

Case report

The application of biomechanics to penalty corner drag-flick training: a case study

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Abstract

The penalty corner is one of the most important game situations in field hockey with one third of all goals resulting from this tactical situation. The aim of this study was to develop and apply a training method, based on previous studies, to improve the drag-flick skill on a young top-class field hockey player. A young top-class player exercised three times per week using specific drills over a four week period. A VICON optoelectronic system (Oxford Metrics, Oxford, UK) was employed to capture twenty drag-flicks, with six cameras sampling at 250 Hz, prior and after the training period. In order to analyze pre- and post-test differences a dependent t-test was carried out. Angular velocities and the kinematic sequence were similar to previous studies. The player improved (albeit not significantly) the angular velocity of the stick. The player increased front foot to the ball at T1 ($p < 0.01$) and the drag-flick distances. The range of motion from the front leg decreased from T1 to T6 after the training period ($p < 0.01$). The specific training sessions conducted with the player improved some features of this particular skill. This article shows how technical knowledge can help with the design of training programs and whether some drills are more effective than others.

Key words: Hitting/batting, biomechanics, techniques, field hockey, training.

Introduction

The penalty corner is one of the most important game situations in field hockey, with one third of the goals resulting from this tactical situation (Laird and Sutherland, 2003; Piñeiro, 2008). The drag-flick is between 1.4 and 2.7 times more efficient than hitting or push-shooting the ball towards the goal when playing a penalty corner (McLaughlin, 1997; Piñeiro et al., 2007; Yusoff et al., 2008).

Only a few studies have analyzed the drag-flick. Some of them have provided kinematic information about players from different levels (McLaughlin, 1997; Yusoff et al., 2008; López de Subijana et al., 2010). These authors reported the cues which indicated a drag-flick: a wide stance, a whipping action of the stick before the hips and shoulders were rotated, and a final acceleration of the stick. In addition, Baker et al. (2009) focused on anticipation skills of the goalkeepers, while Jennings et al. (2010) studied the registered forces on the face of the stick. All of these studies were descriptive in nature.

Most of the previous field hockey experimental studies have focussed on training topics, such as endurance (Manna et al., 2009; Chapman et al., 2009), general

physical condition (Astorino et al., 2004; Spencer et al., 2004), velocity (Bloomfield et al., 2007) and strength (Cochrane and Stannard, 2005). In relation to technical training, Beckamnn et al., (2010) applied different treatments for the push and the flick in indoor hockey twice per week during six weeks, obtaining very heterogeneous findings. To date, no studies have been conducted concerning the training of the drag-flick skill in field hockey.

Therefore, the aim of this study was to develop and apply a training method, based on previous studies, to improve the drag-flick skill on a young top-class field hockey player.

Methods

One male drag-flicker (19 years old; 66.8 kg; 1.71 m; eight years of field hockey experience) participated in this study. He was a drag-flicker from the under-21 Spanish National Team. The participant was requested to provide informed consent prior to his participation. The University's Ethics Committee approved the research protocol.

The training sessions were conducted in the hockey field of the Spanish Sports Council's High Performance Centre. The player exercised three times per week using specific drills over a four week period, completing a total of 12 sessions (Beckamnn et al., 2010). The average duration of the training sessions was 45 minutes and they were supervised by a qualified hockey coach and ex-Olympic athlete. The training sessions started with a preliminary warm up which was followed by four drills ordered by increasing complexity (Figures 1 to 4). Each drill was related to findings from previous studies (McLaughlin, 1997; Yusoff et al., 2008; López de Subijana et al., 2010) and it was performed in 2 sets with 7 repetitions per set (2x7). After each drill, 10 free drag-flicks were performed in order to add the new information to the overall movement. The training sessions were designed and organized according to a panel of expert. All the coaches selected had a minimum of 10 years experience as hockey coaches and they were members of the staff of the Royal Spanish Hockey Federation. Three dimensional (3D) data analysis was conducted prior to and after the training period.

All of the measurements were carried out in the Biomechanics Laboratory of the Faculty of Physical Activity and Sport Sciences at the Technical University of Madrid. A VICON optoelectronic system (Oxford Metrics, Oxford, UK) captured the drag-flicks with six cameras, sampling at 250 Hz. The experimental space was 5m

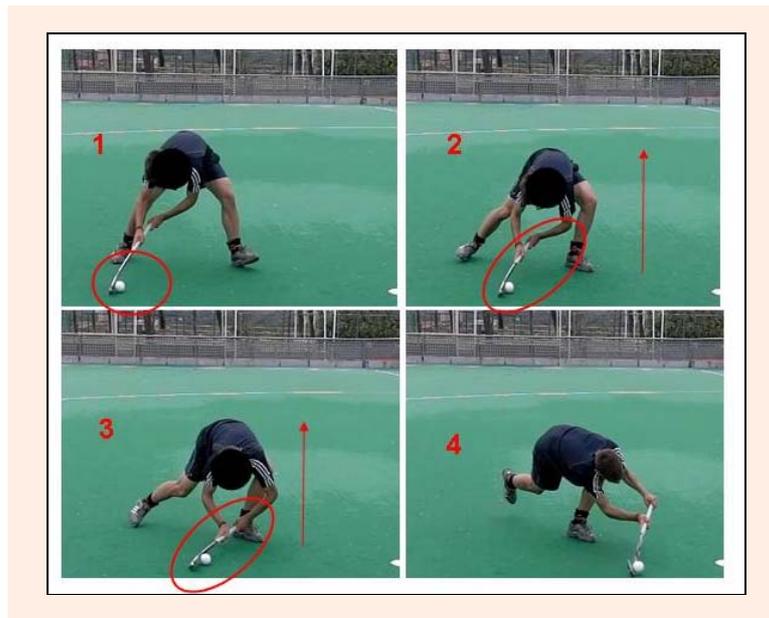


Figure 1. Drill 1: Isolating the ball's movement along the stick. The player takes the ball with his trunk in a low position and then advances his hands so the balls move towards his grip. After he accelerates the stick (whipping effect), and the ball moves back to the end of the stick.

long, 2.5m wide and 2m high, and was dynamically and statically calibrated with an error of less than 2 cm and a static reproducibility of 0.4%. A total of 49 retro-reflective markers (46 body markers and three 14 mm diameter stick markers) were attached to anatomical landmarks following VICON's kinematics model (Vicon

Motion Systems, 2003). The stick markers were placed where the player's grip began, at the toe of the shaft, and at the end of the shaft. The stick's features (height: 94 cm; mass: 584.6 g; distance between the center of mass position and the end of the shaft: 38.4 cm) were approved by the International Hockey Federation (2009). Raw data

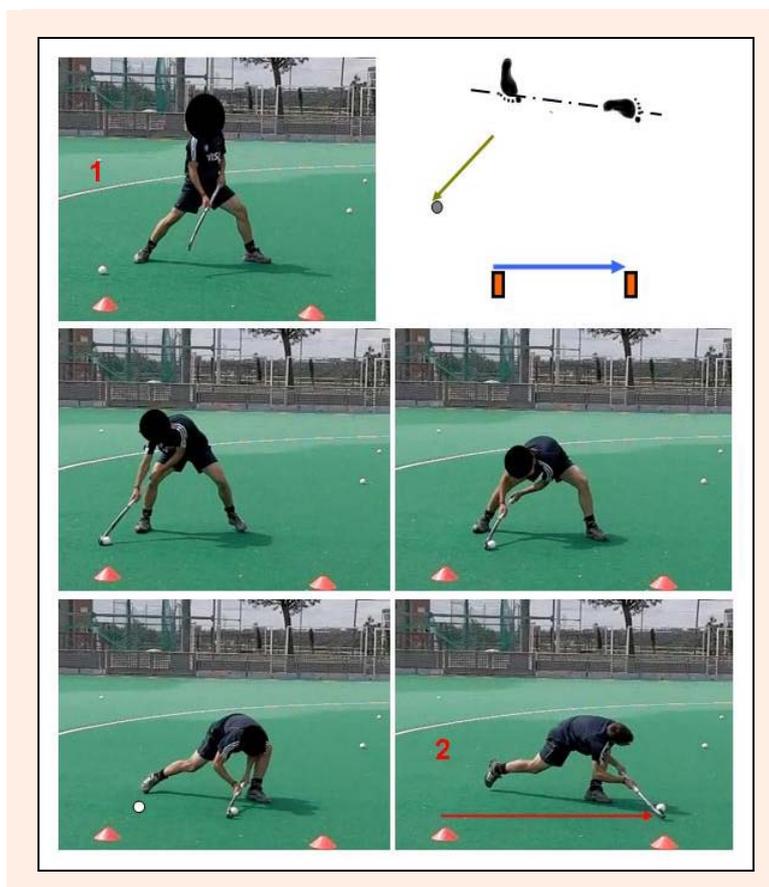


Figure 2. Drill 2: Taking the ball behind the rear foot. The signals are at 80% of the height of the player and the ball is behind his back foot. He performs the drag-flick from a static position.

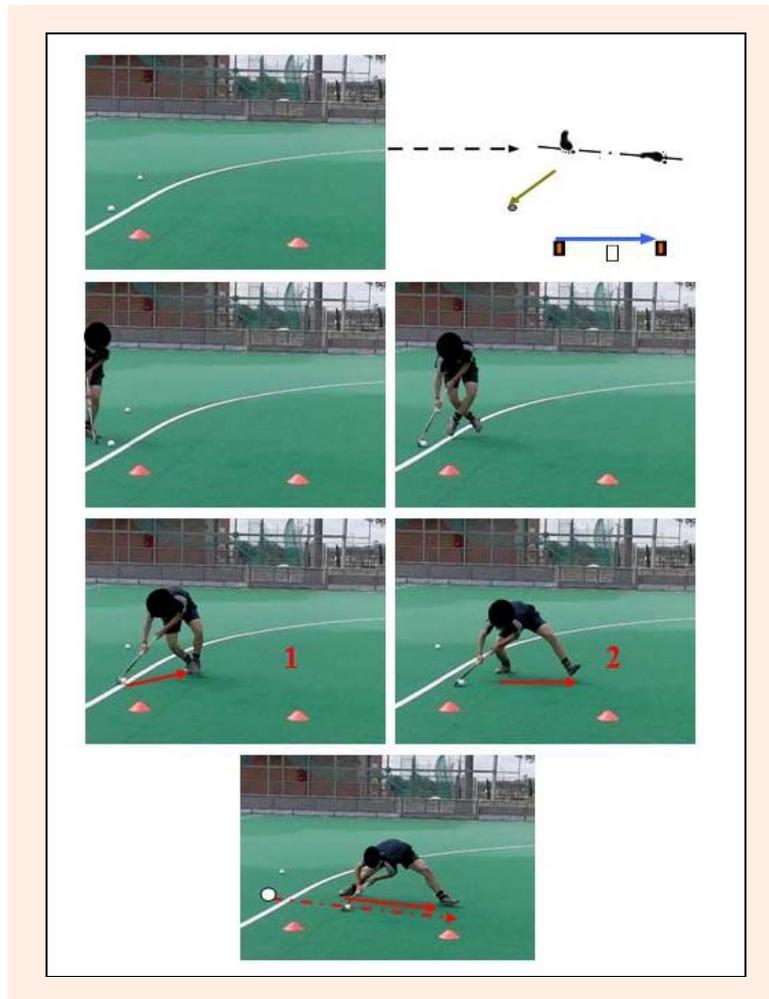


Figure 3. Drill 3: Making the last stance wider. After four or five previous runs to measure the correct distance to the ball and the signal, the player combined drills 1 and 2, taking the ball behind the back foot and placing the last double foot contact in a wide position.

were filtered using quintic spline functions based on Woltring's Generalized Cross-Validation (GCV) method for calculating the smoothing factor (Woltring, 1986). As markers could not be placed on the ball, an official field hockey ball was covered with adhesive reflective material. VICON cameras recognized the ball as a marker and ball velocity was estimated.

After a specific warm-up, 20 trials were carried out and captured at habitual speed. In each trial, the participant shot into a goal area marked with a fence in front of the player. If the participant did not score in the goal area, the trial was rejected. The ball was placed by the subject approximately 1.5 to 2 m away from the centre of the calibrated area. The drag-flick movement commenced once the front foot made contact with the floor, and finished 20 frames after the stick's peak positive angular velocity. The pelvis, upper trunk and stick angles were calculated using the line of the double foot contact as the y-axis, the x-axis as 90° to the right of the y-axis and the z-axis as the vertical axis. The angular velocities were computed from the angles formed by the upper trunk (shoulder line), pelvis (hip line), and stick with the x-axis on the xy plane. The knee flexion angle was computed for the front leg only. The knee flexion angle was computed for the front leg only.

The following key events of the drag-flick were identified: T1 (front foot contact); T2 (maximum angular velocity of the pelvis); T3 (peak negative angular velocity of the stick); T4 (maximum angular velocity of the upper trunk); T5 (maximum angular velocity of the stick); and T6 (ball release). The event times were normalized to the T1-T6 times. The stance width, drag-flick distance and the front foot-ball distance at T1 were normalized to the player's height.

Statistical analysis was carried out using SPSS v.16 software (SPSS Inc., Chicago, IL, United States). The means and standard deviations of the study parameters were calculated. In order to analyze pre- and post-test differences, a dependent t-test was carried out. The alpha level of significance was set at $p < 0.05$ for all statistical tests.

Results

The player achieved ball velocities of $24.9 \pm 0.9 \text{ m}\cdot\text{s}^{-1}$ prior to the training period and $24.6 \pm 0.8 \text{ m}\cdot\text{s}^{-1}$ after the training period. The angular velocities are shown in Table 1. The angular velocities of the stick in the post-test improved ($p > 0.05$) up to $-256.0 \pm 56.05 \%$ the negative peak and $1315.4 \pm 153.9 \%$ the maximum peak. The

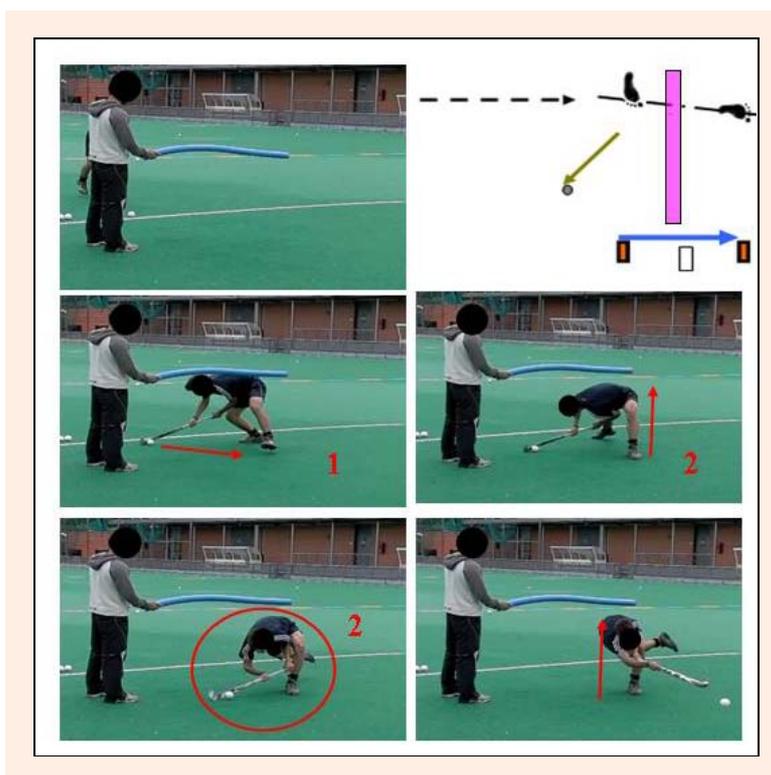


Figure 4. Drill 4: Keeping low the centre of mass. The player performed the drag-flick by passing the ball under the tube.

maximum angular velocity of the upper trunk reached 475.3 ± 32.4 %/s after the training period ($p > 0.05$). Table 2 shows the kinematic sequence, which was similar before and after the training period. Peak angular velocity of the pelvis was recorded at 35.9 ± 5.4 and 38.9 ± 2.8 % of the total time. The whipping effect of the stick was found close to 50% of the duration of the drag-flick (51.8 ± 4.4 and 50.8 ± 4.1 %). The maximum angular velocity of the stick was achieved near the release (101.3 ± 5.9 and 100.3 ± 5.1 %). Distance and angular parameters are shown in Table 3. The player increased 9 cm ($p < 0.01$) the distance from the front foot to the ball at T1 and 7 cm ($p > 0.05$) the drag-flick distance. The range of motion from the front leg decreased from T1 to T6 after the training period ($p < 0.01$), from $37.7 \pm 3.7^\circ$ to $27.3 \pm 3.9^\circ$, respectively.

Table 1. Summary of the peak angular velocity parameters (%/s). Data are means (\pm SD).

Parameter	Pretest	Posttest
Stick (negative)	- 237.0 (56.1)	-256.8 (50.8)
Pelvis	381.7 (48.5)	373.9 (40.5)
Upper trunk	461.2 (43.6)	475.3 (32.4)
Stick (positive)	1261.9 (93.9)	1315.4 (153.9)

Discussion

The present study has shown improvements on the technical performance of a young top-class player, even though the training period was only four weeks long. The player achieved ball velocities which were close to those recorded by high performance players who have participated in previous studies (López de Subijana et al., 2010; Yusoff et al., 2008;), but lower than the $30.5 \text{ m}\cdot\text{s}^{-1}$ measured using radar by Baker et al. (2009). The values reported for the negative peak of the angular velocity of the

stick, the maximum angular velocity of the pelvis and the maximum angular velocity of the upper trunk were in the range suggested in a previous study (López de Subijana et al., 2010). The angular velocity of the stick was lower than that of a skilled drag-flicker (1890.1 ± 72.8 %/s) and the male's group (1473.2 ± 177.8 %/s) from López de Subijana et al. (2010). This could be due to the age of the participant in this case study, as the player was young (19 years old), compared with the samples in previous studies (López de Subijana et al., 2010; Yusoff et al., 2008). The kinematic sequence was similar to that previously reported. Data concerning the stance width were similar to those found by McLaughlin (1997), Yusoff et al. (2008) and López de Subijana et al. (2010). Drag-flick velocity was lower than the $11.6 \text{ m}\cdot\text{s}^{-1}$ and $12.3 \text{ m}\cdot\text{s}^{-1}$ recorded by López de Subijana et al. (2010) and McLaughlin (1997), respectively.

Table 2. Summary of the normalized event times (% T1-T6 time). Data are means (\pm SD).

Event	Pretest	Posttest
T2	35.9 (5.4)	38.9 (2.8)
T3	51.8 (4.4)	50.8 (4.1)
T4	59.9 (7.1)	58.4 (2.9)
T5	101.0 (5.9)	100.3 (5.1)

Abbreviations: T1: foot contact; T2: peak pelvis angular velocity; T3: peak negative angular velocity of the stick; T4: peak upper trunk angular velocity; T5: peak positive angular velocity of the stick; T6: ball release.

The results of this study have shown improvements during the earlier phases of the skill. The player increased drag-flick front foot to the ball at double foot contact (T1) distances. These improvements could be due to drills number 1 (rolling the ball on the stick), 2 (taking the ball behind the rear foot), and 3 (making the last stance wider). The previous phase is very important in order to

Table 3. Summary of the distance and angle parameters. Data are means (\pm SD).

	Pretest	Posttest
Stance width (m)	1.49 (.03)	1.51 (.02)
Normalised stance width (% BH)	87.43 (2.00)	88.59 (1.70)
Front foot ball distance at T1 (m)*	-1.13 (.03)	-1.22 (.05)
Normalized front foot ball at T1 (% BH)*	-66.12 (1.90)	- 71.20 (3.30)
Drag-flick distance (m)	1.98 (.15)	2.05 (.12)
Normalised drag-flick length (% BH)	116.30 (8.63)	119.97 (7.30)
Drag-flick mean velocity (m/s)	9.9 (.8)	9.9 (.5)
Knee angle at T1 (°)*	161.8 (2.3)	157.1 (1.4)
Knee angle at T6 (°)*	124.3 (2.7)	130.2 (4.0)
Knee range of motion T1-T6 (°)*	37.7 (3.7)	27.3 (3.9)

Abbreviations: BH: body height; T1: foot contact; T6: ball release.* p<0.01

prepare a clear drag of the stick before the final acceleration. Complementarily, the player achieved a no statistically significant higher maximum angular velocity of the stick. The front leg flexion decreased after training, similarly to the skilled drag-flicker studied by López de Subijana et al. (2010).

A limitation of this study could be that there were two data collection, prior and after the training period. Beckamnn et al. (2010) also registered the precision six and twelve weeks later in order to measure the retention of the treatments.

Conclusion

The specific training sessions conducted with the player improved some features of this particular skill. The player took the ball further at double foot contact, dragged the ball a longer distance and obtained higher angular velocity of the stick.

This article shows how technical knowledge can help with the design of training programs and whether some drills are more effective than others.

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Key points

- This article adds information about the drag-flick kinematics.
- This article adds information about how to train the drag-flick.
- The drag-flick is the most efficient technique shooting for goal after a penalty corner.

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