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Assessment of triple jump techniques employed by senior men athletes

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Abstract
The purpose of the study was to present the magnitude of the kinematic parameters of the triple jump observed in Kerala state senior athletes regarding the technique and effect of the performances. Three male triple jumps were selected for the study. Three men (n = 3), top-level senior level triple jumpers (age: 23±5.5years; body height: 1.75 m±0.05; body mass: 68.71 kg±5.2, average standard deviation, respectively). They were selected for the study in Kerala state senior athletics team selection for Senior Nation Athletics Championships 2015. Section trails held in the Maharajas college ground, Kochi. Kinematic variables selected for the studies are Officially Measured Distance, Real Distance, Loss of Take-off, Hop, Step, Jump and Loss of Landing, Linear Velocity, Flight and Support times during the triple jump, Angle of leading leg knee joint from peak height to descending phase in hop, step and jump, Trunk angle between 2 frames before and after at peak height of hop, step and jump. All trial Jumps of the participants were recorded using two cameras. The recordings were acquired with two stationary Sony DSR-PD 170 DVCAM digital video camera (Sony Company Japan Ltd), operating with a sampling frequency of 59.94fps and a shutter speed of to 1/10000. The first camera was positioned on1.2 m high fixed tripod in the stands at a distance of about 11 m from the middle of the runway and parallel to the side of run way. The second camera was placed on the stands at the 10 m away from the end of the landing area. The data analysis was done using Quintic Biomechanics version 26, Quintic Consultancy Ltd. England. Result of the study help us to analysis the skill efficiently and the skill correction based on the analysis, coaches and teachers use kinematics analysis to determine which action may improve performance of jumpers, it helps to identify mistakes and make the athlete aware bout those and rectify it, it helps the coaches and teachers to assess the kinematics defaults of particular skill during execution and it generates multiple information for coach during rectification process of an athlete.

Keywords: Triple jump, kinematics, flight and support phase, linear velocity, senior athletes

Introduction
The triple jump is one of the more complicated events in track and field competition. A triple jump consists of an approach run followed by a hop, a step, and a jump. One of the most important considerations in triple jump techniques is the optimum phase ratio. In the triple jump, the distance measured from the toe of the athlete's take off foot on the board to the nearest mark the athlete made in the sandpit is referred to as actual distance. The distance from the toe of the athlete's take-off foot at the take-off to the toe of his or her landing foot at the landing during each phase is referred to as the phase distance. The percentage of a phase distance to the actual distance is referred to as phase percentage. The ratio of three phase percentages is referred to as phase ratio. (Hay &Miller, 1985) [4]. suggested the discrimination of triple jump techniques as follows: 1) The hop-dominated technique, where the hop distance is at least 2% of the actual distance greater than the next longest phase distance, 2) The jump-dominated technique, where the jump distance is at least 2% of the actual distance greater than the next longest phase distance, and 3) The balanced technique, where the longest phase distance is less than 2% of the actual distance greater than the next longest phase distance (Bing Yu, 1982) [3].
The techniques employed in the men Triple jump have been the subject of many biomechanical analyses. In sharp contrast in Indian athletes, the techniques employed in the triple jump the second of the so called horizontal jumps in athletics-have received very little attention from coaches and researchers in biomechanics. This is somewhat surprising, given that with three times as many take offs and landings the event makes much greater technical demands on those who compete in it than does the long jump.

The purpose of this study was to describe selected kinematic characteristics of the techniques used by elite triple jumpers and to determine which of these characteristics are significantly related to the officially recorded distance of the jump.

Materials and Methods

Three men (n = 3), top-level senior level triple jumpers (age: 23±5.5years; body height: 1.75 m±0.05; body mass: 68.71 kg±5.2, average standard deviation, respectively) were examined during Kerala state senior athletics team selection for senior nation athletics championship 2015. Section trails held in the Maharajas college ground, Kochi for the present study. The study was conducted in accordance with the Institutional Research Committee's Guidelines for the use of human subjects.

Data acquisition: All trial Jumps of the participants were recorded from the camera one was placed perpendicular to the plane of motion and filed the lateral view of run up, the hop, the step, the jump and landing Camera two placed in the end of the landing pit it is all so perpendicular to the run way. Front and lateral view simultaneously capture with two cameras The recordings were acquired with two stationary Sony DSR-PD 170 DVCAM digital video camera (Sony Company Japan Ltd), operating with a sampling frequency of 59.94fps and a shutter speed of. To 1/10000. The first camera was positioned on1.2 m high fixed tripod in the stands at a distance of about 11 m from the middle of the runway and parallel to the side of run way. The second camera was placed on the stands at the 10 m away from the end of the landing area. (Figure 1). The recording Y-axis direction that defined by calibration frame is 24.5m.with 16 reference markers, Total station is needed to put two cameras so as to ensure can shoot the 3D frame coordinate origins 0, point Indirection and point j in direction Y In each digitized field, 22 anatomical landmark points were manually digitized to the athletes.

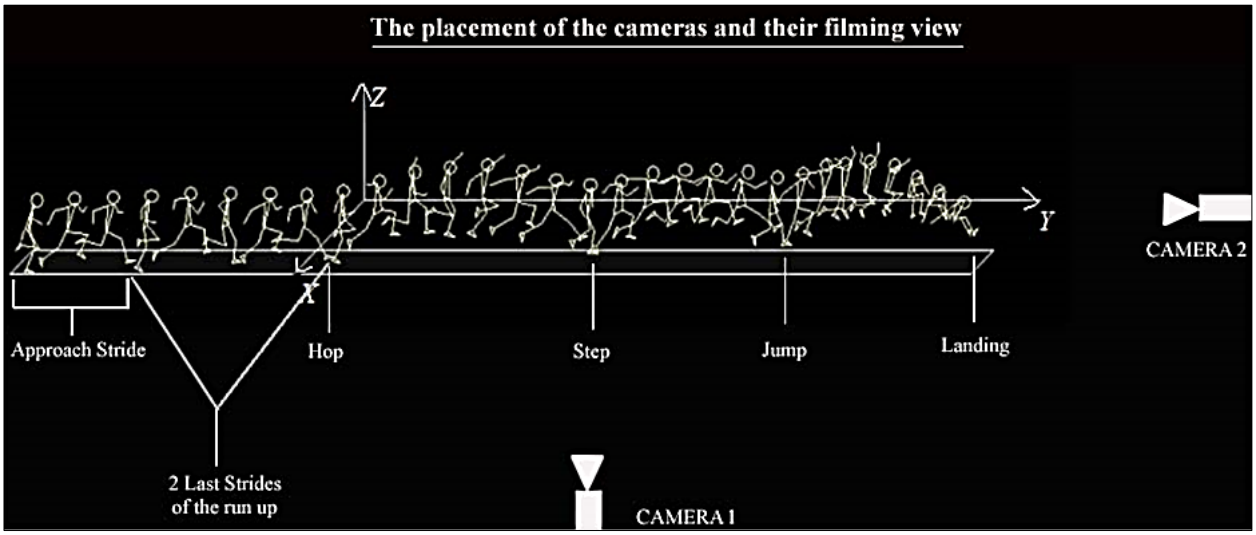

Fig 1: The placement of the cameras and their filming view

Kinematic parameters

All trials were recorded, but the best valid jump for each athlete was selected for further analysis. Variables were selected for this study is Officially Measured Distance, Real Distance, Loss of Take-off, Hop, Step, Jump and Loss of Landing, Linear Velocity, Flight and Support times during the triple jump, Angle of leading leg knee joint from peak height to descending phase in hop, step and jump, Trunk angle between 2 frames before and after at peak height of hop, step and jump.

Software used for the study

The values of the variables were obtained using the software for Quintic Biomechanics version 26, Quintic Consultancy Ltd. England.

Results and Discussion

The data collected has been analysed and presented below in the Tables.

Table 1: Descriptive variables of Officially Measured Distance, Real Distance, loss of Take-off, Hop, Step, Jump and Loss of Landing, and Linear Velocity of approach run

Athletes	Attempt	Officially Measured (m)	Real Distance (m)	Loss of Take-off (m)	Hop Distance (m)	Step Distance (m)	Jump Distance (m)	Loss of Landing (m)	Linear Velocity (m/s) (Approach)
Athlete A	1	13.71	13.88	0.17	4.69	3.72	5.30	0.00	6.82
	2	13.72	13.84	0.12	5.21	3.22	5.29	0.00	6.80
	3	13.99	14.16	0.17	4.98	3.88	5.13	0.00	6.92
Athlete B	1	13.94	14.08	0.14	4.71	4.65	4.58	0.00	8.25
	3	13.69	13.76	0.07	4.65	4.45	4.59	0.00	8.41
Athlete C	1	15.02	15.29	0.27	5.30	4.11	5.61	0.00	7.55

Table 2: Descriptive variables of flight and support times during the triple jump

Athletes	Attempt	Take off (Sec)	Hop (Sec)	Support (Sec)	Step (Sec)	Support (Sec)	Jump (Sec)	Total Duration (Sec)
Athlete A	1	0.10	0.52	0.16	0.36	0.16	0.88	2.18
	2	0.08	0.58	0.15	0.28	0.18	0.70	1.97
	3	0.08	0.59	0.19	0.39	0.15	0.67	2.07
Athlete B	1	0.09	0.56	0.11	0.54	0.15	0.76	2.21
	3	0.11	0.49	0.13	0.55	0.16	0.69	2.13
Athlete C	1	0.08	0.60	0.12	0.40	0.14	0.64	1.94

Table 3: Descriptive variables of angle of leading leg knee joint from peak height to descending phase in hop, step and jump.

Athletes	Attempt	Hop (^{0})	Step (^{0})	Jump (^{0})
Athlete A	1	96.34	86.99	67.17
	2	100.53	111.12	86.78
	3	96.34	96.84	60.87
Athlete B	1	116.77	90.00	77.37
	3	116.57	91.19	75.28
Athlete C	1	99.59	102.96	83.09

Table 4: Descriptive variables of Trunk angle between 2 frames before and after at peak height.

Athletes	Attempt	Trunk angle (0)					
		Hop ↓	Hop ↑	Step ↓	Step ↑	Jump ↓	Jump ↑
Athlete A	1	76.76	80.54	75.26	82.23	70.02	81.87
	2	85.24	84.81	71.59	81.87	77.01	78.69
	3	81.25	84.81	78.69	82.57	78.69	81.87
Athlete B	1	84.81	83.16	82.87	79.70	57.72	82.57
	3	82.57	85.24	80.13	85.60	72.35	83.16
Athlete C	1	84.81	85.03	81.87	78.69	84.74	77.74

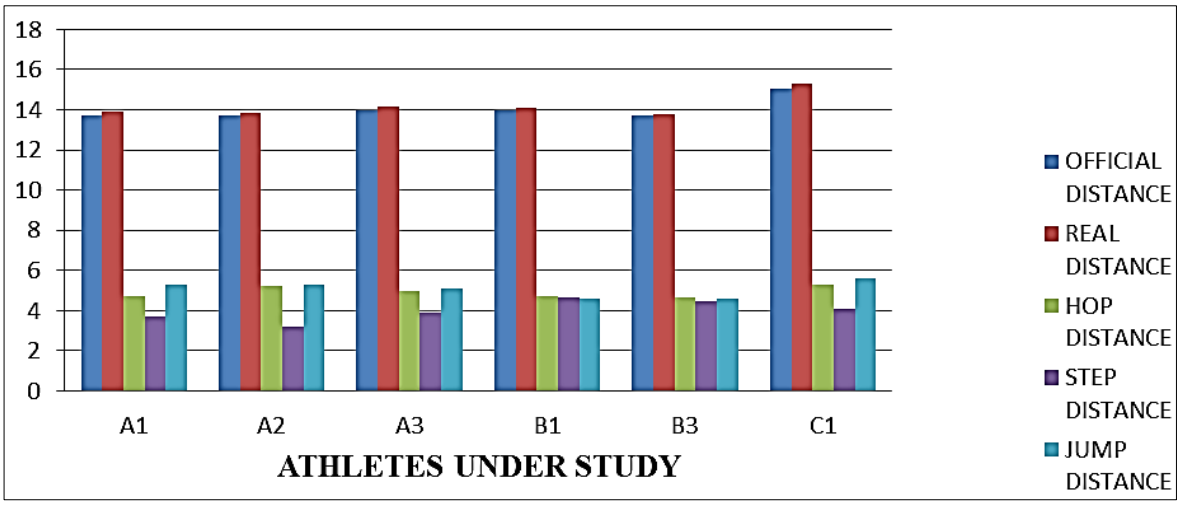

Fig 2: Comparison of official distance, real distance, hop distance, step distance and jump distance of men athletes

The above graph shows the representation of performance in jumpers in different attempt of a competition. Under this study there were three participants athletes A, B and C, athlete C made better performance among the all three athletes under study. But he made good result (15.02m) in the first attempt later all his jumps were foul. Athlete A made his all the three attempts but he made his good jump at third attempt (13.99m).Athlete B made good result at the first attempt (13.94) which is less than 0.5m of the Athlete A.

Real distance is the distance measured between the athletes take off to landing. The graph shows similarity with that of the official distance measured. Here also athlete C showed his maximum real distance and Athlete A shows second maximum. The takeoff mark is a board, and in modern championships a strip of plasticize or modeling clay is attached to the board to record athletes overstepping the mark. The first landing has to be done with the takeoff foot. The next phase is a step, landing on the opposite foot, and is followed by the jump, into a sand-filled box, as in the long jump. 1) The hop-dominated technique, where the hop distance is at least 2% of the actual distance greater than the next longest phase distance, 2) The jump-dominated technique, where the jump distance is at least 2% of the actual distance greater than the next longest phase distance, and 3) The balanced technique, where the longest phase distance is less than 2% of the actual distance greater than the next longest phase distance. Best jumper under our study was athlete C he had done a balanced jumping technique. All the three jumpers used balanced technique in their better performance.

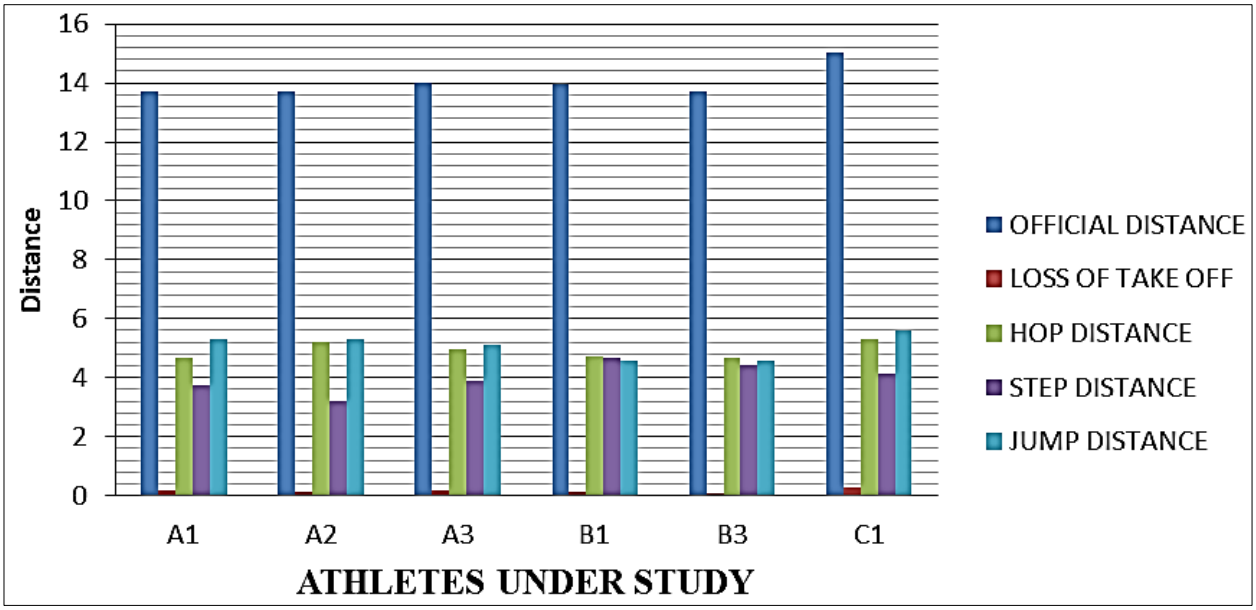

Fig 3: Comparison of official distance, Loss of take-off, hop distance, step distance and jump distance of men athletes

Loss of take-off is the take-off distance from the outer edge of the plasticinemarker support. From our study its clear it's clear that athlete B made correct take off i.e. his loss of take-off is very less (0.07m).Whereas athlete C Committed large loss of take-off almost 0.27m that even may change his official distance to 20m.

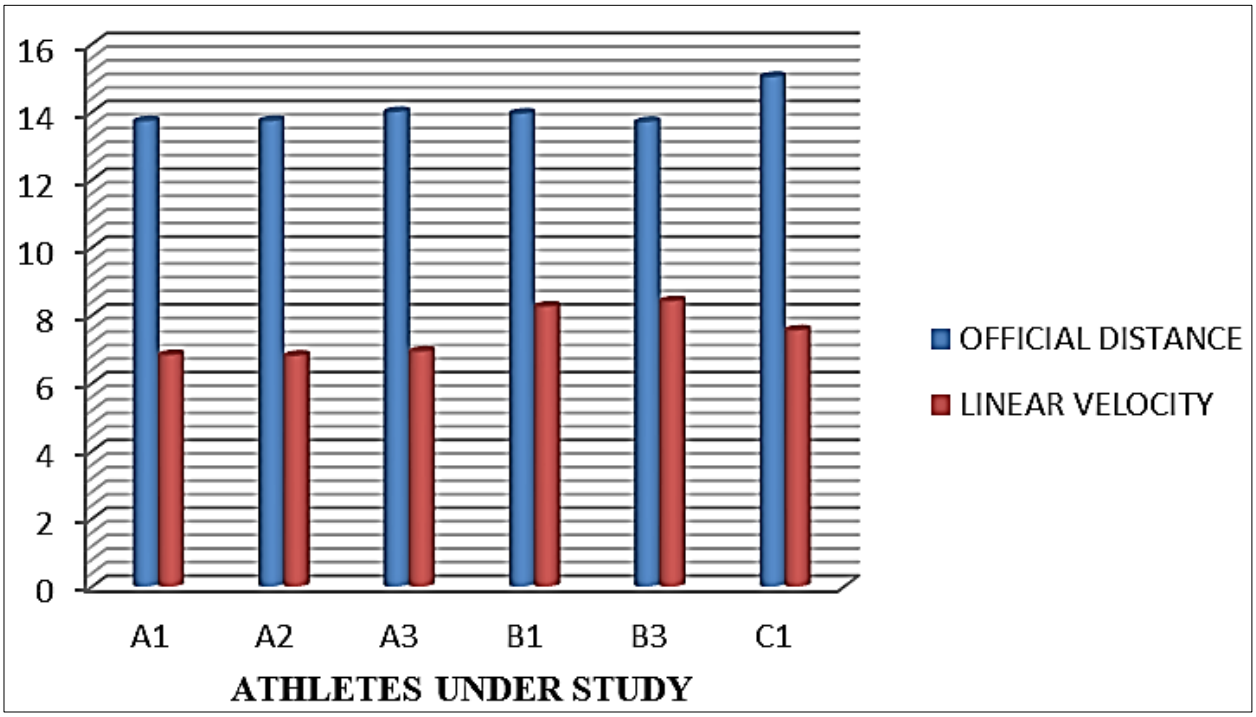

Fig 4: Comparison of official distance and linear velocity of men athletes

Linear velocity: Linear velocity was measured form the approach run of the jumper. An increase in linear velocity which in turn helps in maintained of optimum height for jumping. So maximum is the linear velocity maximum will be the performance (distance) expected from the jumpers. In the case of liner velocity compare to athlete C and athlete A the linear velocity of athlete B was high then also he was placed second in the competition. That may be due to time he took to complete the distance travelled during the jump. But the best performer athlete C took less linear velocity may be due to his fast running to cover the distance of jump.

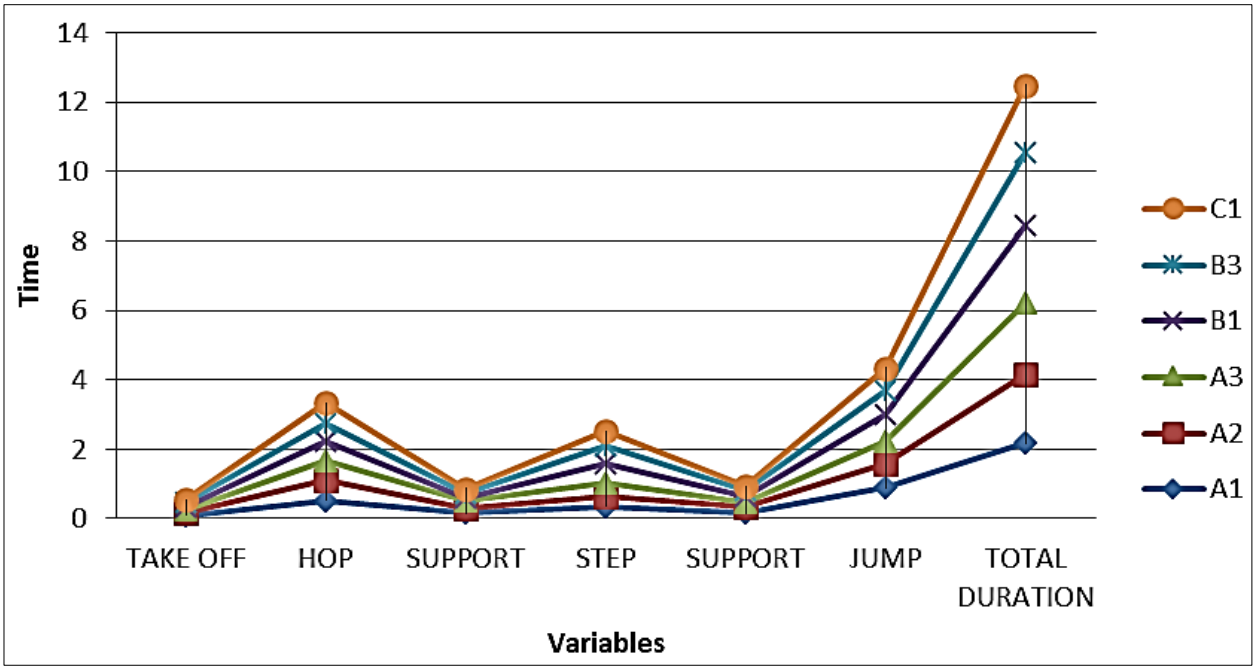

Fig 5: Comparison of flight and support times during the triple jump of men athletes

From the result it is clear that time analysis of flight phase and support phase are very important as far as an outstanding jumper is concerned. According to the result athlete C and athlete A is speed oriented jumpers having quick take off time and Support phase. Hence total times taken by best performing athletes are compared to the rest of the athletes. So increase in flight phase is accompanied by improvement in the performance. Athlete B showed strength oriented jumps having slow take off time and support phase. Hence total time taken by poor performers is less compared to best performers. As far as the study, it is clear that improvement in the performance is related to reduction in take-off time and support phase too. The result of the above figure (Fig 5) is similar to the result obtained by (S.J. Allen, & all, 2013) [6]. Difference in some triple jump rhythm parameters

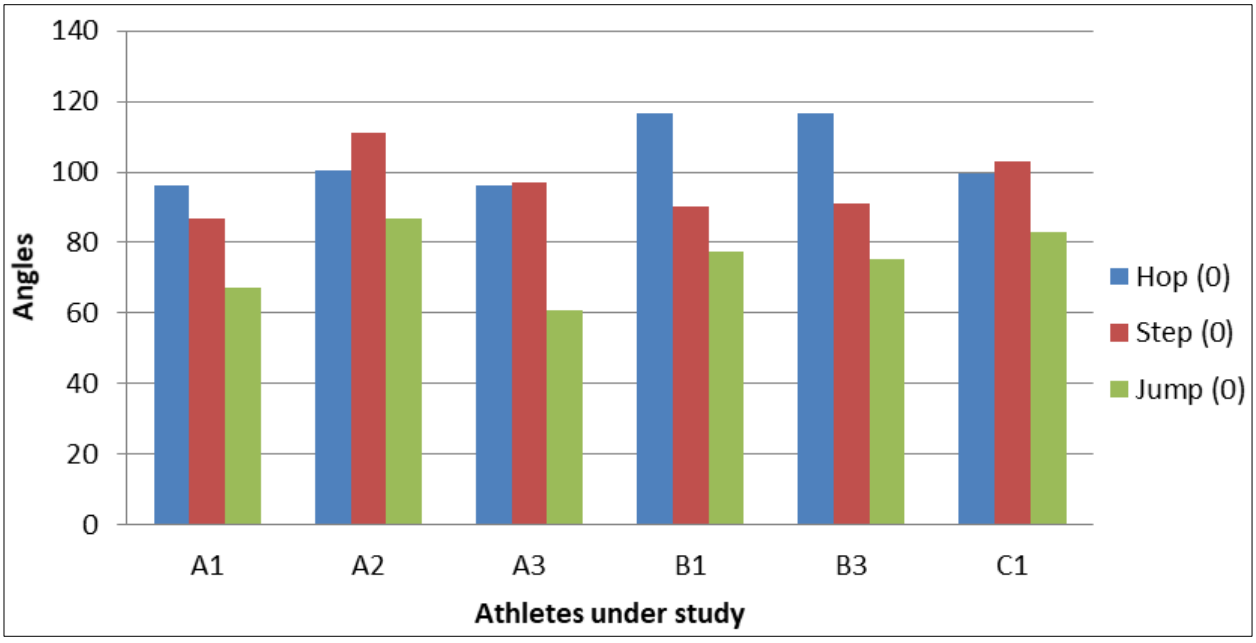

Fig 6: Comparison of angle of leading leg knee joint from peak height to descending phase in hop, step and jump of men athletes

From result its evident that after reaching the peak height, if the athlete extend her knee joint, that is where there is an increase in the angle of knee joint, the time of flight is increased and there by the time and distance to touch down and is increased which results in the increased horizontal range. Athlete C and athlete A maintained an angle above 90^0 during the peak height to descending phase of hop, step and jump. So these leading leg knee angles helped her in performance better.

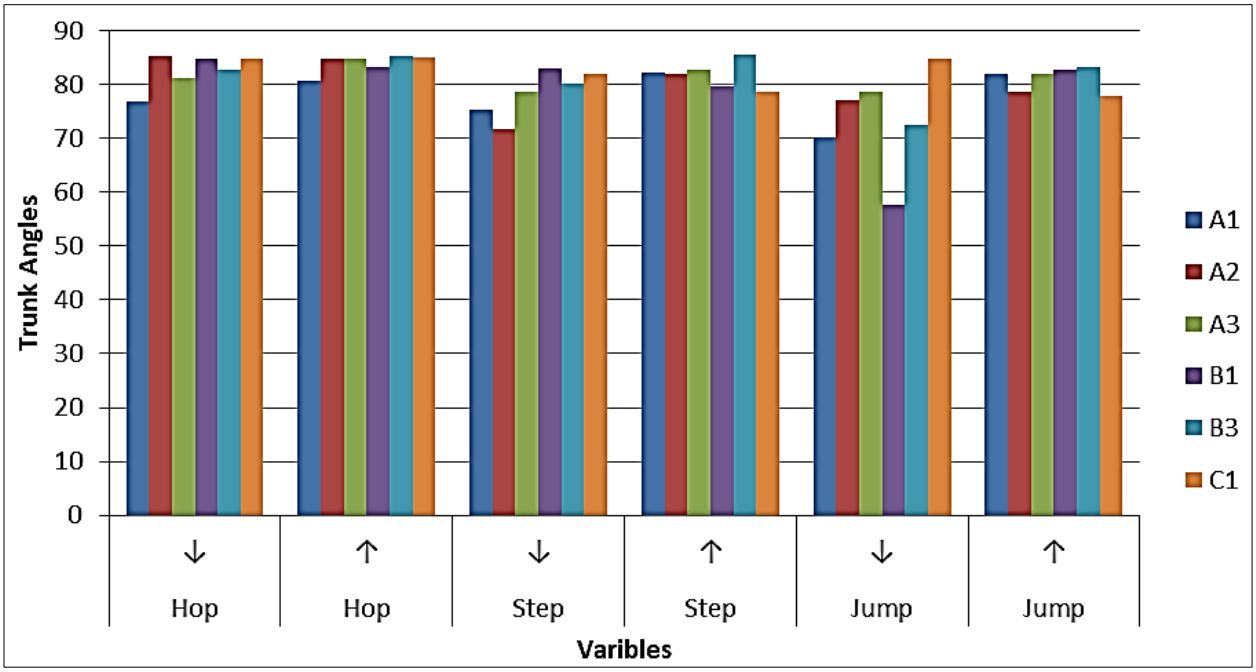

Fig 7: Comparison of trunk angle between 2 frames before and after at peak height of hop, step, and jump of men athletes.

From result it's clear that three athlete's took Trunk angles near 80-85 in their best performance. This trunk angle will produce acceleration body in order to cover more horizontal distance. Using this method, the contribution of a given segment to whole body motion was expressed as a function of the motion of the base (trunk) segment and the relative motion that occurs at each joint connecting the given segment to the base segment. Other methods have been used to describe the contribution of a segment to whole body motion in previous studies of different sports skills (Ae & Shibukawa, 1980; Ae, Shibukawa, Yokoi, & Hahihara, 1983; Hinrichs, 1982) [1, 2, 5]. Although the range of the support leg motions may not be as great as that of the free limb motions, and the velocities and angular velocities of the support leg motions may not be greater than those of the free limb motions, the support leg motions control the movements of the trunk, which is the largest segment of the body. Even a small and relatively slow movement of the support leg may cause a relatively large change in the velocity of Gravity because of the large mass of the trunk.

Conclusion

The kinematics analysis outlined in this research highlight the usefulness of measuring most relevant kinematics parameters during competition to assess the triple jump technique. The parameters measured are easy to collect and relatively quick to analyse. This type of analyses can assist the coaches and athlete diagnoses the weakness in the triple jump technique and makes assessment of the athletes to current level of physical ability.

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