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A kinematic analysis of the two types of soccer throw-in techniques

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ABSTRACT

This study aimed to identify kinematic variables in two soccer throw-in techniques, examine their relationship to throw distance, and explore differences based on technique. A descriptive approach was used, with a purposive sample of 15 first-grade players from the Hussein Youth Club. Each player performed both types of throw-in techniques, recorded at 60 f/s using a Nikon D3400 camera placed laterally. A total of 30 successful attempts were analyzed using Kinovea 0.8.27 x64. Variables studied included foot distance, skill duration, release velocity and angle, and ball release height. Data were analyzed with SPSS. The results revealed weaknesses in the side throw-in technique, such as a low release angle, though better distances were achieved with the second technique. Significant correlations were found between foot distance, release angle, release velocity, vertical velocity, and throw distance ($p<0.05$). There were also statistically significant differences in knee angle, moment of throw, and throw distance, favoring the second technique ($p<0.05$). The sample's technique shows several weaknesses impacting performance. Projectile variables strongly influence throw distance, closely linked to various kinematic factors. Moreover, the throw-in method is crucial in determining the overall distance.

KEYWORDS

Throw-in Technique; Kinematics; Soccer; Release Velocity

1. INTRODUCTION

Football is one of the most popular games in the world and is often referred to as "the world game." This is evident from the number of countries registered with FIFA—209 countries for men and 170 for women—as well as the 270 million players, who make up 4% of the world's population. Of these, 0.04% play in professional tournaments (Haugaasen & Jordet, 2012). Additionally, the 2015 UEFA Champions League final between Barcelona and Juventus drew 180 million viewers from more than 200 regions (UEFA, 2016).

This sport is characterized by complex dynamic interactions, such as tactical strategies and technical performance at the team level, and it requires many physical and psychological demands at the player level (Bradley et al., 2011). It also encompasses various skills, including passing, shooting, dribbling, and receiving (Lees et al., 2010).

The skill of the side throw is considered one of the key techniques that can significantly impact match outcomes when exploiting the opposing team's disorganized defensive positions. It poses a great threat to the opponent’s goal, especially in the attacking third of the field, as it can be controlled to reach the goal. The side throw is also an offensive tool used to develop and execute team strategies (Arak, 2011). A long side throw is particularly important near the opponent's goal (Linthorne & Everett, 2006). This technique has evolved into a strategic attacking element in football, performed either from a stationary or running start, and both styles require coordination between different body parts during execution (Lees et al., 2005).

To perform a successful side throw, it is essential to focus on the mechanical variables affecting performance. The biomechanics of shooting in football plays a crucial role in guiding and controlling the training process by identifying these variables (Lees et al., 2010). A coach’s experience and knowledge of the mechanical performance model are vital in correcting player performance (Smith et al., 2006). Biomechanical techniques serve as valuable tools for coaches, as they help identify the characteristics of skills, improve the mechanical efficiency of body movements during various skills, and determine the variables that influence successful performance (Amiri-Khorasani et al., 2010). Biomechanics is also fundamental to player development, as every skill has a mechanical structure that helps coaches explain performance methods, focus on the relevant mechanical conditions, and facilitate faster learning and improved performance (Davids & Burwitz, 2000).

In this area, Langhorne & Everett (2006) highlight that the optimal angle for launching the ball to achieve maximum distance is 30 degrees. This angle is also related to the speed and height of the ball launch, as the speed decreases with increasing angle due to the rise in the vertical component and reduction of the horizontal component. Additionally, the height of the ball launch increases as the launch angle increases, with the arm's angle relative to the trunk contributing to this rise. Nicholas & Jamie (2016) state that the average ball launch speed is 14.4 m/s, with a 31.8-degree angle and 2.17 meters for the height of the ball launch. Meanwhile, Brag & Kerwin (2004) note that the ball's release velocity ranges between 12–19 m/s with a launch angle of 22–40 degrees. Linthorne & Everett (2006) also indicate that the average release speed of the ball is 13.4 m/s, with a 32.1-degree angle and a release height of 2.23 meters. Sabri et al. (2014) report that the height of the pelvic point at the moment of ball release is 8.97±80.42 cm.

The importance of motor analysis lies in the fact that the human eye cannot track all the movements of different body parts and joints simultaneously. This necessitates the use of various tools and devices in scientific research, such as video cameras and computer analysis software (Singh, 2013). Video analysis has been widely used in football as a means of recording objective observations and gathering statistical data (Reilly, 2001), in addition to evaluating the technical and tactical aspects of the game (Hughes et al., 2007). Feedback is a critical component in influencing learning and performance, and technological advancements have greatly improved the quality of feedback available to athletes during training and competition (Liebermann et al., 2002).

This study aims to identify the values of certain kinematic variables of the two types of soccer throw-in techniques, examine the relationship between these values and throw distance, and explore the differences in the study variables based on the type of soccer throw-in technique.

2. METHODS

2.1. Study Design and Participants

The researchers used a descriptive approach due to its suitability to the nature and objectives of the study. The study population consisted of 20 first-grade players from the Hussein Youth Club, with a sample of 15 players. Table 1 provides a description of the study sample.

Table 1. Descriptive data of the study sample

Variants	Arithmetic mean	Standard deviation	Torsion coefficient
Length/ M	1.82	0.10	0.26
Mass/ kg	77.3	2.69	0.48
Training Age/ year	8.5	0.80	0.54

2.2. Tools for Data Collection

To obtain the numerical values of the kinematic variables, the researchers used the following tools:

- A medical scale to measure the players' mass and height.
- A Nikon D3400 video camera with a frame rate of 60 images per second.
- One adjustable tripod to hold the camera.
- A 50-meter metal measuring tape.
- A scale drawing with dimensions of 1 × 1 × 1 meter.
- Registration forms.
- Adhesive phosphoric markers (indicative markers) placed on body joints (shoulder, elbow, wrist, pelvis, knee, ankle) and the ball.
- A Dell i5 L31 computer.
- Kenova software for kinematic analysis.
- Legal size 5 footballs.

2.3. Study Procedures

2.3.1. Filming Procedures

The filming took place during one of the club's training sessions. After a warm-up, a trial attempt was conducted. A camera, mounted on a stand at a height of 1.45 m, was positioned vertically at the player's side, 5 meters away. The scale drawing was also filmed using the camera. The camera's accuracy was verified by filming experimental attempts. Each player performed two attempts: one using the first method and the other using the second method. The footage was reviewed and confirmed before the study sample was dismissed.

2.3.2. Descriptions of the Side Throw Methods

First Method: The player stands behind the sideline with one foot ahead of the other, then steps forward so the feet are positioned side by side, shoulder-width apart, in accordance with FIFA rules.

Second Method: The player stands behind the sideline with both feet together, then takes a step forward, positioning one foot in front and the other behind, while complying with FIFA rules for executing the side throw.

2.4. Study Variables

The Kenova analysis program was used to obtain the values of the variables under study. The following are the characterizations of the independent variables (1-11) and the dependent variable (12):

- The distance between the feet / m: is the distance extended from the front of the back foot to the front of the front foot.
- Height of the pelvic point at the start of the movement / m: is the vertical distance extended from the pelvic point to the ground at the moment of the start of the movement.
- Height of the pelvic point at the moment of throwing the ball / m: is the vertical distance extended from the pelvic point to the ground at the moment of launching the ball.
- The angle of the trunk at the moment of throwing / degrees: it is the angle between the line extending from the shoulder joint to the pelvic joint and the other line extending from the knee joint to the pelvic joint.
- The height of the ball release point / m: is the vertical distance of the center of the ball from the ground at the moment of the ball release.
- Ball launch angle / degrees: it is the angle between the line of the result of the ball launch speed and the horizontal line parallel to the ground.
- The release speed of the ball / m/s: is the speed of the ball at the moment of its release from the player's hands and is measured in the unit m/s.
- Skill time / seconds: is the time extended from the moment the player starts moving until the moment the ball is released.

- Knee angle moment of throw / degrees: it is the angle between the line extending from the pelvic joint to the knee joint and the other line extending from the knee joint to the ankle joint.
- Horizontal velocity / m/s: obtained by multiplying the tangent of the angle of launch of the ball by the sum of the velocity.
- Vertical velocity / m/s: obtained by multiplying the sine of the ball's launch angle by the horizontal velocity.
- Completion distance / m: is the horizontal displacement extending from the sideline to the first impact the ball leaves on the ground.

2.5. Statistical Analysis

To analyze the data of the study sample, the researchers used the SPSS program, along with arithmetic averages, standard deviations, correlation coefficients, and the Mann-Whitney test. Statistical analysis was conducted using version 24 of the software, with a confidence level of 95%.

3. RESULTS AND DISCUSSION

To analyze the kinematic variables of the side throw in football using two different styles, researchers calculated arithmetic means and standard deviations for a sample of 15 participants. Table 2 presents the values of the studied variables across both methods.

Table 2. The values of the variables under study in the first and second methods

Variants	Lowest value		The highest value		Arithmetic mean		Standard deviation	
	First	Second	First	Second	First	Second	First	Second
Distance between feet/ m	0.84	1.13	2.05	2.06	1.40	1.65	0.39	0.28
Height of the pelvic point at the start of the movement/m	0.80	0.84	1.08	1.15	0.91	0.97	0.09	0.10
Height of the pelvic point at the moment of throwing the ball/m	0.81	0.78	1.20	1.05	0.95	0.89	10.1	0.09
The angle of the trunk is the	31	32	78	73	56	55.53	13.28	14.23

moment of throwing / degree								
Height of the ball release point/ M	1.76	1.66	2.34	2.35	2.03	2.04	0.20	0.22
Ball release angle/ degree	2	2	17	22	10.60	12.07	4.64	4.89
Ball release speed M / s	10.30	10.60	15.50	14.82	12.68	13.14	1.38	1.14
Skill time/ SEC	0.72	0.72	1.70	1.67	1.16	1.19	0.25	0.26
Knee angle throwing moment/ degree	108	104	176	165	134.6	154	24.38	20.86
Horizontal speed M / s	10.07	10.36	14.89	14.42	12.41	12.79	1.29	1.18
Vertical speed M / s	0.40	0.47	4.26	4.60	2.39	2.68	1.11	1.07
Completion distance/m	9.20	9.10	15.50	17	11.59	13.03	2.02	2.51

Reviewing the values of the kinematic variables given in the table, the researchers found a decrease in the angle of launching the ball, which averaged 10.60 degrees in the first method and 12.07 degrees in the second method, noting that the launch angle was better in the second method. In both methods, it is lower than the results achieved in the study by Linthorne & Everrett (2006), which indicated that the optimal angle for launching the ball to achieve the maximum distance is 30 degrees, as well as in the study by Jamie (2016), which reached 31.8 degrees, in addition to the study by Linthorne & Everrett (2006), which reached 32.1 degrees.

Considering the average release speed of the ball, it reached 12.68 m/s in the first method and 13.14 m/s in the second method, with an advantage for this method. These results are consistent with the study by Brag & Kerwin (2004), which indicated that the launch speed of the ball ranged between 12-19 m/s, while the launch speed in the second method was closer to the results achieved in the study by Linthorne & Everrett (2006). It should be noted that the launch speed is related to the launch angle, as this speed decreases with increasing angle.

As for the average height of the ball launch, it reached 2.03 m in the first method and 2.04 m in the second method, and this result does not agree with the study by Nicholas and Jamie (2016), which indicated that the height of the ball launch was 2.17 m, while the study by Linthorne & Everrett (2006) indicated that the height of the ball launch was 2.23 m, noting that the height of the

ball launch increases with an increasing launch angle because the angle of the arm with the trunk contributes to this increase. This is clearly shown by the angle of the torso at the moment of throwing, which reached 56 degrees in the first method and 55.53 degrees in the second method.

The researchers believe that this is a clear indication of the lack of attention to the kinematic variables affecting throwing distance, and that this skill is used as a tool to operate the game without paying attention to it within the tactical plans of the team. Noting that the height of the pelvic point at the moment of throwing in the first method was 0.95 m, and 0.89 m in the second method, this result is consistent with the study by Sabri et al. (2014), which indicated that the height of the pelvic point at the moment of launching the ball was 8.97 ± 80.42 cm. However, the players could not take advantage of this to increase the height of the ball launch, and this is an indication of the poor technique of the study sample in this skill, which emphasizes the need to swing back and stretch the upper body (abdominal and chest muscles).

This is confirmed by the fact that the height of the pelvic point at the moment of starting the movement was 0.91 m in the first method and 0.97 m in the second method, and this is a clear indication of the weakness of the study sample in raising the pelvic point to the maximum possible extension at the moment of throwing.

There was also no full extension of the knees at the moment of throwing the ball, which was clearly shown in the results of the study, indicating that the average of this angle reached 154 degrees in the second method and 134.6 degrees in the first method, although full knee extension helps to transfer the speed of approach (step) to the upper limb and then the ball. It can be noted that the superiority of the study sample in the achievement distance in the second method is due to the better utilization of the kinematic variables affecting this distance, such as the angle and the speed of launching the ball, which positively reflected on the average horizontal speed, which reached 12.79 m/s, and the average vertical speed, which reached 2.68 m/s. The throwing distance was also low, with an average throwing distance of 11.59 m by the first method and 13.03 m by the second method, which is lower than the results achieved in the study by Linthorne & Everrett (2006)

Table 3 presents the correlation values between various kinematic variables of the side throw in two different styles and the distance of the throw (N=15).

Table 3. Correlations of kinematic variables with throw distance

Variants	The first method		The second method	
Distance between feet/ m	Correlation coefficient	P value	Correlation coefficient	P value
Height of the pelvic point at the start of the movement/m	0.73	0.002*	0.64	0.01*
Height of the pelvic point at the moment of throwing the ball/m	-0.07	0.814	0.46	0.083
The angle of the trunk is the moment of throwing / degree	-0.51	0.053	0.43	0.11
Height of the ball release point/ M	0.48	0.072	0.62	0.013*
Ball release angle/ degree	-0.13	0.636	0.61	0.015*
Ball release speed M / s	0.77	0.001*	0.62	0.014*
Skill time/ SEC	0.63	0.011*	0.16	0.043*
Knee angle throwing moment/ degree	-0.29	0.303	0.69	0.004*
Horizontal speed M / s	-0.19	0.504	0.43	0.112
Vertical speed M / s	0.55	0.033*	0.03	0.907
Distance between feet/ m	0.85	0.00*	0.65	0.009*

($\alpha \leq 0.05$) *

Reviewing the values of the significance level of the correlation coefficient given in Table 3, the researchers find that there is a statistically significant correlation between the variables (distance between the feet, ball launch angle, ball launch speed, vertical speed) and throwing distance for both methods. They note that the variables (trunk angle at the moment of throwing, skill time, and height of the ball launch point) were associated with statistically significant relationships with the achievement distance in the second method. It should also be noted that the horizontal speed variable was associated with a statistically significant relationship with the achievement distance in the first method.

This indicates the interrelated relationships between the kinematic variables of the projectile, where the angle of launch of the ball is related to both speed and height. The speed decreases with an increasing angle due to an increase in vertical speed and a decrease in horizontal speed, while the height of the launch increases with an increasing launch angle because the angle of the arm with the trunk contributes to this increase. Uday (2019) indicates that ball launch speed is one of the most significant variables contributing to throwing distance, accounting for 96.7%. This percentage increases when the ball launch height is ideal and can reach 98.1%.

The distance between the feet also helps establish a suitable fulcrum for the player to use maximum possible force when throwing. Additionally, it contributes to the execution of an ideal

movement sequence for the skill, positively reflecting on throwing distance. This highlights the importance of approaching and choosing the appropriate style when performing this skill, necessitating a focus on executing the side throw in different ways.

The researchers utilized the Mann-Whitney test to analyze differences in the study variables based on the method of performing the side throw in football, as shown in Table 4.

Table 4. Differences in study variables by side throw style in football

Variants	Style	Average ranks	Total ranks	Z	P value
Distance between feet/ m	The first	12.67	190.00	1.763	0.078
	The second	18.33	275.00		
Height of the pelvic point at the start of the movement/m	The first	12.57	188.50	1.827	0.068
	The second	18.43	276.50		
Height of the pelvic point at the moment of throwing the ball/m	The first	17.90	268.50	1.497	0.134
	The second	13.10	196.50		
The angle of the trunk is the moment of throwing / degree	The first	15.60	234.00	.062	0.950
	The second	15.40	231.00		
Height of the ball release point/ M	The first	15.57	233.50	.042	0.967
	The second	15.43	231.50		
Ball release angle/ degree	The first	14.33	215.00	.729	0.466
	The second	16.67	250.00		
Ball release speed M / s	The first	13.83	207.50	1.038	0.299
	The second	17.17	257.50		
Skill time/ SEC	The first	15.27	229.00	.145	0.884
	The second	15.73	236.00		
Knee angle throwing moment/ degree	The first	19.17	287.50	2.287	0.022*
	The second	11.83	177.50		
Horizontal speed M / s	The first	14.07	211.00	.892	0.372
	The second	16.93	254.00		
Vertical speed M / s	The first	14.33	215.00	.726	0.468
	The second	16.67	250.00		
Completion distance/m	The first	12.57	188.50	1.831	0.047*
	The second	18.43	276.50		

($\alpha \leq 0.05$) *

Reviewing the values given in Table 4, the researchers found statistically significant differences in the study variables based on the method of performing the side throw in football. This was evident in the variable of the knee angle at the moment of launching the ball, which favored the second method, as well as in the variable of achievement distance. The full extension of the knee helps to transfer the speed of approach (step) to the upper limb and then the ball, contributing to the height of the ball release point, which is a crucial variable for throwing distance. In both methods, the player needs to interact between different body parts when performing the throw. However, the results of the study did not show any significant differences in the remaining variables, as the value of the significance level was greater than 0.05.

4. CONCLUSIONS

The conclusions drawn from the study indicate that the technique of the sample is marked by several weaknesses, which impact performance. Additionally, the projectile variables significantly affect the throwing distance, highlighting that this distance is closely related to various kinematic variables. Moreover, the method of performing the side throw plays a crucial role in determining the overall throwing distance.

5. RECOMMENDATIONS

In light of the conclusions of the study, the researchers recommend the following:

1. The need to inform players and coaches about the kinematic analysis of the side throw in football.
2. The need to employ mechanical principles and laws in the implementation of the side throw.
3. The need to train players on different methods of performing the side throw in football.
4. The need to include the side throw within the offensive plans of the team and not limit it to restarting the match.
5. The need to conduct further studies that address other variables, such as ground reaction and elbow angle at the moment of throwing.

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CONFLICTS OF INTEREST

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