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Penalty Stroke in Field Hockey: A Biomechanical Study

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Abstract. In the execution and conversion of penalty stroke various factors are involved. Amongst all, biomechanical factor is one of the decisive factor which has been neglected by the Indian researchers. Thus the present study was designed to reveal the associated biomechanical factors of penalty stroke execution. For the purpose of this study six intervarsity level male hockey players were recruited using stratified random sampling method. Their mean age, height and weight were 20 yrs (SD 0.89), 169.67 cm (SD 5.68) and 59.5 kg (SD 4.63), respectively. Three stances i.e. 90 degree, 45 degree and Wrong Foot stances were considered. Each player performed 3 penalty strokes for all pre-assigned stances targeted at four critical corners of the goal post. The 2×2 feet marked scale targets were placed at each critical corner of the goal post to determine the ball accuracy position. To acquire biomechanical quantities, one high speed Canon Legria HF S10 camcorder operating at 60 Hz mounted at a height of 5 feet was placed at 8 meters away, perpendicular to the penalty spot. The players and ball movement during the penalty stroke execution were recorded. Video footages were downloaded, slashed to desired footages and edited for biomechanical analysis. The ball velocity, acceleration, accuracy, stride length, contact time and length, were digitized with the help of Silicon Coach Pro7 motion analysis software. The acquired data of the variables were subjected to descriptive statistical analysis. The results showed that at right top corner in 90 degree stance position subjects gained maximum accuracy that is 52.08 percent with acceleration 14.88 ms^{-2}, velocity 27.30 ms^{-1}, stride length 0.83 mts., contact time 0.055 sec. and contact length 0.915 mts. At right ground corner in wrong foot stance position subjects gained accuracy 50 percent with acceleration 20.85 ms^{-2}, velocity 27.84 ms^{-1}, stride length 1.12 mts., contact time 0.045 sec. and contact length 0.93 mts. At left top corner in 45 degree stance position subjects gained accuracy 47.91 percent with acceleration 17.34 ms^{-2}, velocity 30.35 ms^{-1}, stride length 1.256 mts., contact time.061 sec. and contact length 1.08 mts. At left ground corner in 45 degree stance position subjects gained accuracy 47.92 percent with acceleration 19.92 ms^{-2}, velocity 33.60 ms^{-1}, stride length 1.278 mts., contact time 0.06 sec. and contact length 1.131 mts.

Keywords: Field hockey, penalty stroke, biomechanics, 90 degree stance, 45 degree stance and wrong foot stance, right top corner, right ground corner, left top corner, left ground corner.

1. Introduction

At its essence, performance enhancement breaks down a sport into its intrinsic movements and makes those movements better - whether stronger, agile, faster, stable, or less fatigued. But to truly enhance them, those movements must be dissected and diagnosed so that player's domination can occur. The need for biomechanical analysis has become fundamental in any sport with complex movements. New to the amateur sports world, a Biomechanical Motion Analysis which displays for coaches and players definitive data on joint angles, body positions, velocity and energy transfer during a repeatable sport-specific (and often position-specific) movement. Even at the top levels, players eventually break down after their physical compensations create enough stress on the system. Biomechanical Motion Analysis will directly lead to improved performance and injury prevention.

In the game of hockey every team has one or two penalty stroke specialists. Conversion of a goal via penalty stroke is highly technical aspect. In a 12×7 feet goal which is guarded by a goal keeper it is difficult for penalty stroke specialist to score defeating the goal-keeper as demands quick deceiving qualities of the specialist alongwith speed of movement and accuracy. Only four extreme corners of the goal-post are vacant when a penalty stroke is set into motion. Thus it is important for the striker to use proper skill and put the ball into the vacant space of the goal post to score a goal. As seen at the international matches every specialist uses their own specific stances when they are going to execute penalty stroke.

On the mechanics standpoint, regardless of a particular school of thought for sports techniques; the body can only move optimally in one way. This is due to the alignment of bones, the direction of muscle fibers and the designated contractile properties of those fibers. For example, hitting a baseball, swinging a golf club, serving a tennis ball, throwing a javelin, taking a lacrosse shot on goal, hitting or pushing a hockey ball, etc are complex rotational movement. These very different sports all rely on rotational movements and since the body can only rotate its parts in one ideal way. The planes of the action might be different, but the ideal chain of movements, or kinematic sequence, is the same. Starting with the feet, each body segment must transfer energy efficiently to the next in a sequential process. Power created from the push of the feet travels up the legs and then through the rotating 1) pelvis, 2) torso, 3) arms and finally to the 4) bat/driver/racquet/hockey stick/etc. This sequencing is what creates optimal power and consistency and reduces the risk of injury. But the subtleties of such movements are undetectable by the naked eye. Thus the use of motion analysis is soughed.

Penalty stroke become extremely important aspect of field hockey because it gives a clear chance to convert it into a goal. However, there is still a lack of scientific research done on field hockey as compared to other sports. Researcher unable to locate a single study related to penalty stroke in field hockey this clearly indicates that area is neglected by researcher. It will be of great interest for sports scientist, hockey coaches and players/ specialist to study the mechanics involved in the penalty stroke execution. This would provide information that will enhance the performance of penalty stroke specialists. Hence, this study is purpose to analyze the different penalty stroke considering stances variation and observe the mechanical efficiency of every stance and suggest the best stance for penalty stroke execution.

2. Methods

2.1. Participants

In order to do comprehensive analyses of biomechanical factors of penalty stroke execution. Six intervarsity level male hockey players were selected using stratified random sampling method. Their mean age, height and weight were 20 yrs (SD 0.89), 169.67 cm (SD 5.68) and 59.5 kg (SD 4.63), respectively.

2.2. Equipments and Facilities

The experimental apparatus used in this research work were camcorder, tripod, measuring tap, lime power, markers, 2×2 feet marked scale targets, hockey sticks and hockey balls.

2.3. Data Acquisition

To acquire biomechanical data, one high speed Canon Legria HF S10 was used to capture movements of penalty stroke execution. The camcorder mounted at a height of 5 feet, placed at 8 meters away perpendicular to the penalty spot. The shutter speed of the camcorder was adjusted at a higher speed (1/1000 of a second) in order to eliminate the blurring effects while processing the recordings. The 2×2 feet marked scale targets were placed at each critical corner of the goal post to determine the ball accuracy position. The subjects were asked to perform 3 penalty stroke each at four corners of the goal post with different stance position i.e. 90 degree, 45 degree and Wrong Foot (right leg forward and left leg behind in a diagonal line at the angle of 45 degree) stances were considered. Each player and ball movement during the designed penalty stroke execution was recorded.

2.4. Data Analysis

After recording, all the video footages were downloaded into personal computer and slashed to desired footages. Considering the clarity of the footage, accuracy bit and experts judgment only one best of three for each corner execution of penalty stroke were selected and subjected to biomechanical analysis. The ball velocity, acceleration, accuracy, stride length, contact time and length, were taken as variables and digitized with the help of Silicon Coach Pro7 motion analysis software.

2.5. Statistical methods

The acquired data of the variables were subjected to descriptive statistical analysis i.e. mean and standard deviation.

3. Results

The results of the statistical analysis, mean and standard deviation are presented in the following tables.

Table 1: Descriptive analysis of the Selected Variables at 45 Degree Stance

Corners		Accuracy (Per)	Acceleration (ms^{-2})	Velocity (ms^{-1})	Stride Length (mts)	Contact Time (sec)	Contact Length (mts)
RTC	Mean	50.00	18.29	25.42	1.11	0.05	0.97
	Standard Deviation	23.72	4.96	6.42	0.11	0.008	0.13
RGC	Mean	33.33	22.22	27.40	1.17	0.05	0.98
	Standard Deviation	12.91	12.86	2.74	0.15	0.021	0.127
LTC	Mean	47.91	17.34	30.35	1.26	0.061	1.08
	Standard Deviation	30.01	3.44	5.35	0.18	0.017	0.196
LGC	Mean	47.92	19.92	33.60	1.28	0.06	1.131
	Standard Deviation	14.61	4.51	6.14	0.13	0.021	0.25

RTC= Right Top Corner, RGC= Right Ground Corner, LTC= Left Top Corner, LGC= Left Ground Corner

A critical examination of table 1 indicated that in 45 degree stance position at right top corner subjects gained accuracy 50 percent with acceleration 18.29 ms^{-2}, velocity 25.42 ms^{-1}, stride length 1.11 mts, contact time 0.05 sec and contact length 0.97 mts, at right ground corner subjects gained accuracy 33.33 percent with acceleration 22.22 ms^{-2}, velocity 27.40 ms^{-1}, stride length 1.17 mts, contact time 0.05 sec and contact length 0.98 mts, at left top corner subjects gained accuracy 47.91 percent with acceleration 17.34 ms^{-2}, velocity 30.35 ms^{-1}, stride length 1.256 mts, contact time 0.061 sec and contact length 1.08 mts and at left ground corner subjects gained accuracy 47.92 percent with acceleration 19.92 ms^{-2}, velocity 33.60 ms^{-1}, stride length 1.278 mts, contact time 0.06 sec and contact length 1.13 mts.

Table 2: Descriptive analysis of the Selected Variables at 90 Degree Stance

Corners		Accuracy (Percent)	Acceleration (ms^{-2})	Velocity (ms^{-1})	Stride Length (mts)	Contact Time (sec)	Contact Length (mts)
RTC	Mean	52.08	14.88	27.30	0.83	0.055	0.915
	Standard Deviation	27.86	3.89	5.38	0.099	0.017	0.19
RGC	Mean	37.5	18.84	27.89	0.87	0.051	0.94
	Standard Deviation	25.00	3.80	5.84	0.20	0.011	0.09
LTC	Mean	29.17	17.92	32.34	1.021	0.05	0.89
	Standard Deviation	23.27	1.56	8.09	0.146	0.0063	0.153
LGC	Mean	29.17	21.26	33.57	1.09	0.06	1.08
	Standard Deviation	15.14	11.94	5.22	0.133	0.0357	0.3815

Table 2 indicated that in 90 degree stance position at right top corner subjects gained accuracy 52.08 percent with acceleration 14.88 ms^{-2}, velocity 27.30 ms^{-1}, stride length 0.83 mts, contact time 0.055 sec and contact length 0.915 mts, at right ground corner subjects gained accuracy 37.5 percent with acceleration 18.84 ms^{-2}, velocity 27.89 ms^{-1}, stride length 0.87 mts, contact time 0.051 sec and contact length 0.94 mts, at left top corner subjects gained accuracy 29.17 percent with acceleration 17.92 ms^{-2}, velocity 32.34 ms^{-1}, stride length 1.021 mts, contact time 0.05 sec and contact length 0.89 mts and at left ground corner subjects gained accuracy 29.17 percent with acceleration 21.26 ms^{-2}, velocity 33.57 ms^{-1}, stride length 1.09 mts, contact time 0.06 sec and contact length 1.08 mts.

Table 3: Descriptive analysis of the Selected Variables at Wrong Foot Stance

Corners		Accuracy (Percent)	Acceleration (ms^{-2})	Velocity (ms^{-1})	Stride Length (mts)	Contact Time (sec)	Contact Length (mts)
RTC	Mean	35.42	16.99	24.96	1.10	0.051	0.87
	Standard Deviation	27.86	5.28	3.81	0.18	0.01	0.28
RGC	Mean	50	20.85	27.84	1.12	0.045	0.93
	Standard Deviation	37.08	3.77	2.44	0.14	0.0054	0.0823
LTC	Mean	41.67	19.47	34.68	1.24	0.05	1.025
	Standard Deviation	20.41	3.08	2.96	0.13	0.01	0.18
LGC	Mean	35.41	18.29	30.16	1.25	0.061	1.06
	Standard Deviation	12.29	4.23	1.89	0.14	0.02	0.17

Table 3 documented that in wrong foot stance position at right top corner subjects gained accuracy 35.42 percent with acceleration 16.99 ms^{-2}, velocity 24.96 ms^{-1}, stride length 1.10 mts, contact time 0.051 sec and contact length 0.87 mts, at right ground corner subjects gained accuracy 50 percent with acceleration 20.85 ms^{-2}, velocity 27.84 ms^{-1}, stride length 1.12 mts, contact time 0.045 sec and contact length 0.93 mts, at left top corner subjects gained accuracy 41.67 percent with acceleration 19.47 ms^{-2}, velocity 34.68 ms^{-1}, stride length 1.24 mts, contact time 0.05 sec and contact length 1.025 mts and at left ground corner subjects gained accuracy 35.41 percent with acceleration 18.29 ms^{-2}, velocity 30.16 ms^{-1}, stride length 1.25 mts, contact time 0.061 sec and contact length 1.06 mts.

4. Discussion

The right top corner of the goalpost, in 90 degree stance position is scored the maximum score on accuracy (52.08 percent), whereas in 45 degree stance scores 50 percent and at wrong foot only 35.40 percent was gained by the subjects that is low than 90 degree stance for right top corner. The other variables like acceleration in 45 degree stance is best because there is acceleration 18.21 ms^{-2} is present with velocity 25.21 ms^{-1} if we consider these three variable then 45 degree stance position seems best from other two stance position because other variable have almost same score as in 45 degree stance stride length is 1.10 mts, contact time .055 sec, contact length .91 mts and in wrong foot stance 1.10 mts stride length, 0.05 sec, contact time and .85 mts contact length.

From the results of the study its is evidenced that at right ground corner in wrong foot stance was better compared to 45 degree and 90 degree due to the accuracy at this corner was 50 percent and other two 33.33 and 37.5 percent respectively, but if we considered acceleration and other parameters then 45 degree stance is better compared than other two stances.

If we discussed about left top corner with accuracy 47.91 percent, 45 degree stance showed maximum accuracy when we compared it with 90 degree stance (29.17) and wrong foot stance (41.67), however, at wrong foot stance the acceleration, velocity and contact length is higher than other two stance position and stride length and contact time was higher in 45 degree stance. At this corner 90 degree stance seems lower values in all selected parameters which are suggested that left top corner, 90 degree stance is not a better option.

When we critically examined the score of left top corner we found that at 45 degree stance subjects scored accuracy 47.92 percent which is maximum but acceleration is less than 90 degree and, velocity, stride length and contact length was higher than other two stances.

Pertaining to accuracy as depended variable, 45 degree stance was better compared with other two stance due to in this stance subjects gained almost better scores in all. It is suggested that amongst all three stances 45 degree stance given maximum change of scoring via penalty stroke in field hockey.

5. Conclusions

On the basis of the findings of the study it is concluded that:-

At right top corner subjects gained maximum accuracy that is 52.08 percent in 90 degree stance position with acceleration 14.88 ms^{-2}, velocity 27.30 ms^{-1}, stride length 0.83 mts, contact time 0.055 sec and contact length 0.915 mts.

At right ground corner subjects gained accuracy 50 percent which is maximum in wrong foot stance position with acceleration 20.85 ms^{-2}, velocity 27.84 ms^{-1}, stride length 1.12 mts, contact time 0.045 sec and contact length 0.93 mts.

At left top corner subjects gained accuracy 47.91 percent in 45 degree stance position with acceleration 17.34 ms^{-2}, velocity 30.35 ms^{-1}, stride length 1.256 mts, contact time.061 sec and contact length 1.08 mts.

At left ground corner subjects gained accuracy 47.92 percent in 45 degree stance position with acceleration 19.92 ms^{-2}, velocity 33.60 ms^{-1}, stride length 1.278 mts, contact time 0.06 sec and contact length 1.131 mts.

On the basis of above mentioned conclusions it is evident that 45 degree stance position of penalty stroke execution is better than other two execution stances i.e. 90 degree stance and wrong foot stance.

Hockey players have their own specific stance but it is recommended that coaches while training their trainees the findings of this study shall provide much orientation.

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