BIOMECHANICAL ANALYSIS OF PENALTY CORNER DRAG FLICK IN FIELD HOCKEY

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To identify the dominant factors influencing ball velocity in field hockey drag flicking from selected biomechanical variables in male hockey players (N=50). Relevant biomechanical variables were analysed across; approach, stick contact, drag and follow through phases. Basler and Canon cameras were used to capture the drag flick performance in two-dimensions (2D) using MAX TRAQ Software. Pearson product moment correlation, partial correlation, and multiple regression was used to predict the influence of selected independent variables on ball velocity. Both forms of correlation results reveal that ball velocity had a high positive correlation with stick velocity. Multiple regression showed that the selected biomechanical variables accounted for 74% of the final ball velocity. The results of regression equation model show that apart from other selected independent variables, drag length, stick velocity and distance of left foot from ball are the highly predictive of the ball velocity in the drag flick.

KEYWORDS: field hockey, drag flick, prediction.

INTRODUCTION: Team success in field hockey has been linked to the effectiveness of penalty corner conversion. The penalty corner is one of the most important components of the game of field hockey, with one third of the goals resulting from this tactical situation (Laird & Sutherland, 2003)(Mosquera, Molinuevo, & Román, 2007). If executed correctly, the drag flick can lead to more goals. In technical terms, the drag is a hybrid stroke with components of the more common flick and scoop strokes. It is an impressive technique that makes the game more spectators orientated (Lees, 2002), with it being shown that correct motor execution of the drag flick techniques is essential to achieve a success (Canal-Bruland et al., 2010). Penalty corner success depends on the correct push in, stop of the ball outside the circle, analysing defending pattern of opponents, and timing and accuracy in execution. The drag flick should follow the biomechanical pattern of throwing and hitting skills which aims to maximize the speed of the free end (distal) segment at release. Previous research has identified the major contribution to drag flick ball speed being; stance width, the distance between the front foot and the ball at the beginning of the double foot contact, and the level of pelvis and upper trunk angular velocity at ball release (Kerr & Ness, 2006). The purpose of this study was to identify the influence of selected biomechanical variables on drag flick ball velocity in a field hockey penalty corner task.

METHODS: Fifty male right handed drag flickers were selected from Tamil Nadu and Karnataka States to participate in this study. The subjects were experienced in penalty corner drag flick techniques. The drag flick was recorded in sunny and clear weather at synthetic hockey field at YMCA College of Physical Education during morning session. Pylon Basler Gige and Canon EOS 5D Mark II cameras were positioned in the sagittal and frontal planes respectively (Figure 1), and were used to capture 2D penalty corner drag flick performance at 100Hz. An auditory signal was used to synchronise both cameras. The shutter speed of the camcorder was set at 1/2000s and exposure time was kept 1500th of a second in order to eliminate blurring. A cage with the dimensions of 1m x 1m at four control points was used to calibrate the space in which drag flick was performed. Each participant performed 10 trials after a specific warm-up. The trial which resulted in a successful goal with the highest ball velocity, was selected for further analysis. Videos were analysed using the MAX TRAQ Software.

Figure 1: camera set up

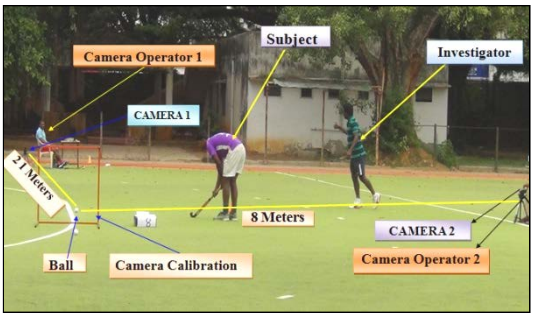

Figure 2: Four phases of drag flick in field hockey

Biomechanical parameters were measured across the approach, stick contact phase, drag and follow through phases. Time of Approach (TOA), Total Distance of Approach (TDA), Distance of Right Foot from Ball (DRFB) were investigated in the approach phase, Distance of Ball from Right Foot (DBFRF), Time of Stick Contact with Ball (TSCB), Time of Left Foot Contact with Ground (TLFCG) variables were investigated during the stick contact phase. Drag Length (DL), Drag Time (DT), Drag Velocity (DV), Left Knee Angle (LKA), Stance Width (SW), Stick Angle (SA) in drag phase, Stick Velocity (SV), Distance of Left Foot from Ball (DLFB), Time of Ball Release (TBR), Total Time of Drag Flick (TTDF) were analysed in the follow-through phase. Ball velocity served as the dependent variable.

The time of approach (TOA) is the time taken to contact the ball from starting position, Total distance of approach (TDA) is the distance between starting position and ball contact position and Distance of right foot from the ball (DRFB) is the distance between right foot and the ball in approach phase. Distance of Ball from Right Foot (DBFRF) is the distance of ball from right foot, Time of Stick Contact with Ball (TSCB) is the duration of stick contact with the ball, Time of Left Foot Contact with Ground (TLFCG) is the duration of left foot contact with the ground at contact phase. Drag Length (DL) is the distance of ball dragged, Drag Time (DT) is the duration of drag, Drag Velocity (DV) was derived by dividing drag length and drag time, Left Knee Angle (KA) is the flexion of knee joint, Stance Width (SW) is the distance between two feet, Stick Angle (SA) is the maximum angle of stick with reference to the ground in drag phase. The stick velocity (SV) was measured by dividing the distance of the stick traveled divided by the time of travel of the stick, Distance of Left Foot from Ball (DLFB) is the distance from the left foot to point of release of ball, Time of Ball Release (TBR) is the duration between the contact of left foot on the ground and ball release from the stick, Total Time of Drag Flick (TTDF) is the duration of stick contact with ball to ball release in follow through phase. Pearson's product moment correlation and partial correlation was used to determine the relationship between the selected independent variables and ball velocity. Multiple regression was used to determine the influence of selected independent variables on ball velocity during the drag flick. In all cases, an alpha level of 0.05 was used to determine statistical significance.

Results and Discussion

The ball velocities of drag flick of present study of 28.65 ±1.69 m/s were similar to the values (19.6 to 27.8 m/s) reported by Yusoff et al. (2008), larger than the values reported by McLaughlin (1997) (15.2 to 21.8 m/s) , de Subijana, Daniel, Mallo, & Navarro (2010) (25.4 m/s), De Subijana, Gómez, Martín-Casado, & Navarro (2012) (24.9 m/s) and Gómez, De Subijana, Antonio, & Navarro (2012) (22.49 m/s)**.** This is simply due to higher quality player in present study. In the approach phase, the distance of right foot from ball (r = 0.358) had a moderate correlation with the ball velocity of drag flick. Hence, it is obvious that the drag flickers, who have a good distance of his right foot from the ball during approach phase, would be able to release the ball at high velocity.

S.No No	Variables	Mean	SD (±)	r
1.	Ball Velocity (m/s)	28.65	1.69	-

1.	Height (m)	1.74	0.10	-0.035
2.	Body Weight (kg)	72.84	5.30	**-0.312**
	Drag Flick - Approach Phase			
3.	Time of Approach (1/100th Sec)	1.00	0.11	-0.100
4.	Total Distance of Approach (1/100th Sec)	2.93	0.30	-0.123
5.	Distance of Right Foot from Ball (1/100th Sec)	1.31	0.17	**0.358**
	Contact Phase			
6.	Distance of Ball from Right Foot (1/100th Sec)	0.69	0.11	-0.021
7.	Time of Stick Contact with Ball (1/100th Sec)	0.49	0.04	0.166
8.	Time of Left Foot Contact with Ground (1/100th Sec)	0.23	0.02	**-0.341**
	Drag Phase			
9.	Drag Length (1/100th Sec)	2.31	0.07	**0.465**
10.	Drag Time (1/100th Sec)	0.36	0.03	-0.051
11.	Drag Velocity (m/s)	6.89	0.50	0.152
12.	Left Knee Angle (degrees)	141.85	3.26	0.261
13.	Stance Width (m)	1.37	0.08	**-0.448**
14.	Stick Angle (degrees)	73.32	3.69	-0.072
	Follow Through Phase			
15.	Stick Velocity (m/s)	26.18	2.39	**0.561**
16.	Distance of Left Foot from Ball (m)	1.08	0.12	**0.317**
17.	Time of Ball Release (1/100th Sec)	0.19	0.02	0.098
18.	Total Time of Drag Flick (1/100th Sec)	1.60	0.09	-0.105

Table 1: Descriptive results on the selected variables (N=50)

In the contact phase, mean value of TCLG (0.23s), is larger than 0.16s achieved by Corbett (McLaughlin, 1997) and similar to the value 0.22s achieved by the players of Pakistan and lesser than the value 0.44 s performed by Argentines (Yusoff et al. 2008). The time of left foot contact with ground (r = 0.687) was highly correlated with ball velocity which is reinforced by the results of partial correlation. The ball velocity generated during the left leg extension step represents approximately one third of the final resultant of ball velocity. The time of left foot contact with ground after cross over step in contact phase related with the ball velocity of drag flick performance. In drag phase, the drag length (r = 0.465) had a moderate relationship with ball velocity of the drag flick performance. The drag length values (mean 2.31m, SD± 0.66m) of the present study is lesser than the value of 2.18m reported by McLaughlin (1997), and 2.14m drag flick reported by Bari et al. (2014) but close to the value of 2.30m presented by Bari et al. (2014). If drag length increases with minimum time of drag, the drag velocity increases to generate the ball velocity. The stance width at left foot contact with ground (mean 1.37m, SD ±0.08m) is lesser than the 1.42m (McLaughlin, 1997), 1.49m (Subijina et al. 2010), 1.51m (Subijina et al. 2011), 1.42m (Bari et al. 2014) and 1.5 m to 1.81m (Yusoff et al. 2008). The stance width (r = 0.508) had a high correlation with ball velocity. The stance width depends upon the anthropometric, technique of drag flick and physiological variables of the players. The larger the stance width that the flicker can create, the lower the body position and centre of mass is low would contribute better drag flick performance. If the stick angle (mean 73.32 degree SD ± 3.68 degrees) deceases during the drag phase, it supports to increase the drag length and generate the ball velocity.

In the follow through phase, stick velocity was highly correlated (r = 0.561) with the ball velocity (mean 26.18 m/s, SD ± 2.39 m/s) among drag flickers in the present study. This value was similar when compared to 18.91m/s (Gomez, 2010), 25.9 m/s (Yusoff, 2008). The distance of the left foot from the ball at release (mean 1.08 m, SD ±0.12 m) is larger than the value (0.80m) reported by Yusoff (2008), (0.32 m to 0.91m) McLaughlin (1997), and (0.50 m & 0. 67 m) Gomez et al. (2012). In the game situation, in the case of total time of drag flick (mean 1.60 s, SD ± 0.93 s), the quicker the flick can be executed, the less time the opposition defenders have the chance to stop the ball. The distance of left foot from the ball at release (r = 0.371) had a moderate correlation with the ball velocity. The partial correlation was applied to find out the accurate relationship of ball velocity with each independent variable by partialling out the influence of the remaining independent variables. It is revealed that drag length, and the distance of right foot from ball has a medium correlation with ball velocity, with stick velocity returning a high correlation. The drag length (r = 0.475) was highly correlated with ball velocity which is reinforced by the results of partial correlation. It is clearly evident from the results of the study that drag length (DL) is a predictor of ball velocity in drag flick. This highlights the need for the drag length to be maximized. By positioning the body correctly at right foot touchdown, this gives the player the opportunity to maximize drag length. The players established the greatest potential for maximal drag length by placing the right foot closer to the net than the ball at right foot contact. Thus they achieved a maximal drag length and an optimal ball velocity of drag flick. It is evident that stick velocity (SV) is a predictor of ball velocity in drag flick. The highest stick velocity help to generate momentum force and greater velocity and both are directly associated with ball velocity of drag flick (Bartlet, 2007).

Multiple Regression Analysis

Multiple regression is an extension of simple linear regression. It is used to predict the value of a dependent variable (ball velocity) based on the value of selected independent variables in this study. Multiple regression also determines the overall fit of the model and the relative contribution of each of the predictors to the total variance explained. The table-2 shows the R, R^2, adjusted R^2, and the standard error of the estimate, which can be used to determine how well a regression model fits the data. The R value is 0.860 and R^2 value is 0.740. The adjusted R^2 value 0.589 reveals that there is a high correlation (58.9%) between the selected variables and ball velocity. From R^2 value (0.740), it was clear that 74% of ball velocity value of the drag flick among hockey players was determined by the selected biomechanical variables. It was also found that the multiple correlation co-efficient R = 0.860, which indicates that there was a high level of multiple correlation (86%) with penalty corner drag flick ball velocity and a good predictor of dependent variable the drag flick.

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate
1	0.860[a]	0.740	0.589	1.08017

Table 2: Multiple regression values on ball velocity and selected independent variables in drag flick

The table - 3 shows that the independent variables statistically significantly predict the dependent variable, ***F*** (18, 31) = 4.91, ***P*** < 0.05. The results of ANOVA table reveals that the regression model is a good fit of the data and its significance validates the data to move for further analysis of regression equation model.

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	103.06	18	5.73		
Residual	36.17	31	1.17	4.91	0.00[a]
Total	139.23	49			

Table 3: Analysis of Variance

Regression equation model

The unstandardized Coefficient B (UCB) value of drag length (9.619) means that for each meter increase in drag length, there is an increase in ball velocity of 9.619 m/s. Whereas the standard coefficient beta value SCB) 0.381 reveals that increase in one standard deviation in drag length (Independent Variable) increases 0.381 standard deviation in ball velocity (dependent variable). Similarly, stick velocity (UCB=0.335, SCB=0.475), left foot from ball at release (UCB=6.432, SCB=0.443) increases ball velocity and standard deviation.

Predicted Ball Velocity of Drag Flick = – 19.146 + (1.368 x Height) – (0.20 x Weight) + (4.746 x TA) – (0.134 x TDA) + (1.887 x DRFB) + (0.530 x DBRF) + (0.530 x DBRF) + (8.280 x TSCB) – (7.103 x TLF) + **(9.619 x DL)** + (0.500 x DT) + (0.166 x DV) – (0.020 x LKA) – (2.789 x SW) + (1.22 x SA) + **(3.35 x SV)** + **(6.432 x DLFB)** – (5.403 x TBR) – (2.088 x TTDF)

Table 4: Regression Equation of ball velocity in Drag flick

Table 4 shows that drag length, stick velocity and distance of left foot from ball are the major predictors of ball velocity in drag flick.

CONCLUSION: Drag length, distance of right foot from ball has medium correlation and stick velocity has high correlation with ball velocity after partialling out the influence of remaining independent variables. The results of multiple regression analysis show that 74% of ball velocity value of the drag flick among hockey players was determined by the selected biomechanical variables. Finally, the results of regression equation model show that apart from other selected independent variables, Drag length, Stick Velocity and Distance of Left Foot from Ball are the highly predicting variables of the ball velocity in drag flick.

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