# TRAINING-INDUCED CHANGES IN DRAG-FLICK TECHNIQUE IN FEMALE FIELD HOCKEY PLAYERS

**AUTHORS:** de Subijana C.L.[1], Gómez[1] M., Martín-Casado[2] L., Navarro E.[1]

[1] Facultad de Ciencias de la Actividad Física y del Deporte-INEF, Technical University of Madrid, Spain
[2] Facultad de Ciencias del Deporte, Castilla-La Mancha University, Toledo, Spain

**ABSTRACT:** The penalty corner is one of the most important goal plays in field hockey. The drag-flick is used less by women than men in a penalty corner. The aim of this study was to describe training-induced changes in the drag-flick technique in female field hockey players. Four female players participated in the study. The VICON optoelectronic system (Oxford Metrics, Oxford, UK) measured the kinematic parameters of the drag-flick with six cameras sampling at 250 Hz, prior to and after training. Fifteen shots were captured for each subject. A Wilcoxon test assessed the differences between pre-training and post-training parameters. Two players received specific training twice a week for 8 weeks; the other two players did not train. The proposed drills improved the position of the stick at the beginning of the shot (p<0.05), the total distance of the shot (p<0.05) and the rotation radius at ball release (p<0.01). It was noted that all players had lost speed of the previous run. Further studies should include a larger sample, in order to provide more information on field hockey performance.

**KEY WORDS:** field hockey, biomechanics, shooting, training, women

Reprint request to:
**Cristina López de Subijana**
Facultad de Ciencias de la Actividad
Física y del Deporte-INEF
Technical University of Madrid
Avda. Martín Fierro 7
28040 Madrid, Spain
Phone: 0034 91 336 4143
Fax: 0034 91 544 1331
Email: c.lopezdesubijana@upm.es

## INTRODUCTION

The penalty corner is one of the most important scoring plays in field hockey [13,18]. The drag-flick is used for shooting at goal with speed and precision, as it is more effective than other techniques such as hits and pushes when playing a penalty corner [16,19,20,26]. According to the rules of hockey, there are no limits regarding the maximum ball height when the first shot at goal is a push or a drag-flick. Women players tend to use the drag-flick less than deflections or hits [18–20].

Most studies that have analysed strike techniques in field hockey were based on male samples [5,9,7,12,16,26]; only de Subijana et al. [14] included females in their study. Previous studies have provided kinematic information about the drag-flick [14,16,26]. These authors described the technique as a wide stance, a whipping action of the stick before the hips and shoulders are rotated and a final acceleration of the stick. Recent studies have focused on the anticipation skills of goalkeepers and on the forces recorded on the face of the stick [2,11].

Moreover, of all hockey experimental studies [1,4,6,8,15,22], only one was based on training technique [3]. The latter study involved different training methods for the push and flick in indoor hockey twice a week for 6 weeks, with variable findings. To date, no studies have considered training in the drag-flick technique in women field hockey players.

Therefore, the aim of this study was to describe training-induced changes in the drag-flick technique in female field hockey players.

## MATERIALS AND METHODS

*Subjects.* Four female drag-flickers (18.35 ± 1.94 years old; 68.88 ± 7.58 kg; 165.53 ± 5.04 cm; 2.45 ± 1.79 years of experience in this skill) participated in this study, all of whom were drag-flickers in the first division of the Spanish Field Hockey League. The participants were requested to provide informed consent prior to their participation. The University's Ethics Committee approved the research protocol.

*Data collection*
The training sessions were conducted on the hockey pitch of the Spanish Sports Council's High Performance Centre. The players

exercised twice a week using specific drills over an 8-week period, completing a total of 16 sessions [3]. 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 method was based on technique. The training sessions started with a preliminary warm-up, which was followed by three drills ordered by increasing complexity (see Fig. 1). Each drill was based on findings from previous studies [14,16,26] and was performed in two sets with seven repetitions per set. After each drill, ten free drag-flicks were performed in order to provide information on the overall movement [24]. The training sessions were designed and organised according to a panel of experts. All of the selected coaches had a minimum of 10 years' experience as hockey coaches and were members of staff of the Royal Spanish Hockey Federation. Three-dimensional (3D) data analysis was conducted prior to and after the training period.

All measurements were carried out in the Biomechanics Laboratory of the Faculty of Physical Activity and Sport Sciences at the Technical University of Madrid, Spain. A VICON optoelectronic system (Oxford Metrics, Oxford, UK) captured the drag-flicks with six cameras, sampling at 250 Hz. The experimental space was 5 m long, 2.5 m wide and 2 m 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 50 retro-reflective markers (46 body markers and four 14-mm diameter stick markers) were attached to anatomical landmarks following VICON's kinematics model [23]. The stick markers were placed at the centre of mass of the stick, at the top of the shaft, at the head of the shaft and at the bottom of the shaft. The parameters of the stick (height: 94 cm; mass: 584.6 g; distance between the centre of mass and the end of the shaft: 38.4 cm) were approved by the International Hockey Federation. Raw data were filtered using Quintic Spline functions based on Woltring's generalised cross-validation method for calculating the smoothing factor [25]. As markers could not be placed on the ball, an official field hockey ball was covered with adhesive reflective material. VICON cameras recognised the ball as a marker and ball velocity was estimated.

After a specific warm-up, 15 trials were carried out and captured at habitual speed. In each trial, the participant shot into a goal area marked with a fence. If the participant did not score in the goal area, the trial was rejected. The ball was placed by the subject approximately 1.5–2 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.

*Biomechanical parameters*

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 90º 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 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 normalised to the T1–T6 times. The stance width, drag-flick distance and the front foot–ball distance at T1 were normalised to the player's height. The speed of the previous run was the speed of the centre of mass registered before T1.
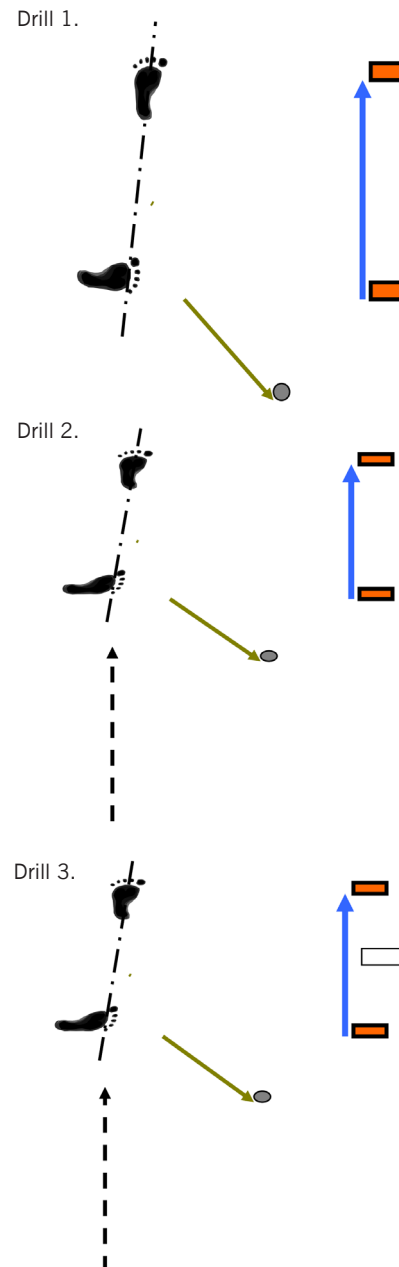


**FIG. 1.** THE DRILLS EVALUATED IN THE STUDY

Drill 1: Isolating the ball's movement along the stick. The signals are at 80% of the height of the player and the ball is behind her back foot. The player takes the ball behind the back foot with her trunk in a low position and then advances her hands so that the ball moves towards her grip. Next, she accelerates the stick (whipping effect) and the ball moves back to the end of the stick.

Drill 2: Making the last stance wider. After four or five runs to measure the correct distance to the ball and the signal, the player takes the ball behind the back foot and places the last double foot contact in a wide position.

Drill 3: Keeping the centre of mass low. The player performs the drag-flick by passing the ball under the tube.

*Statistical analysis*
Statistical analysis was carried out using SPSS v.15 software (SPSS Inc., Chicago, IL, United States). The means and standard deviations of the study parameters were calculated. A Wilcoxon test was conducted to identify pre- and post-training differences. The alpha level of significance was set at $p < 0.05$ for all statistical tests.

**RESULTS** ◼◼◼◼◼◼
Players 1 and 2 received specific training in the High Performance Centre, while Players 3 and 4 received no relevant training.

*Performance criterion*
As drag-flicks that had already scored in the goal area were analysed, the performance criterion was the speed of the ball. The ball velocities recorded at pre- and post-training were, for Player 1: 22.5 and 22.4 $m \cdot s^{-1}$; for Player 2: 19.1 and 18.9 $m \cdot s^{-1}$; for Player 3: 20.5 and 21.2 $m \cdot s^{-1}$, and for Player 4: 19.9 and 20.0 $m \cdot s^{-1}$. Post-training ball velocity differed significantly in Player 3 ($p < 0.05$).

*Timing of key events*
The absolute and the normalised times for each event are shown in Table 1. All players except Player 3 were slower executing the skill post-test. For Players 1 ($p < 0.01$), 2 and 4 ($p < 0.05$) the absolute times of each event were higher post-test. Players 1 and 4 had delayed their kinematic sequence, and Players 2 and 3 had changed their kinematic sequence from pre- to post-test. Initially, Player 2 showed the following sequence: minimum angular velocity of the stick–maximum angular velocity of the hips–maximum angular velocity of the shoulders. This sequence changed to: maximum angular velocity of the hips–minimum angular velocity of the stick–maximum angular velocity of the shoulder. For Player 3, the maximum angular velocity of the hips occurred earlier ($p < 0.05$) than before.

*Previous run and angular velocities*
All players except Player 2 decreased their speed from the previous run. Significant differences were found for Player 1 ($p < 0.01$), whose speed decreased from 3.9 to 3.6 $m \cdot s^{-1}$, Player 3 ($p < 0.05$), from 3.2 to 2.9 $m \cdot s^{-1}$, and Player 4 ($p < 0.001$), from 3.9 to 3.5 $m \cdot s^{-1}$.

The angular velocities are shown in Table 2. All players decreased the maximum angular velocity of the hips post-test. This difference was significant for Players 1 and 2 at $p < 0.01$ and for Players 3 and 4 at $p < 0.05$. The maximum angular velocity of the stick increased for Players 2, 3 and 4 post-training.

**TABLE 1.** SIGNIFICANT DIFFERENCES BETWEEN THE PRE- AND POST-TRAINING TEST AT KEY EVENTS AND NORMALISED KEY

| | Player 1 | | Player 2 | | Player 3 | | Player 4 | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Pre | Post | Pre | Post | Pre | Post | Pre | Post |
| Key events (s) | | | | | | | | |
| tt2 | 0.096**±0.01 | 0.141±0.02 | 0.088*±0.03 | 0.11±0.03 | 0.13±0.02 | 0.102±0.03 | 0.087*±0.02 | 0.105±0.01 |
| tt3 | 0.144**±0.03 | 0.183±0.01 | 0.072**±0.02 | 0.123±0.02 | 0.128±0.03 | 0.127±0.02 | 0.059*±0.02 | 0.074±0.02 |
| tt4 | 0.140**±0.02 | 0.17±0.03 | 0.122*±0.03 | 0.16±0.03 | 0.149±0.02 | 0.143±0.02 | 0.105±0.02 | 0.119±0.02 |
| tt5 | 0.241**±0.01 | 0.278±0.02 | 0.181**±0.01 | 0.218±0.02 | 0.25±0.01 | 0.238±0.02 | 0.155**±0.01 | 0.18±0.02 |
| tt6 | 0.246**±0.01 | 0.272±0.01 | 0.182**±0.01 | 0.218±0.02 | 0.228±0.01 | 0.224±0.02 | 0.165±0.01 | 0.17±0.01 |
| Normalised key events (%) | | | | | | | | |
| t2n | 38.9**±2.9 | 51.6±5.5 | 48±13.7 | 50.6±12.1 | 57.1*±6.9 | 45.3±9.7 | 52.7*±9.8 | 62.1±5.2 |
| t3n | 58.5***±10.3 | 67±3 | 38.8**±8.2 | 56.4±8.1 | 56.5±13.6 | 56.3±5.5 | 35.5*±9.5 | 43.8±10.4 |
| t4n | 56.6±5.6 | 62.5±11.2 | 66.9±16.6 | 73.6±13.1 | 65.3±5.8 | 64.1±6.1 | 63.7±10.7 | 70.2±9.4 |
| t5n | 98.1±5 | 101.9±6.8 | 99.2±1.6 | 100±0 | 109.7*±2 | 106.2±3.6 | 93.6**±4.4 | 106.4±10 |

Note: Data represent: mean ± SD. Significant differences at * $p < 0.05$; **$p < 0.01$ and ***$p < 0.001$.
Abbreviations: 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 normalised, with 0%: T1 and 100%: T6.

**TABLE 2.** SIGNIFICANT DIFFERENCES BETWEEN THE PRE- AND POST-TRAINING TEST PEAK ANGULAR VELOCITIES (°/s)

| | Player 1 | | Player 2 | | Player 3 | | Player 4 | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Pre | Post | Pre | Post | Pre | Post | Pre | Post |
| Hips | 388.1**±59.9 | 338.3±31.5 | 357.4**±59.2 | 311.2±64 | 262.8*±30 | 227.1±21.1 | 420.5*±94.8 | 348.7±30.7 |
| Stick (negative) | -152.5±72.8 | -134.5±59.8 | -177.9±32.2 | -134.3±71.9 | -235.5*±52 | -281±57.1 | -142.8±93.2 | -286.3±20.7 |
| Shoulders | 494.5±113 | 503.3±68.6 | 402±107.3 | 424.7±138.6 | 323.6±25 | 332.9±39.9 | 418.3±49.2 | 453.8±51.3 |
| Stick (positive) | 1360.4±293 | 1232±78.1 | 1033.9±75.9 | 1252±127.6 | 1386*±90 | 1498±153.8 | 984.4*±79 | 1224±224.7 |

Note: Data represent: mean ± SD. Significant differences at * $p < 0.05$; **$p < 0.01$

**TABLE 3.** SIGNIFICANT DIFFERENCES BETWEEN THE PRE- AND POST-TRAINING ANGLES (º)

| | Player 1 | | Player 2 | | Player 3 | | Player 4 | |
|---|---|---|---|---|---|---|---|---|
| | Pre | Post | Pre | Post | Pre | Post | Pre | Post |
| Line of double foot stance | 82.3***±1.5 | 77.4±2 | 78.2*±2.3 | 74.2±3.2 | 84.4**±2.5 | 80.1±4 | 76.8*±3 | 79.5±2.6 |
| Hips at T1 | 10.8***±2.3 | 18.2±2.9 | 17.8***±2.8 | 7.4±9.1 | 21.6±2.7 | 25.2±7.3 | 17.9±5.2 | 22.1±5.1 |
| Shoulders at T1 | -31.4±27.4 | -18.3±1.4 | -16±29.5 | -13.2±5.9 | -4.5±2.5 | -4.8±4.8 | -6.3±7.8 | -8.1±7 |
| Stick at T1 | -72.7**±33.6 | -97.7±2.2 | -75.9*±2.5 | -85±3.3 | -82.1±3.8 | -80.8±4.1 | -90.8±2.5 | -89±5.9 |
| Range of movement of the hips | 38.8***±4.1 | -36±4 | 28.6**±3.2 | -41.2±24.3 | 26.9±3.2 | 28±4.8 | 34.6±5.7 | 31.6±5.8 |
| Range of movement of the shoulders | 67.1±17.1 | 45.1±12 | 43.2±2.8 | 42.3±5.4 | 41.9**±3.4 | 25.3±8.6 | 43.1**±8.1 | 27.9±12 |
| Shoulder at T6 | -65.3±8.2 | -68.8±5.2 | -46.9±11.6 | -48.1±13.3 | -41±3.4 | -43.2±3.2 | -46.1±9.8 | -42±5.8 |
| Knee flexion at T1 | 160.2**±2 | 168.7±1.8 | 155.9±2.4 | 155.7±1.8 | 167.2±2.3 | 163.9±4 | 168.8**±3 | 165±2.3 |
| Knee flexion at T6 | 120**±2.6 | 128.4±3.5 | 123.4**±2.9 | 129.2±2.4 | 132.5**±5.7 | 125.5±3.6 | 121.4±4.5 | 117±3.6 |
| Range of movement of the front knee | -40.2±3 | -40.4±4.6 | -32.4±3.9 | -26.5±2.4 | -34.7±5.4 | -38.4±4.3 | -47.4±4.9 | 48.5±4.6 |

Note: Data represent: mean ± SD.
Significant differences at * p<0.05; **p<0.01; and ***p<0.001.
Abbreviations: T1: front foot contact; T6: ball release.

**TABLE 4.** SIGNIFICANT DIFFERENCES BETWEEN THE PRE AND POST-TRAINING ABSOLUTE (m) AND RELATIVE-TO-BODY-HEIGHT DISTANCES

| | Player 1 | | Player 2 | | Player 3 | | Player 4 | |
|---|---|---|---|---|---|---|---|---|
| | Pre | Post | Pre | Post | Pre | Post | Pre | Post |
| Wide stance | 1.52±0.02 | 1.53±0.02 | 1.42**±0.05 | 1.36±0.05 | 1.29**±0.02 | 1.2±0.03 | 1.4*±0.03 | 1.42±0.02 |
| Wide stance (BH) | 0.89±0.01 | 0.9±0.01 | 0.86±0.03 | 0.82±0.03 | 0.77**±0.01 | 0.72±0.02 | 0.88*±0.02 | 0.89±0.01 |
| Front foot ball distance at T1 | -1.5*±0.07 | -1.59±0.06 | -1.05*±0.06 | -1.37±0.03 | -1.14±0.03 | -1.12±0.07 | -1.17±0.06 | -1.18±0.11 |
| Front foot ball distance at T1 (BH) | -0.88*±0.04 | -0.93±0.03 | -0.63*±0.04 | -0.83±0.02 | -0.68±0.02 | -0.67±0.04 | -0.74±0.04 | -0.74±0.07 |
| Total drag-flick distance (BH) | 1.35**±0.14 | 1.71±0.38 | 0.98*±0.07 | 1.2±0.31 | 1.33±0.39 | 1.07±0.17 | 1.03±0.06 | 1.09±0.46 |
| Rotation radius at T1 | 1.47±0.02 | 1.47±0.02 | 1.47±0.02 | 1.47±0.02 | 1.49±0.02 | 1.49±0.03 | 1.39±0.03 | 1.4±0.02 |
| Rotation radius at T1 (BH) | 0.86±0.01 | 0.86±0.01 | 0.86±0.01 | 0.86±0.01 | 0.89±0.01 | 0.89±0.02 | 0.87±0.02 | 0.82±0.22 |
| Rotation radius at T6 | 1.51*±0.04 | 1.56±0.03 | 1.51**±0.04 | 1.56±0.03 | 1.43*±0.03 | 1.48±0.04 | 1.46±0.04 | 1.36±0.27 |
| Rotation radius at T6 (BH) | 0.84*±0.11 | 0.91±0.02 | 0.84**±0.11 | 0.91±0.02 | 0.85*±0.02 | 0.89±0.03 | 0.92±0.02 | 0.85±0.17 |

Note: Data represent: mean ± SD.
Significant differences at * p<0.05; **p<0.01; and ***p<0.001 levels.
Abbreviations: BH: Body height units; T1: front foot contact; and T6: ball release.

*Angles*

The angles are shown in Table 3. Players 1, 2 and 3 flexed their front knee significantly (p<0.01) less at the end of the movement (T6) post-test. Player 2 showed closer alignment of the hips with the shooting direction at T1 post-test. (p<0.01). Players 1 and 2 rotated the stick further clockwise at T1 (p<0.05) post-test. Players 3 and 4 reduced the range of movement at their shoulders from T1 to T6 (p<0.01) post-test.

*Distances*

The absolute and relative-to-height distances are shown in Table 4. The width of the last double foot stance decreased for Player 2 and 3 (p<0.01) and increased for Player 4 (p<0.01) post-test. The distance between the front foot and the ball at T1, both absolute and relative to the height, increased for Players 1 and 2 (p<0.05). The total distance described by the head of the stick showed a significant improvement (p<0.05) for Players 1 and 2. The rotation

radius at ball release (T6) was higher after the training period in Players 1, 2 and 3 (p<0.05), while this parameter decreased in Player 4 (p<0.05).

## DISCUSSION

The ball velocity ranged from 22.5 to 18.9 m·s$^{-1}$, and exceeded that of 17.9 m·s$^{-1}$ achieved by the female sample in a previous study [14]. It also exceeded that of amateur players reported by McLaughlin [16], but was lower than that reported for international male hockey players (25.4 and 27.8 m·s$^{-1}$) [14,26]. This variation could reflect the gender difference between male and female players. The total drag-flick time ranged from 0.165 to 0.246 s, similar to previous studies. The angular velocities of the hips ranged from 227 to 420 º·s$^{-1}$, being lower than the 520 º·s$^{-1}$ reported by de Subijana et al. [14] but higher than the 155–175 º·s$^{-1}$ reported by McLaughlin [16]. The minimum angular velocity of the stick ranged from -142 to -281 º·s$^{-1}$, which was higher than the male sample from a previous study [14], but lower than the -390 º·s$^{-1}$ recorded for the drag-flicker in the same study. The angular velocity of the shoulders ranged from 323.6 to 520 º·s$^{-1}$, being lower than the 420–492 º·s$^{-1}$ reported by de Subijana et al. [14] and higher than the 260–265 º·s$^{-1}$ reported by McLaughlin [16]. The McLaughlin study [16] was performed on a sample of regional and national level hockey players. The maximum angular velocity of the stick ranged from 984 to 1498 º·s$^{-1}$ and was higher than the 1198 º·s$^{-1}$ reported for the female sample but lower than the 1473 º·s$^{-1}$ and 1890 º·s$^{-1}$ reported for the male and the drag-flicker, respectively, in a previous study [14]. The width of the last stance ranged from 1.20 to 1.53 m and the relative values ranged from 0.72 to 0.90. This parameter was similar to values reported by de Subijana et al. [14] and McLaughlin [16]. Following training, Players 1 and 2 rotated their stick further clockwise at T1 (p<0.05), increased the distance between their front foot and the ball at T1 (p<0.05), improved the total distance described by the head of the stick (p<0.05) and achieved a greater (p<0.01) rotation radius at ball release (T6). These improvements could be related to drills 1 and 2 (see Appendix 1). Both drills had the goal of making the stance wider, taking the ball behind the back foot and making the movement over a larger distance. However, Players 1 and 2 did not increase the velocity of the ball. On the other hand, Player 3 increased the ball velocity at release and Player 4 increased the width of the last stance, despite having received no specific training.

Beckmann et al. [3] reported changes in technique after four different training strategies. They measured the efficiency of the push based on goal precision. They monitored skills at five different times: pre-training, post-training (6 weeks later), a transference test (6 weeks later), short-term retention (2 weeks) and long-term retention (4 weeks). Three of the training conditions resulted in a decrease in efficiency and one group showed increased precision after training. The highest retention was shown by the control group, who achieved heterogeneous results in comparison with the other three groups. The fact that the trained players did not improve as expected could be due to the variability in the type of practice [3]. As the drag-flick is a very complex type of skill, it is difficult to control the constraints of the task.

The amount of practice was similar to that in previous studies, at twice a week for 8 weeks. Forty-five minutes of specific training were completed in each of 16 sessions. It was notable that all players had lost speed of the previous run. This could reflect a short-term 'plateau' in performance during the learning period [17,21].

The players had 2.45 ± 1.79 years of experience of the skill, which may have interfered with the final results [10]. Differences in individual motivation could lead to an untrained individual achieving higher results than in the pre-training test. Another limitation of this study is that data were only recorded prior to and after the training period, with no data on retention and transfer of learning.

## CONCLUSIONS

The proposed drills improved the position of the stick at the beginning of the shot, the total distance of the shot and the rotation radius at release. In terms of technique, the players placed the stick in a more rotated position at the double foot stance, completed a longer drag-flick and increased the rotation radius at ball release after the training sessions.

The lower speed of the previous run combined with the changes in angular velocities of the segments could explain why women use this skill less often than men. In fact, the goalkeeper has more time to react to shots made by women than those made by men. The female sample was limited because each team normally has only one drag-flicker. Future studies should include a larger sample.

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