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Kinematic analysis of hurdle clearance in steeple chase

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Abstract
The purpose of the study was to see the correlation of selected angular and linear kinematic variables and performance of hurdle clearance in steeplechase. 10 students (boys) on the basis of purposive sampling technique of age 26 ± 2 years were selected as a subject from Laxmibai National University of Physical Education, Gwalior, those who had been undergoing training. Time taken by the subject to clear the hurdle was considered as a performance, and sequential photography was done at sagittal plane with the help of Canon- EOS T3 motor driven camera. From the photographic sequence, the stick figures were prepared by using joint point method, and segmentation method was used to measure the selected linear kinematic variable at selected moments. To see the correlation between performance of hurdle clearance and selected angular and linear kinematic variables at selected moments, the pearson's correlation coefficient was employed and found significant correlation in the angle of hip during take-off phase at 0.05 level of significance.

Keywords: angle at elbow, angle at shoulder, angle at hip, angle at knee, angle at ankle, centre of gravity.

Introduction
The science of biomechanics is concerned with the force, which act on a human body and the effects, which these forces produce. The internal and external forces acting on a human body determine how the parts of the body move during the performance of motor skill. (Kumar Gray 2004) [6]
Biomechanics is relatively young as a recognized field of scientific inquiry biomechanical considerations is of interest in several different scientific disciplines and professional fields. Biomechanical instructors may have academic backgrounds in zoology; orthopedic, cardiac, or sports medicine; biomedical or biomechanical engineering; physical therapy; or kinesiology. (J. Hall Susan 1995) [7]
Steeple chase is derived from cross- country running and obstacle course races. It is a combination of distance running, hurdling, and water jumps. The name "Steeplechase" inherited form horse racing over jumps. Various theses exist on the origins of hurdle races. The race is run over 3000M. Athlete covers just over seven laps of the track and have to clear 35 obstacles (4 hurdles and a water jump on each lap), but there is a run in distance from the start to the beginning of the first lap, then several laps. In Steeple chase an athlete has to cross the hurdles of 0.914M high and 3.96M wide. The hurdles and the water jump barriers used in the Steeple chase are solid and weight between 80 kg. and 100 kg. Heavy barriers are designed to support the weight of several athletes at the same time obstacles (4 hurdles and a water jump on each lap), but there is a run in distance from the start to the beginning of the first lap, followed by several laps.
The athlete faces difficulty in estimating the take-off position for the hurdle and the water jump. This varies taking into account the fatigue he experiences. Whatever method he uses, it is important that he clears hurdles or water jumps as best as he can. The hurdles and the water jump should be stable and strong enough to bear the weight and pressure of the athletes. The shoes should be such that it is easier to run with them when wet. He should have a clear view of the barrier and for this purpose; he should not run close behind another athlete. Three phases need to be individually analyzed in order to arrive at the complete biomechanical analysis of the event. The three phases in the order they will be analyzed will be the preparation, flight, and follow through.

Procedure

Selection of Subjects

Seven male hurdlers from Amity University, Noida, were selected as the subjects for the present study. Since the subjects had been undergoing training for a considerable period, therefore it was considered that subjects possess reasonable level of technique of hurdling. Their age ranged between 26 ± 2 years. The subjects were explained about the objectives of the study.

Selection of variables

For the kinematic analysis of Hurdle clearance in steeplechase following kinematic variables were selected:

a) Linear kinematic variables

i. Height of center of gravity at takeoff
ii. Height of center of gravity at swinging
iii. Height of center of gravity at landing

b) Angular kinematic variables at takeoff, swinging and landing phase

i. Angle at shoulder joint
ii. Angle at elbow joint
iii. Angle at hip joint
iv. Angle at knee joint
v. Angle at Ankle joint

Criterion Measures

The criterion measure for this study was the technique of each subject. The standard height of steeplechase (0.914 mts.) was measured. The timing of take-off to the landing was measured and recorded in second

Filming protocol and Analysis of the Film

Sequential photography was employed in order to register the technique of hurdle clearance in steeplechase. The subject was photographed in sagittal plane. The camera being used at sagittal plane for the purpose was Canon- EOS T3, a motor driven camera, with the frequency of 30 frames per second. 3 frames one at the moment take off, moment flight and one at the moment landing was selected for the purpose of analysis. The subjects were photographed in sagittal plane for obtaining individual photographic sequence, the subject were photographed in a controlled condition (figure – 1, 2 and 3). The distance of camera from the subject was 8.67 mts and was fixed at height of 1.22 mts. The takeoff and landing time were measured manually for each subject.

Statistical Procedure

To find out the relationship between selected biomechanical variables and performance of hurdle clearance, Statistical Package for Social Science (SPSS)
version 20 was used. For testing hypothesis the level of significance was set at 0.05 level.

Results

Table 1: Relationship of Selected Angular Kinematic Variables with The Performance of Hurdle Clearance in Steeplechase at the Moment of Take off

S. No.	Variables	Coefficient of correlation At the moment of Take off
1	Angle of Left Elbow	0.108
2	Angle of Left Shoulder	0.317
3	Angle of swinging leg Hip	-0.328
4	Angle of swinging leg Knee	-0.504
5	Angle of swinging leg Ankle	-0.328
6	Angle of Take-off leg Hip	0.791*
7	Angle of Take-off leg Knee	0.254
8	Angle of Take-off leg Ankle	0.491

*Significant, $r_{.05}(5)= .754$

Since the value of coefficient of correlation required to be significant for 5 degree of freedom is.754, the above table clearly show that "Angle of Take-off leg hip indicating significant relationship with the performance (.754), whereas the above table clearly show that remaining biomechanical variable that is (Left elbow, Left Shoulder, Swinging leg hip, knee, ankle, take-off leg knee and ankle) is lower than the tabulated value therefore it has no significant relationship with the performance of subjects in steeplechase.

Table 2: Relationship of Selected Angular Kinematic Variables with the Performance of Hurdle Clearance in Steeplechase at the Moment of Flight

S. No.	Variables	Coefficient of correlation At the moment of Flight
1	Angle of Left Elbow	0.041
2	Angle of Left Shoulder	0.295
3	Angle of swinging leg Hip	-0.126
4	Angle of swinging leg Knee	0.099
5	Angle of swinging leg Ankle	-0.247
6	Angle of Take-off leg Hip	0.330
7	Angle of Take-off leg Knee	-0.283
8	Angle of Take-off leg Ankle	-0.751

*Significant, $r_{.05}(5)= .754$

Since the value of coefficient of correlation required being significant for 5 degree of freedom is.754, the above table clearly show that in case of all the joints are lower than the tabulated value. Therefore, it has no significant relationship with performance of subject during Flight phase while clearing the hurdle in steeplechase.

Table 3: Relationship of Selected Angular Kinematic Variables with the Performance of Hurdle Clearance in Steeplechase at the Moment of Landing

S. No.	Variables	Coefficient of correlation At the moment of Landing
1	Angle of Left Elbow	0.086
2	Angle of Left Shoulder	-0.853*
3	Angle of swinging leg Hip	-0.517
4	Angle of swinging leg Knee	-0.415
5	Angle of swinging leg Ankle	-0.565
6	Angle of Take-off leg Hip	-0.085
7	Angle of Take-off leg Knee	0.169
8	Angle of Take-off leg Ankle	0.289

*Significant, $r_{.05}(5)= .754$

Since the value of co-efficient of correlation required to be significant for 5 degree of freedom is.754, the above table clearly show that "Angle of Take-off leg hip indicating significant relationship with the performance (.754), whereas the above table clearly show that in case of Angle of Left shoulder indicating significant negative relationship with the performance where as in case of (Left Elbow, Swinging leg Hip, Knee, Ankle and Supporting leg Hip, Knee, Ankle) are lesser than the table value, therefore it has no significant relationship with performance of subject during landing phase in steeple chase.

Table 4: Relationship of Selected Angular Kinematic Variables with the Performance of Hurdle Clearance in Steeplechase at the Moment of Landing

S. No.	Variables	Mean	Coefficient of correlation
1.	Height of CG (Take-off)	0.97	0.419
2.	Height of CG (Flight)	1.31	-0.058
3.	Height of CG (Landing)	1.08	0.051

*Significant, $r_{.05}(5)$= .754

Since the required value of coefficient of correlation required being significant for 5 degree of Freedom is .754 the result of table 4 show that height of Centre of Gravity at selected moments has insignificant relationship with performance of subjects in Steeplechase.

Discussion and Conclusion

In case of angular kinematics variables the value of coefficient of correlations at selected moments were found significant in case of moments Take-off and Landing, where as insignificant values were found in case of Flight phase. But this does not mean that this angle of different joints at selected moment do not play any important role while clearing the hurdle in steeplechase. In case of moment Take-off there was significant positive correlation between the angle of Take-off leg Hip joint and performance. It indicates that increasing the angle of Hip during the Take-off also increase the time of Hurdle clearance, which means a poor performance.

In case of moment landing a significant negative correlation was found between the angle of left shoulder joint and performance. It indicating that increasing the angle of shoulder joint during the Landing will decrease the time of hurdle clearance, which means a better performance.

The relationship of selected linear kinematic variables (Height of CG at selected moments) with the performance of the subject at steeplechase found insignificant as the subject at steeplechase found insignificant as in the study the researcher was only confined to the relationship of Height of CG in steeplechase.

On the whole it may be as ascertained that the low value coefficient of correlation shown by selected variables does not mean that these variables are not contributing to the performance of subjects in steeplechase. In the insignificant value of coefficient correlation of these variables with the performance may be due to small sample size and availability of sophisticated equipment.

Recommendations

Based on the conclusion, drawn in this study, the following recommendations have been made:

1. The variables such as different angles and center of gravity may be kept in mind as the factor contributing to performance of player in steeple chase.
2. Similar study can also be conducted on female steeple chase players.
3. The results of this study may be helpful in preparing a model of hurdle clearance in steeple chase.
4. The results of this study may help the coaches and researcher to evaluate the performance of subject in steeple chase.
5. The athlete can make self-assessment with the result of the study.
6. Similar study may be conducted by using sophipments.
7. Similar study may be undertaken to analysis other techniques in track and other game.

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