be useful for Sports bio-mechanists, long jump coaches, physical educationists and athletes and will contribute to the understanding of this event.

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REFERENCES

[1] Alexander, R. M. (1990). Optimum take-off techniques for high and long jumps. Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences, 329(1252), 3-10.

[2] Arampatzis, A., & Brüggemann, G. P. (1999). Mechanical energetic processes in long jump and their effect on jumping performance. New Studies in Athletics, 14(4), 37-44.

[3] Avela, J., Kyrolainen, H., & Komi, P. V. (1988). Changes in mechanical energy transfer and moment analysis during long jump take-off. Scandinavian journal of sports sciences, 10(1), 1-5.

[4] Bedi, J. F., & Cooper, J. M. (1977). Take off in the long jump—Angular momentum considerations. Journal of Biomechanics, 10(9), 541-548.

[5] Bruggemann, G. P., & Conrad, T. (1986). Long jump. Biomechanical Research in Athletics-1st World Junior Championships, Athens, 89-119.

[6] Campos, J., Gámez, J., Encarnación, A., Gutiérrez-Dávila, M., & Rojas, J. (2013). Three dimensional kinematic analysis of the long jump at the 2008 IAAF World Indoor Championships in Athletics. New Studies in Athletics, 28(3/4), 115-131.

[7] Fukashiro, S., Takayama, A., Kojim, T., Araj, T., Itoh, N., Ae, M., ... & Matsui, H. (1994). World record long jump: Three dimensional analysis of take-off motion of Powell and Lewis. Journal of Biomechanics, 27(6), 666.

[8] Graham-Smith, P., & Lees, A. (2005). A three-dimensional kinematic analysis of the long jump take-off. Journal of Sports Sciences, 23(9), 891-903. https://doi.org/10.1080/02640410400022169

[9] Hay, J. G., & Miller, J. A. (1985). Techniques used in the transition from approach to takeoff in the long jump. Journal of Applied Biomechanics, 1(2),174-184.

[10] Hay, J. G., & Nohara, H. (1989). Techniques used by elite long jumpers in preparation for takeoff. Journal of Biomechanics, 22(10), 1020.

[11]Herzog, W. A. L. T. E. R. (1986). Maintenance of body orientation in the flight phase of long jumping. Medicine and science in sports and exercise, 18(2), 231-241.

[12] Lees, A., Fowler, N., & Derby, D. (1993). A biomechanical analysis of the last stride, touch-down and take-off characteristics of the women's long jump. Journal of sports sciences, 11(4), 303-314.

[13] Lees, A., Graham-Smith, P., & Fowler, N. (1994). A biomechanical analysis of the last stride, touchdown, and takeoff characteristics of the men's long jump. Journal of applied Biomechanics, 10(1), 61-78.