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Biomechanical Analyses of Scoop in Field Hockey
Análisis biomecánicos de la pala en el hockey sobre césped

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Abstract. Field hockey is an Olympic sport played all over the world. Hockey is played with a stick where one requires endurance, agility, balance coordination, and high skill to convert the shot. There are various kinds of skills i.e. hitting, dribbling, scooping, tackling etc. Only scoop was selected for the study in different phases (stance phase, execution phase, follow through phase). Field hockey scoop is the aerial passing by lifting the ball from the ground inserting head of hockey stick under the ball. Scoop plays vital role in competitive field hockey games. The aim of the study was to find out the kinematic difference in the elbow joint, knee joint, and ankle joint. The objective of the study was to find out the angular differences of elbow joint, knee joint, and ankle joint in different phases of delivery of field hockey scoop shot. Researchers hypothesised that there are significance differences in elbow joint angle, knee joint angle, and ankle joint angle during delivering of field hockey scoop shot. Six males inter university players aged from 20-24 years were selected for the study and at least they represented at inter university games /national level. Set of the camera is at 1.10 m in height and 3.70 meters. The focal length is 5.6, the resolution is 1080, and the frame rate is 100 per sec. A Sony FRD-AX700 camera was placed 3.7 meters apart on the right side of the hockey player. Angle of elbow joint, angle of knee joint, angle ankle joint, cadence, stride length, and numbers of frames were analysed using Kinovea 0.9.5 software. This research will help the players to execute scoop after knowing elbow joint angle, knee joint angle, and ankle joint angle.
Key Words: Field Hockey, Scoop, Elbow, Ankle, Knee

Resumen. El hockey sobre césped es un deporte olímpico que se practica en todo el mundo. El hockey se juega con un palo y se requiere resistencia, agilidad, coordinación del equilibrio y gran habilidad para convertir el tiro. Hay varios tipos de habilidades, es decir, golpear, driblar, recoger, taclear, etc. Solo se seleccionó la cuchara para el estudio en diferentes fases (fase de postura, fase de ejecución, fase de seguimiento). La pala de hockey sobre césped es el pase aéreo levantando la pelota del suelo insertando la cabeza del palo de hockey debajo de la pelota. Scoop juega un papel vital en los juegos competitivos de hockey sobre césped. El objetivo del estudio fue descubrir la diferencia cinemática en la articulación del codo, la rodilla y el tobillo. El objetivo del estudio fue descubrir las diferencias angulares de la articulación del codo, la rodilla y el tobillo en diferentes fases del lanzamiento del golpe de pala de hockey sobre césped. Los investigadores plantearon la hipótesis de que existen diferencias significativas en el ángulo de la articulación del codo, el ángulo de la articulación de la rodilla y el ángulo de la articulación del tobillo durante el lanzamiento del golpe de pala de hockey sobre césped. Se seleccionaron para el estudio seis jugadores masculinos interuniversitarios de edades comprendidas entre 20 y 24 años y que al menos representaban en juegos interuniversitarios a nivel nacional. El conjunto de la cámara se encuentra a 1,10 m de altura y 3,70 metros. La distancia focal es 5,6, la resolución es 1080 y la velocidad de fotogramas es 100 por segundo. Se colocó una cámara Sony FRD-AX700 a 3,7 metros de distancia en el lado derecho del jugador de hockey. El ángulo de la articulación del codo, el ángulo de la articulación de la rodilla, el ángulo de la articulación del tobillo, la cadencia, la longitud de la zancada y el número de fotogramas se analizaron utilizando el software Kinovea 0.9.5. Esta investigación ayudará a los jugadores a ejecutar la pala después de conocer el ángulo de la articulación del codo, el ángulo de la articulación de la rodilla y el ángulo de la articulación del tobillo.
Palabras clave: hockey sobre césped, pala, codo, tobillo, rodilla

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Introduction

Men and women worldwide participate in field hockey, an Olympic sport, at all levels from recreational to competitive (Delfino Barboza S, 2018). Although participating in field hockey may enhance players' health due to the well-known advantages of exercise (Warburton DER, 2006). Undoubtedly, a thorough examination of various biological signals during physical activity (Gusril et al., 2022; Pranoto et al., 2023) will yield crucial insights into the psychological factors that influence athletic performance. Field hockey scoop shot is the technique to pass the ball lifting in the air. Scoop shot is an aerial pass executed by lifting the ball from the ground by placing the head of hockey stick under the ball delivering a lifting movement. Early specialization is defined by involvement in intensive, sport-specific training (Baker, 2003). Different kind of techniques are used in different games and sports and high level of skill is required to deliver field hockey scoop (Podgórski T., 2011). Bishop D, Lawrence S, and Spencer M. conducted a study on "Predictors of Repeated-sprint Ability in Elite Female Hockey" (Bishop D, 2003). Especially the literature review related to sports with a long history, like field hockey is rare (Malik, 2019). The objective of the study was to find out the angular kinematic of elbow joint, knee joint, and ankle joint in different phases during delivery of field hockey scoop in different phases of delivery-stance phase, execution phase, and follow through phase. How does over all angular kinematics (elbow joint angle, knee joint angle, and ankle joint angle) contribute to execute field hockey scoop? It was hypothesised that there are differences in

Elbow joint angle, knee joint angle, and ankle joint angle in during delivering of field hockey scoop shot. For a very long time, it was thought that the proficient athlete had a variety of better qualities or aptitudes, and via natural selection, the players with the best "nervous system" would prevail (Starkes, 1987). The ability to control one's dribble, shoot accurately, and push quickly would help one fully comprehend the skill requirements of field hockey (Keogh, 2003). A playing surface that is 90-100 yards long and 50-60 yards wide is used to play field hockey (MD, 1981). A long-standing sport, field hockey has experienced significant and quick change in the last decades or so. The introduction of artificial turf has altered the game's tactical, technical, and physiological demands at every level, but especially at the elite level (Reilly, 1992). Players who participate in field hockey, a high-intensity, competitive, intermittent team sport, must meet demanding aerobic requirements (Lythe, 2011). The reason field hockey was chosen is that it is an open sport (Starkes, 1987). A multidirectional, intense sport, the game of field hockey is played in multiple directions (Lemmink KAMP, 2004). In their research, they focused on youth field hockey players who were already had designated as talented and skilful were performing better every year (Elferink-Gemser, 2004). Manual video-based time–motion analysis was used to demonstrate that international male field hockey players (Jennings, Cormack, Coutts, & Aughey, 2012). Brétigny, Perrine et al conducted a study on "Upper-Limb Kinematics and Coordination of Short Grip and Classic Drives in Field Hockey (Brétigny, Seifert, Leroy, & Chollet, 2008). This research will help the player to dragonise their mistakes during delivery of hockey scoop. After getting feedback from the researcher, player can work on their lacking part to improve the skill because scoop shot plays major role in field hockey.

Materials & Methods

Six (06) male inter university player (high level) field hockey players at least they participated in inter university level or national level aged from 20 to 25 years were randomly selected as subjects for this study. The subjects had no upper extremity injuries at the time of data collection. The Camera: Sony FRD set the camera at 3.70 meters and a height of 1.10 meters. The focal length is 5.6, the resolution is 1080, and the frame is 100 per sec. White and black retro-reflective markers were used to mark the joint positions. The markers were one inch in diameter.

Furthermore, the film recording was conducted in sunny and clear weather at the synthetic hockey ground of Aligarh Muslim University for data collection. The players were asked to perform a scoop from the selected point. A Sony FRD-AX700 camera was placed 3.7 meters apart on the right side of the hockey player and the height of the camera was 1.10 m. Recording the footage in sagittal plane. All six male players were given instruction about data collection. The markers were placed on the subject's different points such as elbow joint, knee joint, and ankle joint, respectively. Proper warm-up time was given to the players. A calibration stick (length 1.20 meters) was used for all subjects.

Each player was given three attempts to deliver field hockey scoop. Then all data were digitized through software Kinovea 0.9.5 to make separate clips of each player for separate phases. This software provides to identification of the angles, velocity (linear and angular), cadence, step length stride length, and number of frames. To analyse the video recording, the following software was used: Kinovea 0.9.5 (Ahmed Mottakin, 2020).

The selected biomechanical variables in the study were as angle of the elbow at the time of execution of scoop, angle of the knee at the time of execution scoop, and angle of ankle at the time of execution of scoop. To find out the differences of selected kinematical variables with the performance of hockey, the two-way ANOVA was used with the help of SPSS software. The level of 0.05 (Singh, 2019).

Result

The study's criterion measure was the male hockey players performing scoop in different phases (Stance phase, execution phase, and follow through phase). Each subject was allowed three chances to complete. The study has chosen biomechanical variables were as follows: elbow joint angle during the scooping, knee angle during the scooping, angle of ankle during the scooping. Differences of kinematical variables during scooping was seen at 0.05 level of significance (Turcotte, 2009)

Table 1.
Descriptive statistics of angles and hockey skill during hockey scoop shot

Angle	Hockey Skill Phases	Mean	Std. Dev.
Elbow Angle	Stance Phase	150.03	14.88
	Execution Phase	168.66	6.49
	Follow Throw	166.73	8.19
Knee Angle	Stance Phase	134.71	9.58
	Execution Phase	143.72	22.07
	Follow through	157.68	18.99
Ankle Angle	Stance Phase	108.51	31.59
	Execution Phase	113.58	12.47
	Follow through	125.46	16.25

Table 2.
Two-way ANOVA table showing F values for all the model

Source	Sum of square	df	Mean Square	F	Sig.
Angles	19521.08	2	9760.54	32.67	0.00
Hockey Phases	3231.81	2	1615.90	5.41	0.008
Angle*Hockey Phases	543.827	4	135.957	0.455	0.00
Error	13445.56	45	298.790		
Corrected Total	36742.29	53			

Dependent variable is hockey skill
R Squared = .634 (Adjusted R squared = 0.569)

The p-value of the angle during hockey scoop in the table is (p-value = 0.00) less than 0.05; hence, F-value is significant 5% level (verma, 2013). Thus, the null hypothesis for the angles in the scoop shot may be rejected at a 0.05 level. It might be said that researcher got significant value. In the same way, the p-value in different hockey

phases is (p-value = 0.008) less than 0.05; hence, the F-value is significant at the 5% level. Thus, the null hypothesis for the angle in the scoop shot may be rejected at a 0.05 level of significance. And interaction Angle * hockey phases in table 1 (p-value 0.00) which is less than 0.05; hence, the F-value is significant at the 0.05 levels. Thus, the null hypothesis for the (Angle * Hockey) fails to reject at a 0.05 level of significance at a 0.05 level (Field, 2013). Now the post hoc comparison analysis shall be done for these factors and interaction.

Table 3.
Pairwise comparisons of different joint angles during hockey scoop

		Mean Difference			95% Confidence Interval for difference	
(I) Angle	(J) Angle	(I-J)	Std. Error	Sig[a]	Lower Bound	Upper Bound
Elbow Angle	Knee Angle	16.434	5.76	0.007	4.82	28.03
	Ankle Angle	45.96	5.76	0.007	34.35	57.56
Knee Angle	Elbow Angle	-16.43	5.76	0.007	-28.03	-4.82
	Ankle Angle	29.52	5.76	0.007	17.91	41.12
Ankle Angle	Elbow Angle	-45.95	5.76	0.007	-57.56	-34.35
	Knee Angle	-29.52	5.76	0.007	-41.12	-17.91

Dependent variable: Hockey scoop shot based on marginal means
Adjustment for multiple comparisons: least significant difference (Equivalent to no adjustment)
The mean difference is significant at 0.05 level Based on observed means.

Table 4.
Pairwise comparisons of different phases of hockey shots during hockey scoop

		Mean Difference			95% Confidence Interval for Difference	
(I) Angle	(J) Angle	(I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
Stance Phase	Execution Phase	-10.90	5.76	0.65	-22.50	.70
	Follow throw	-18.87	5.76	0.002	-30.47	-7.26
Execution Phase	Stance Phase	10.90	5.76	0.65	-.70	
	Follow Throw	-7.97	5.76	0.17	-19.57	
Follow Throw	Stance Phase	18.87	5.76	0.002	7.26	
	Execution Phase	7.97	5.76	0.17	-3.63	

Based on observed means.
The mean difference is significant at 0.05 level
Adjustment for multiple comparisons: least significant difference (Equivalent to no adjustment)

Table 5.
Comparison of the mean of all the angles during hockey scoop (all phases combined)

Elbow Ankle	Knee Ankle	Ankle Angle	CD at 5% level
161.81	145.37	115.85	47.42

Discussion

The researchers aimed to investigate the angular kinematics (angle of elbow joint, angle knee joint, angle of ankle joint, and different phases of execution while delivering field hockey scoop). A two-way ANOVA test was employed to analyse the study. In the ANOVA table Angles, Hockey Phases, and Angle * Hockey Phases were found significant. The mean performance of hockey scoop shots in the elbow joint and knee joint was found more significant than the ankle joint and on the other hand average performance of hockey scoop shots in the knee and elbow ankle were found to be nearly equal. While pairwise comparisons are done between the elbow joint and knee joint got significance in the same way the elbow joint and ankle joint found significance and the angle and knee joint also found significance which means we interpret the results further. While pairwise compression is done between the stance phase and execution phase it is found insignificance. It was found to be significant stance phase and follow-through phase. In the stance phase and execution result was found insignificant. The study's findings indicate that there are only negligible variations in hockey players' plantations of their left foot behind the ball and stick velocities during the approach which create differences in angle of ankle joint and angle of knee joint (López de Subijana C, 2010). The placement of the left foot behind the ball is important for several aspects of the hockey scoop shot because while you place the leg behind the ball with comfortable stance it helps ankle joint and knee joint to generate force (Mosquera, 2007). Such as force generation during the field hockey scoop is needed to reach behind the ball appropriately, and required to adjust the body further so that the ball is dragged a longer distance which will help the ball to travel in air more time (Mohd Arshad Bari, 2014). Variation was found from player to player during the stance phase. The variation may be due to having different leg lengths of the players This incredibly wide stance width allowed the ball to accelerate more distance toward the target and allowed the drag-flicker to get the low hip (Yusoff, 2008). Angle * Hockey Phases demonstrate the notable variation in performance. Ahmed M., & Ghai, G., conducted a study on" Joint Study and Its Role in the Upper Extremity in Badminton Strokes: A Biomechanical Perspectives of Sports Education" variables of their research were shoulder joint and wrist joint. In shoulder joints, researchers found significant differences but researchers failed to get significant differences in elbow joint and wrist joint. The research supported the earlier investigation conducted by Singh, H., and Singh, D. (2017). Ten intercollegiate volleyball players were used in the "Biomechanical Analysis of Spiking in Volleyball" study, and the results showed a significant relationship at the wrist, elbow, and shoulder joints (Singh H, 2017). To determine the motor fitness factor that contributes to biomechanical anthropometric flexibility in Judo, the previous result established criteria for various variations of the Seoi Nage technique.

They discovered that the right shoulder joint angle, right wrist joint angle, right knee joint angle, and right ankle joint are among the variables that significantly differ (Sao). In their 2012 study, Rajpoot, Y. S., Ghai, G. D., & Bagchi A. examined the biomechanical analysis of a few holding positions on a parallel bar in gymnastics, including the handstand, straddle L-hold, and L-hold (Rajpoot, 2012). A study titled "Kinematic Analysis of the Drag Flick in Field Hockey" was carried out in 2016 by Ibrahim, R., Faber, G., S., Kingma, I., and Dieen, J. The research involved ten [N=10] professional hockey players of America. The digital segment computed the angular velocity of the shoulder, elbow, and wrist, then applied the Berme and Capozzo equation (Ibrahim, 2016). G.D. Ghai & M. Ahmed conducted a study on "A Comparative Biomechanical Analysis of Three Different Badminton Forehand Overhead Shot" where they found

racket velocity, shuttle velocity centre of mass is found significant whereas they found there is insignificant differences in shoulder joint and elbow joint (G.D.Ghai, 35-38)

Conclusions

The average performance in the follow-through and execution phase of field hockey scoop was substantially higher than the stance. In terms of the follow-through and execution phase, the average performance for hockey scoop shots is nearly equal. The follow-through on an average hockey scoop shot is higher than it is during the stance phase. During the stance phase, the average hockey scope shot from all three angles is nearly equal. An elbow angle hockey scope shot is typically greater than an ankle angle. The average follow-through hockey scope shot from all three angles is nearly equal. Hockey scoop shots perform nearly equally well on average across all stances and angles. This research will help the coaches' players to find out the angular differences of angle of elbow joint, angle of knee joint and angle of ankle joint. Players can diagnose their problem with the help of this research and can deliver better field hockey scoop. Through this research coach may formulate training schedule to rectify their angular kinematic problem further this research can be used by upcoming researchers by adding some more variables and can add different kind of tools like force plate form, E.M.G. etc. This kind of research may conduct in various kinds of games and sports. Further same kind of researches can be carried out by using 3D motion camera.

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