Chapter I

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Hockey is an outdoor team sport, like football (soccer) and cricket (Kundra, Deepmala & Bedi, 2010). It is played between two groups of eleven players each, on a turf (grassy/synthetic) or a hard mud surface, with hooked or bent sticks and a hard ball (Avest, 2010; Narang, 2005). The object is to drive the ball into the opponents’ goal by hitting it with the stick (Thani, 2006). The game is also called ‘field hockey’ to distinguish it from ‘ice hockey’, which is very similar but much faster game played on the hard frozen surface of ice, ‘roller hockey’ ‘indoor hokey’ and ‘street hockey’ (Hockey in India, 2012; Sherker & Cassell, 2002; Thani, 1995). Although hockey is not played in as many countries as football (Murtaugh, 2001), nor it is as popular. It is one of the team sports included in the programme of the Olympics. Hockey is the national game of India and since 1947 of Pakistan (Sanyal, 1972).

Games and sports have always been occupied a significant position in the cultural fabric of India. The sportspersons who bring laurels to the country in any sporting event are highly commended and provided a special place in the society. Hockey being a national game of our county obviously considered a game of masses wherein India reigned supreme starting from its debut in 1928 till 1960 Olympics when they first time lost to its neighbour Pakistan in the finals and secured runners-up position (Genesh, 2005: Singh, 1997; Singh & Walia, 1995). Later on in due course of time India regained its lost glory at Tokyo Olympics in 1964. Thereafter an unprecedented decline in the performance of our hockey team started and in subsequent Olympics in 1968 at Mexico, 1972 at
Munich and 1976 at Montreal we could not justified our previous achievements (Ganesh, 2005). The experts believe that there have been numerous potential causes responsible to this decline in our performance which include prompt changes in the rules of the game, change of surface and introduction of Astroturf and foremost the development of hockey in other nations in a very systematic and scientific manner (Chapman, Newton & McGuigan, 2009; Manna, Khanna & Dhara, 2009; Astorino, Tam, Rietschel, Johnson & Freedman, 2004; Lemmink, Mulder, Elferink-Gemser & Visscher, 2004; Spencer, Bishop & Lawrence, 2004).

Inspite of the declined performance of our teams in premier tournaments, we are still being considered one of the powerful teams globally. With the advent of Astroturf the very nature of the game has totally changed (Caple, James & Bartlett, 2012a; Caple, James & Bartlett, 2012b). The span of playing age remarkably reduced owing to the fighting fit physical fitness (Bartlett, 2001), tremendous speed and other required genetic endowments (Boddington, Lambert, Gibson & Noakes, 2002; Lyle, 2002; Reilly & Borrie, 1992; Wilsmore & Curtis, 1992). As far as the techno-tactical aspect of hockey is considered numerous significant techniques and skills have been emerged that have added tremendous speed to the game thereby there remained no room for slow and unfit players (Joseph, 2012; Boyle, Mahoney & Wallace, 1994). In present day game of hockey merely techno-tactical soundness for which India used to be considered best throughout the world is not enough (Hussain, 2012; Button, Davids & Schollhorn, 2006). There is need to learn and develop all those factors to the level of mastery on which present day performance in hockey lies (Schokman, Rossignol & Sparrow, 2002; Law, 1990).
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Now keeping in view the demand of the game a few new systems of play have also been developed (El-Maati, 2011; Caljouw, Kamp & Savelsbergh, 2004). Beside these systems numerous set plays including taking and defending penalty corner and penalty stroke play a decisive role in winning major competitions and of these penalty corner is considered to be the main weapon for getting goals during the course of competitions (Hussain, Ahmed & Khan, 2012; Meulmana, Berger, Zande, Kok, Ottevanger & Crucq, 2012; DeSubijana, Juarez, Mallo & Navarro, 2011; DeSubijana, Juarez, Mallo & Navarro, 2010; Laird & Sutherland, 2003). Most of the major hockey playing countries such as Australia, Netherlands, Germany, Spain, England and Argentina, have been assigning special weightage to train the experts of penalty corner who could convert every chance of penalty corner into a goal (Canal-Bruland, Kamp, Arkesteijn, Janssen, Kesteren & Savelsbergh, 2010). The major hockey playing countries of Asia, including Pakistan, South Korea, China, Malaysia and of course India have also been making all sort of efforts to bring improvement in this department of the game but of no much avail as they succeed only here and there without any constant results.

There have been various combinations and tactics to convert penalty corner into goal but in recent time drag-flick is considered the most successful tactical method in scoring goals though penalty corner (Sampedro, Pineiro & Refoyo, 2008; Yosoff, Hasan & Wilson, 2008; Pineiro, Sampedro & Refoyo, 2007; McLaughlin, 1997). Therefore every hockey playing country has been focusing to specially train a few penalty corner experts who could prove goal getters during the course of competitions (Sofwan, Norasrudin, Redzuan & Mubin, 2012). Hence the present researcher has ventured to compare the execution methods of...
drag-flick being adapted by the Indian experts and the experts of foreign teams including Australia, Germany, Netherlands, Spain and England. Therefore a biomechanical analysis of the skill (drag-flick) deemed to be most appropriate in order to exactly pin-point the biomechanical differences in the execution of drag-flick at the time of penalty corner of our players to that of the players of foreign teams. Before to have the detailed discussion on the mechanical aspect of penalty corner executions we must have go through the brief history of the game.

**History of Hockey**

It is difficult to state with any certainty when or where hockey was played. There is, however, evidence that some form of game resembling modern hockey was played nearly 4000 years ago in ancient Egypt. On the wall of a tomb built about 2000 BC at Beni Hasan in the Nile valley near Minia in Egypt, there is a drawing which shows two people 'bulling' as in modern hockey (Kundra, Deepmala & Bedi, 2010; Sherker & Cassell, 2002). Before this discovery, it was believed that hockey was born in Persia in 500 BC. The reason for this is that polo was played by the Persians about the time and it was thought hockey was a direct descendent of this game (Kundra, Deepmala & Bedi, 2010). It seems more likely, however, that polo was a refined and more aristocratic variation of hockey, which was played earlier (Singh, 1997; Singh & Walia, 1995; Miray, 1986).

From Persia the game traveled to Greece, and was later taken up by the Romans. Evidence to show that the game very much like hockey was played in ancient Greece was discovered in Athens in 1922. There is a bas-relief found on a wall built by Themistocles in 500 BC which shows
six people playing a game resembling hockey, with two players doing the 'bully-off'. But the peculiar thing is that the players are seen holding their hooked sticks pointing downwards, instead of upwards as in modern hockey. Another Athenians bas-relief discovered not many years ago also shows a game of hockey in progress (Singh, 1997; Singh & Walia, 1995; Miray, 1986; DeMellow, 1980; Singh, 1972; Sahay, 1968).

The Romans develops their own version of the game, which they called 'Pagnacia', which was played with a bent stick. The ball was made of leather, packed with feathers. It is possible that this game was passed on to the conquered European nations by the Romans legions. Traces of the stick game played by the Aztec Indians have also been found in Mexico. There is no doubt that the American Indian tribes played a rough stick game, which did not however, bear much resemblance to modern hockey (Dubey, 1999; Miray, 1986).

Some form of hockey, though called by different names, was also played in several European countries many centuries ago. In Ireland it was called 'Hurley', and was the country's national game. The people of Scotland had their own version of the game, which was popular around the 12th century. They called this game 'Shinty'. Both these games were played with a ball made of cork or rubber covered with layer of string wrapped around it (Kundra, Deepmala & Bedi, 2010).

In France the game was popular in the 15th century. The French called their game 'Hoquet', which is the old French word for the long staff or crook, hooked at one end, used by shepherds. It is also assumed that the word 'hockey' was derived from the French word. Another country where hockey took early root was Holland (Netherlands), which had its own brand of the game, which was played with a large, rather soft ball. But the country to which modern hockey owes its own origin is
England, where it was popular towards the middle of the 16th century. This game was called 'bandy'. Even earlier, around 1425, another form of hockey known as 'Commock' or 'Comocke' was played in England. The name was perhaps derived from the word 'Coman', the Gaelic for 'bent stick'. The first clear mention of 'Hawkie' or 'Hockie', to give its original spelling, occurs in 1838 (Miray, 1986).

The first English hockey club was the Blackheath Club in London which was started in 1608 as a society of golfers. The Club latter became a mixed club of hockey, football and rugby. However, as interest in hockey grew, the Club decided in 1861 to have a section devoted exclusively to hockey (Masood, 1936).

As hockey become popular, efforts were made to draw up proper rules, and further changes occurred in 1875. For one, it was decided to use hard cricket balls. Later on, the ball was painted white to show on the green turf. In the early days of the game, a goal could be scored from any part of the ground, as in the case of the football. A player, however, was not allowed to loiter near the opponents' goal, that is, five yards from the goal line, unless he was actually playing the ball. New rules were added later. One of these required that “the stick must not be raised above the shoulder”; and “no goals be allowed if the ball be hit from a distance of more than 15 yards (13.72 meters) from the nearest post” (Singh, 1997; Singh & Walia, 1995).

The first association to control and regulate the game was setup in April 1875, after a meeting of a number of hockey clubs in London. The association did not, however, last long and was disbanded in 1882. The following years, the Wimbledon Hockey Club was founded, and it marked the revival of the game in Britain. The club drew up new rules of the game (Lodhi, 1984; McWhirter, 1984).
An important landmark in the game, and the real birthday of modern hockey, is January 18th 1886, when the British Hockey Association was born (Singh, 1972). King Edward VII, then Prince of Wales, becomes the first President of the Association. By then hundreds of hockey clubs had been formed all over the England and they all become members of the British Hockey Association. The British Hockey Association drew up more detailed rules for the game to make it safer for players (Miray, 1986; DeMellow, 1980).

Hockey had become an established game, but it was still to become a world sport. Once the game took root, however, there was a demand for 'international' matches. As soon as the Irish Hockey Association was formed, a match was arranged between England and Ireland. Though 'international' only in name, the two 'countries' met at Richmond, near London, in 1894. Six years later, the International Hockey Board was established to organize games among different countries. The Board originally had seven members- two each representing Ireland and Wales, and three from the British Hockey Association. When Scotland formed its own Association and joined the Board in 1902, the membership of the board increased to ten (Miray, 1986; DeMellow, 1980; Sahay, 1968).

The International Hockey Board was confined to the British Isles. Nevertheless, it was responsible for organizing international matches. The first truly international match was played in 1907 between England and France. This was followed by a number of similar encounters among several European countries; Germany, Belgium, Denmark, Holland, Spain, Austria, and Switzerland. But at this, the game was still confined to Europe (Singh, 1972; Sahay, 1968).

Hockey made its appearance in the Olympics even before the International Hockey Board was formed. Largely due to British
enthusiasm, hockey was included in the 2\textsuperscript{nd} Olympic Games at Paris in 1900 but, the match was played as an exhibition event, and no winner was declared. Hockey was included in the Olympic Games, for the first time as competitive sports, in the 4\textsuperscript{th} Games held at London in 1908, but was dropped from the next Olympics. Hockey again figured in the Olympic game at Antwerp (Belgium) in 1920, but was not included in the programme of the Paris Olympics four years later in 1924, because of limited support (Miray, 1986; Sahay, 1968).

Hockey in India

India has vast history in hockey. Hockey was introduced into India by the British during the third quarter of the last century. In the early year, it was confined almost exclusively to British and Indian soldiers; and was especially popular among Indian sepoys, it was in fact their main sports (Hendricks, 1988). The nurseries of Indian hockey were the hundreds of cantonments in the country, where it was almost the only sports of the Indian sepoys. The greatest player the game has ever known, the fabulous Dhyan Chand, whom the world called a 'wizard', learned hockey as a sepoys (Hockey in India, 2012; Jain, 2005; Singh, 1997; Singh & Walia, 1995; Sahay, 1968).

The birth of Indian hockey, as far as civilian team is concerned, dates back to 1885, when the first hockey club was formed in Calcutta (now Kolkata). At about the same time, the game spread to Bombay (now Mumbai), which also become an important hockey center. The first important hockey tournament was the Beighton Cup tournament, which was inaugurated in Kolkata in 1895. The next year the Aga Khan Gold Cup tournament was started in Mumbai (Oxendine, 1988).
The rapid popularity of hockey and the increasing numbers of the club in the country made it necessary to setup regional organizations, with a national body at the top, to regulate control and organize the game. The establishment of a national hockey organization was also thought necessary to enable India to enter the international arena. Once again Calcutta (Kolkata) took the lead, and the Bengal Hockey Association came into existence in 1908. The Army Sports Control Board, which has played a big part in the development of hockey, was setup in 1919. This was followed by a number of similar organizations in different parts of the country (Jain, 2005; Singh & Walia, 1995; Sahay, 1968).

Although the need of the national organization had been felt as early as 1908, the proposal fell through, another attempt was made 12 years later by the president of the Punjab Hockey Association, but this too did not bear fruit. Representatives of provincial organizations and others interested in hockey who met in Gwalior on September 7th, 1925, finally set up Indian Hockey Federation. Mr. Bruce Turnbull was elected its President and Mr. N. S. Ansari the Honorary Secretary. The Federation had only five members. The headquarter of the organization was shifted from Gwalior to Delhi in 1927. At that time, Major I. Burn Murdoch became President, and Mr. T. P. Gateley, then President of the Delhi Hockey Association, took over as Honorary Secretary. This marked the beginning of organized hockey in the country. The membership of the Federation began to increase with the formation of regional units covering every part of the country (Jain, 2005; Singh, 1993).

On 28th April 2008, Indian Hockey Federation was dissolved by Indian Olympic Association (IOA) and an ad-hoc committee was formed by the IOA to supervise the game in the country. Mr. Aslam Sher Khan was appointed as the president of the ad-hoc body, the other
members of the then ad-hock committee were Mr. Zafar Iqbal, Mr. Ashok Kumar, Mr. Ajit Pal Singh and Mr. Dhanraj Pillay (Indo Asian News Service, 2008).

Hockey India (HI) is the new apex body of the country which has the sole mandate to govern and conduct all activities for both men and women hockey in India. Formed on 20th May 2009, it is the recognized National Association affiliated to the International Hockey Federation (FIH), the Indian Olympic Association (IOA) and Asian Hockey Federation (AHF). HI with the assistance of Sports Authority of India and Department of Sports, Government of India, has drawn out a long term development programme to train players and to provide overseas exposure besides regular international competition (The Hindu, 2009)

In recent times, the Indian team, while possessing some of finest stick wielders in the world, has had a tendency to choke on the big occasions. At tournaments like the 2008 Olympics Qualifiers, 2010 Commonwealth Games and the 2010 Men’s Hockey World Cup (which was on home soil) as well as recently concluded London Olympics 2012, the team has shown an inability to glow and has finished in positions well below their talent in a similar vein to the Spanish national football team.

Following the introduction of the synthetic playing surface which has changed the technical, tactical and physiological requirements of the game of hockey at all levels (Chapman, Newton & McGuigan, 2009; Manna, Khanna & Dhara, 2009; Astorino, Tam, Rietschel, Johnson & Freedman, 2004; Spencer, Bishop & Lawrence, 2004), but in particular at the elite level (Reilly & Borrie, 1992). Hockey players in India could not adjust themselves with these changes hence their dominance in the world of hockey declined dramatically. Coaches, especially at the elite level, recognize that the achievement of today’s players is a result of the
integration of many factors. Each may contribute a variable amount to the final outcome (Beckamnn, Winkel & Shollhom, 2010; Manna, Chapman, Newton & McGuigan, 2009; Khanna & Dhara, 2009; Bloomfield, Polman, O'Donoghue & McNaughton, 2007; Cochrane & Stannard, 2005; Astorino, Tam, Rietschel, Johnson & Freedman, 2004; Spencer, Bishop & Lawrence, 2004). The recognition that a successful performance is dependent upon the interaction of these complex factors varies greatly both inter and intra sport, with the final performance being resultant of factors such as; genetics, training, health status, psychology, physiology, skills and the tactics employed (Beckamnn, Winkel & Shollhom, 2010; Martell & Vickers, 2004; Lyle, 2002; Schokman, Rossignol & Sparrow, 2002; Bartlett, 2001; Reilly & Borrie, 1992; Wilsmore & Curtis, 1992) and most importantly the biomechanics (DeSubijana, Juarez, Mallo & Navarro, 2011).

Such continuing development of sport, has led to an increased emphasis towards the provision of scientific support to assist the coaching process (James, Mellalieu & Jones, 2005). Scientific elements of sport play an important part in the coaching process, as devising training schedules (Bompa, 1999), the monitoring of performances, establishing techniques, and preparing the athletes for competition are all the outcome of this scientific knowledge (Thiel, Tremayne & James, 2012; Worden-Rogers, 2012; Vizzaya-Perez, Fernandez-del-Olmo & Martin-Accero, 2005; Maile, 2002). Hughes and Bartlett (2008) described the five main purposes of performance analysis to be tactical evaluation, technical evaluation, analysis of movement, development of a database and modeling, and finally for educational use with coaches and players.

Biomechanists are becoming increasingly recruited as consultants to teams and coaches in sport teams. If they are to be successful, then it is
essential that they apply motion analysis to not only evaluate individual performance, but suggest methods of optimizing technique for enhanced performance and injury risk reduction (MacLeod, Morris, Nevill & Sunderland, 2009; Marino, 1983). As in all scientific fields, the most successful biomechanists will be innovative and pioneers in the technical development of their specialized sport. According to Ferdinands (2010) the biomechanists can apply motion analysis to improve sports performance in the following ways: a) to develop a detailed descriptive biomechanical analysis of sports technique, b) to establish the biomechanical criteria that is characteristic of optimal technique, c) to establish the validity of coaching intervention measures on selected performance outcomes d) to perform a biomechanical performance blueprint or profile, and e) to perform a quantitative talent identification survey.

A detailed understanding of the biomechanics of human motion and movement generally in sports requires the service and knowledge of a multiple camera, three-dimensional/two-dimensional motion analysis system to film, capture, track, digitize and analyze sporting motions over time and time (Ferdinands, 2010; MacLeod, Morris, Nevill & Sunderland, 2009; Upjohn, Turcotte, Pearsall & Loh, 2008; Whitaker, 1992). A variety of motion analysis capture methods such as optical, electromagnetic and image-based techniques can be used (Naud, & Hold, 1980). However, they all serve a common objective to obtain raw positional data of segment points that can be filtered and used to calculate various kinematic and kinetic derived variables (Marino, 1983). These variables are applied to quantify and experimentally validate descriptions of sports technique, and also provide biomechanical explanations of the motion patterns observed in sports (Ferdinands, 2010; Whitaker, 1992).
If aided by a qualitative analysis, then coaches can use biomechanical descriptors of technique and skill to improve the quality and clarity of training instruction (Knudson, 2007; Marino, 1998; Newell & Corcos, 1993). In addition, a biomechanical understanding of sports technique potentially leads to the optimization of technique with respect to various performance outcomes for different sets of constraint functions (Gonzalez & Hull, 1989; Hatze, 1983).

The study of biomechanics in sport movements are directed towards the improvement of motor actions and their knowledge as to how perform them better (Montgomery, Nobes, Pearsall & Turcotte, 2004; Donskoi & Zatziorski, 1988). By using a biomechanical analysis can objectively recognize the traits basics of a particular style or technique, and thus, establish objectively the different techniques of a specialty sports, including finding the most appropriate one (Hochmuth, 1973). The quality of implementation of the technical movements is essential in different sports, including field hockey (Hache, 2002).

At the highest level, hockey is a fast-moving, highly skilled sport, with players using fast moves with the stick, quick accurate passing, and hard hits, in attempts to keep possession and move the ball towards the opponent’s goal (Holmes, 2011; Avest, 2010). Collisions are common while physically tackling and otherwise obstructing players is not permitted. Obstruction typically occurs in three circumstances - i) when a defender comes between the player in possession without first performing a legitimate tackle; ii) when a defender’s stick comes between the attacker’s stick and the ball or makes contact with the attacker’s stick, and iii) also when (usually deliberately) blocking the opposition’s passage to the ball (called third party obstruction). Free hits are awarded when offences are committed outside the scoring circles. The penalty
corner is awarded: - a) for an offence by a defender in the circle which does not prevent the probable scoring of a goal, b) for an intentional offence in the circle by a defender against an opponent who does not have possession of the ball or an opportunity to play the ball, c) for an intentional offence by a defender outside the circle but within the 23 meters area they are defending, d) for intentionally playing the ball over the back-line by a defender, and e) when the ball becomes lodged in a player's clothing or equipment while in the circle they are defending (F.I.H. Rules, 2011).

Importance of Penalty Corner

It has been noticed that average teams with excellent goalkeepers and reliable marksman at penalty corners can beat technically superior teams (Canal-Bruland, Kamp, Arkesteijn, Janssen, Kesteren & Savelsbergh, 2010). The reason for the superiority defeat of the favourites one frequently notice upto a dozen penalty corners wasted because of lack of concentration, careless positioning and too much improvisation in execution of penalty corner (McLaughlin, 1997). It must be added that the penalty corner is grossly neglected in training especially at lower level teams. Nowadays however, the importance of extensive practice in taking penalty corners is proved by the fact that in matches, goals from open play become rarer (DeSubijana, Juarez, Mallo & Navarro, 2010; Arora, 2005; McLaughlin, 1997). It is now an established fact that the fate of matches is now often decided in favour of those teams having penalty corner converting specialists (Mohammad & Hussain, 2012). In penalty corner conversions team should have at least three players who are perfect in pushing, stopping and in taking the strike. For this a perfect understanding between these players is required which come by only hard
combined practice. To obtain the objective the teams from the grass root level must develop and train at least two sets of three such players who should be trained and guided accordingly to take advantage of the penalty corner awards (Jain, 2005; Singh, 1997).

The penalty corner is an important phase or situation in the development of a hockey match (DeSubijana, Gomez, Martín-Casado & Navarro, 2012; Pineiro, 2008; Laird & Sutherland, 2003). It is also known as ‘PC’ or simply ‘penalty’. During the course of penalty corner execution five defenders (including the goal-keeper) positioned behind the backline and at least 5 meters from the ‘insert’ position of the ball. All other players in the defending team must be beyond the centre line that is not in their own half of the field, until the ball is in play. Attacking players begin the play standing outside the scoring circle (the circle has a 14.63 meters radius), except for one attacker who starts the corner by playing the ball from a mark 10 meters either side of the goal (FIH Rules, 2011). This player puts the ball into play by pushing the ball to the other attackers outside the circle; the ball must pass outside the circle and then put back into the circle before the attackers may make a shot at the goal from which a goal can be scored. FIH rules (2011) do not forbid a shot at goal before the ball leaves the circle after being ‘inserted’, nor is a shot at the goal from outside the circle prohibited, but a goal cannot be scored at all if the ball has not gone out of the circle and cannot be scored by a shot from outside the circle.

Whilst the penalty corner has always been an important part of the game, importance has become more pronounced following the introduction of artificial turf. The former great penalty corner strikers like Paul Litjens, Ties Kruize and Michael Peters were successful due to the countless hours they spent in practice perfecting their skills and craft.
Uneven bounce and unpredictability were ironed out when artificial turf was introduced. Hence the proliferation of penalty corner specialists during the eighties and nineties including Floris Jan Bovelander, Jay Stacy, Carsten Fischer, Khalid Bashir, Craig Davies, Jim Irvine and Seong Seo Kim were no doubt largely due to the evenness and predictability of the new surface. While these players are basically hard hitters of the ball, the introduction of the drag-flick provided another dimension to counter the goalkeepers who lie down during the hit. In recent years, the drag-flick technique of penalty corner execution has gained importance as a vital part of the game and as a good goal scoring opportunity (DeSubijana, Juarez, Mallo & Navarro, 2011; Yosoff, Hasan & Wilson, 2008). Different tactics and variations are used by the specialist as drag-flicker during the course of penalty corner execution. Particularly due to high rate of conversion, the drag-flick technique of penalty corner is highly sought for. This new skill of drag-flicking also introduced new exponents of this skill including Sandeep Singh, Jugraj Singh, Dhananjay Mahadik, Raghu Nath, Diwakar Ram (India), Bram Lomans, Taco van den Honert and Taeke Taekema, Steller (Netherlands), Luke Doerner, Chris Ciriello, Eddie Ockenden (Australia), Sohail Abbas, Muhammad Imran, Muhammad Irfan, (Pakistan), Ribas Xavier, Alegre Ramon, Freixa Santi (Spain), Shanmuganathan Kuhar, Muhammad Amin Rahim, Azlan Misron, (Malaysia), Florian Kunz, Christopher Zeller (Germany), Calum Giles, Ashley Jackson, Richard Mantell, Rob Moore (England), Hayden Shaw, Andrew Hayward (New Zealand) Justin Reid-Ross, Gareth Carr (South Africa) and Jorge Lombi (Argentina) who are the modern exponents of this lethal skill. They all have ability to whip the ball at speed more than 120 km/h. This technique has remained the favoured way to score goals on penalty corners.
Scoring a goal from a penalty corner depends on various factors. The most important is the technique and tactical application of the move (Laird & Sutherland, 2003). The technique and tactical aspect is the determinant of the coordination of players and is the process of mastering redundant biomechanical degree of freedom of player's movement. The players select their position coordination pattern via a process of self-organization to find a solution within the context of constraints (Pineiro, Sampedro & Refoyo, 2007). The ability to quantify the coordination patterns or coupling relationship between different player's movements is extremely useful in the set plays of penalty corner. In the penalty corner there are three main aspects: push to 'D' (circle), stop and strike, it is dominated by coordination amongst player's movement control and skills (Hussain, Ahmed & Khan, 2012). The analysis of these factors and adaptation of the method with training will optimize the scoring rate of performance.

Biomechanical analysis to quantify techniques specifically kinematics measurements are necessary (Boone & Birnbaum, 2012). Scientific evaluation of the drag-flick technique of penalty corner execution will suggest relative information on scoring performance and are particularly important. The kinematical analysis that would be easily interpreted in terms of various set play and would be incorporated into training and be beneficial (Bompa, 1999). Kinematics of the drag-flick technique of penalty corner execution would provide useful information about how each set play provides potential scoring move to the system. The acute kinematic differences in the drag-flick technique may reflect the different manner in which various set play in penalty corners provide insight into possible differential mechanism by which set play acts to improve the scoring possibility (Gomez, DeSubijana & António, 2012).
Biomechanics may be defined as the science which investigates the internal and external forces acting on a human body and the effects produced by these forces (Hay, 1973). In the last several decades, biomechanics has demonstrated considerable growth evolving from an exercise in the filming of human movement to an applied science with a powerful array of measurement and modeling techniques (Franks, Weicker & Robertson, 1985). The simple descriptive approach which was characteristic of early work has been superseded by attempts to explain the mechanisms underlying movement (McGinnis, 2002). Consequently, biomechanics has emerged as an important area of scientific investigation in a variety of disciplines. Included among these are automobile safety, biomedical engineering, ergonomics, exercise science, orthopedic surgery, physical rehabilitation, and sports. In biomechanics extensive research has been conducted into the nature of the interaction of arms and legs in walking, running, throwing, human body segment inertial properties, angular momentum analyses, kinematics of jumping etc. (Glazier, Wheat, Pease & Bartlett, 2006; Johnston, Sproule, McMorris & Maile, 2004). However, rule changes and advances in the tactical and technical understanding of play have reduced the advantages of the previous biomechanical analytical research (Beckamnn, Winkel & Shollhorn, 2010; Chapman, Newton & McGuigan, 2009; Manna, Khanna & Dhara, 2009; Bloomfield, Polman, O’Donoghue & McNaughton, 2007; Cochrane & Stannard, 2005; Astorino, Tam, Rietschel, Johnson & Freedman, 2004; Spencer, Bishop & Lawrence, 2004). Therefore pressure on the sports scientist to deliver the research results to opt the latest changes accurately as even to small errors.
Modern movement analysis is the interpretation of computerized data that documents an individual’s motion during movement. Movement analysis has its roots in ancient times (Lafontaine, 2007; Carr, 2004). For decades, taking moving pictures and processing them frame-by-frame, was the primary method for determining movement of athletes, however, the development and subsequent improvement of electronic technology and computer science has made it easier to analyze movement (Joseph, Ganason, Wilson, Teong & Kumar, 2008; Liebermann, Katz, Hughes, Bartlett, McClements & Franks, 2002; Lafontaine, Lamontagne, & Lockwood, 1998). The increasing involvement of technology has made some other methods and tools available for tracking and assessing motion. Hundreds of laboratories around the world are now working on movement analysis. There are important works being done in analyzing sports-related movement. Sports performance is directly linked to human motion and performance (Abdel-Aziz & Karara, 1971). So, movement analysis is automatically a part of human performance assessment and analysis (Enoka, 1988). Today in many sports, sports scientists use movement analysis as a tool to enhance techniques and tactics, correct movement errors related to a variety of movements, and aid in training (Abernethy, Farrow & Berry, 2003).

Biomechanical research of sports techniques and tactics respects the human body as well as the sports equipments as a mechanical system of moving. In the modern computerized systems, computer software programmes are used to evaluate the collected data and process it (Bartlett, Wheat & Robins, 2007; Breiman, 1996). With these software programmes, it is now possible to make sophisticated calculations, statistical evaluations, and comparisons between subjects, cases and models related with the movement (Baker, Farrow, Elliott & Alderson,
2009; Barpanda, 1998). Armed with these valuable information, movement researchers can determine abnormal biomechanics, measure deviations from a desired pattern, and assess a variety of biomechanical errors made by an athlete or athletes.

Hockey playing teams have perfected the art of both drag-flicking as well as many successful variations during penalty corner (DeSubijana, Juarez, Mallo & Navarro, 2011). This has put a huge emphasis on winning penalty corners during matches allowing teams free opportunities for the penalty corner specialists to score from the top of the circle.

It emerged as the fact that among the existing foundations in field hockey, one of the most required technical domains is the penalty corner (DeSubijana, Gomez, Martin-Casado & Navarro, 2012; Pineiro, 2008; Laird & Sutherland, 2003), which is characterized as a free hit from the attacking team, in which the ball is played from the baseline toward a teammate. Penalty corners are extremely important and over the last few years have contributed significantly to the outcome of a match. The technical implementation of the penalty corner can be considered as a pass "pushed", which is used to send the ball accurately and control the pace of the ball (Anders & Myers, 1999). For an execution efficient in such sports gesture, it is necessary, especially rapid hip rotation, change and toward the upper target (Kerr & Ness, 2006).

The coordination of different body segments during the execution of penalty corner is crucial in the ball speed and accuracy of the charge. The alignment of the position of the feet, for example, allows you to transfer adequate body weight forward at the time of launch, maximizing the acceleration of the arms and the club, hence increasing the output speed of the ball (Kerr & Ness, 2006; Mitchelltaverner, 2005).
According to DeSubijana, Juarez, Mallo and Navarro, (2012) the penalty corner is one of the most important phase in field hockey, with one third of the goals resulting from this tactical situation. Other contemporary researchers like Pineiro (2008), Kerr and Ness (2006), Laird and Sutherland (2003), Vizcaya-Perez, Fernandez-del-Olmo and Martin-Acero (2005) also stated that penalty corner is one of the most important scoring play in field hockey. There are numerous ways of striking in hockey during penalty corner execution like push, flick, slap-shot hit, lift, push-in, with the drag-flick a technique that consists of dragging the ball (drag) until the ball raises in air (flick). Following the rules of the International Hockey Federation (FIH, 2009), run a drag-flick at a penalty corner has some advantages compared to other beatings since there is no height limitation. The drag-flick is more efficient than hitting or push-shooting the ball towards the goal when playing a penalty corner (McLaughlin, 1997; Pineiro, Sampedro & Refoyo, 2007; Yusoff, Hasan & Wilson, 2008). It is used by skilled players all around the world, from international level right down to local leagues, as a set play during penalty corners. It was introduced in the year 1992 by Dutch player Taco Hajo van den Honert (Yusoff, Hasan & Wilson, 2008). Prior to this, rules relating to penalty corners limited attacking shots to below 45cm when crossing the baseline. The rule change exploited by the Dutchman permitted the drag-flick to be used to attack any part of the goal (Jennings, Blanchonettea, Lucasa, Morganb, Helmera & Yangc, 2010).

While the mechanics of the drag-flick are relatively simple, the skill required to master the technique can take many years to master (Mohammad & Hussain, 2012). The drag-flick action begins with a stationary ball (usually pushed from the baseline and trapped outside the circle during a penalty corner), with the drag-flicker (usually) set in a
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crouched position before the play begins. As the flicker steps forward, the ball is pushed along the ground using the shaft of the stick. The stick moves in a slinging action, with the ball always remaining in contact with it. As there is no loss of contact, the shot is actually a push, not a hit. During the slinging action the ball is accelerated, sometimes reaching speeds around that achieved using a normal hitting action. Spin is imparted to the ball, giving a curved trajectory to it. As penalty corners are common at all levels of field hockey, highly skilled drag-flickers who can direct the ball to any part of the goal are a much sought after commodity (Gomez, DeSubijana & Antonio, 2012).

Only a few researches have analyzed the drag-flick. Some of them have provided kinematic information about players from different levels (McLaughlin, 1997; Yusoff, Hasan & Wilson, 2008; DeSubijana, Juarez, Mallo & Navarro, 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, Farrow, Elliott and Alderson (2009) focused on anticipation skills of the goalkeepers, while Jennings, Blanchonette, Lucas, Morgan, Helmer and Yang (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 focused on training topics, such as endurance (Manna, Khanna & Dhara, 2009; Chapman, Newton & McGuigan, 2009), general physical condition (Astorino, Tam, Rietschel, Johnson & Freedman, 2004; Spencer, Bishop & Lawrence, 2004), velocity (Bloomfield, Polman, O'Donoghue & McNaughton, 2007) and strength (Cochrane & Stannard, 2005). In relation to technical training Beckammin, Winkel and Shollhorn (2010)
applied different treatments for the push and the flick in indoor hockey twice per week during six weeks, obtaining very heterogeneous findings.

In the most recent of these, DeSubijana, Gomez, Martin-Casado and Navarro (2012) investigated training-induced changes in the drag-flick technique of female field hockey players. 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 ball release. It was noted in their study that all players had lost speed of the previous run. They suggested that further studies should include a larger sample, in order to provide more information on field hockey performance. Meulmana, Berger, Zande, Kok, Ottevanger and Crucq (2012) developed a training tool to improve the drag-flick technique, to decrease the load on the body during the drag-flick, and to increase the fun factor. The survey showed that trainers and hockey players were positive about the tool on all of the three aspects. Video analysis showed that training the drag-flick with the tool reduced the load on the lower back. There was no difference in ground reaction force. Gomez, DeSubijana and Antonio (2012) studied the influence of the direction of the drag-flick on the players’ performance. The aim of their study was to analyze the individual differences in the drag-flick pattern between right and left shots. They suggested that both side shots are equally efficient because there were found no differences in ball velocities neither at the kinematic sequences of both goal areas. DeSubijana, Juarez, Mallo and Navario (2011) examined the application of biomechanics to penalty corner drag-flick training. The aim of their 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. They
suggested that specific training sessions conducted with the player improved some features of drag-flick. This study shows how technical knowledge can help with the design of training programmes and whether some drills are more effective than others. DeSubijana, Juarez, Mallo and Navarro (2010) analyze the penalty corner drag-flick of elite male and female hockey players. For the purpose of the study they have selected thirteen players as the subjects in the study. By comparing these players they established that the cues of the skill level are a wide stance, a whipping action (rapid back lift) of the stick followed by an explosive sequential movement of the pelvis, upper trunk and stick. Jennings, Blanchonettea, Lucasa, Morganb, Helmera and Yangc (2010) investigated the forces between ball and stick and the location of the ball on the stick during a drag-flick. Force sensors were mounted on the surface of the stick to determine both the forces applied and ball position with high temporal resolution during drag-flicking. The force sensor data showed that the force and location of the ball during a drag-flick was important for controlling drag-flicks. The use of the force sensors also affected the friction of the stick surface and made it more difficult for the subjects to impart curvature onto the ball's trajectory consistent with elite competition. They concluded that further development of the sensors is required to improve measurement and analysis. DeSubijana, Antonio, Juarez and Navarro (2009) studied to describe the kinematics of international field hockey players during the drag-flick and to analyze gender differences. Comparing with the drag-flicker they have found the cues of the skill, being necessary a whipping effect of the stick before an explosive movement of hips, shoulders and a maximum acceleration of the stick. Yusoff, Hasan and Wilson (2008) biomechanically analyzed the penalty corner drag-flick performed in a competition. The results of their
study showed that the technique for the penalty corner drag-flickers was consistent with the skill described in the coaching texts. Santos, Pupo, Piucco, Reis and Detanico (2008) analyzed the kinematics characteristics and the velocity of the ball in different techniques of the penalty corner. They selected two players of the Brazilian field hockey team, one male and one female, those who were specialists in penalty corner. They concluded that the first technique, executed by male player, was more similar to the described in literature. According to biomechanical aspects this technique was considered most efficient as well as the techniques executed by female player, was also similar to the described in the literature. Pineiro, Sampedro and Refoyo (2007) investigated international men’s and women’s teams in the development of the strategy when a penalty corner was successful. They reported in the results of the study that the action of the goal in the penalty corner, suggests significant differences between men and women, in the skill of use, the number of players who intervene, the number of passes and the zone of shot. Kerr and Ness (2006) examined the kinematics of the field hockey penalty corner push-in. The results of the study revealed that experienced push-in performers demonstrated greater stance width and faster resultant ball velocity than the novice group. They suggested four coaching recommendations for enhanced push-in performance including training specificity, stance optimization, explosive dragging and kinetic chain awareness. McLaughlin (1997) worked on a project to perform a detailed kinematic analysis of penalty corner drag-flick skill from a dead ball situation, so as to provide a sound technical foundation for coaching and learning the skill at all levels of hockey in Australia. In order for the understanding of the skill to increase, he broken down the penalty corner drag-flick into four significant temporal positions- right foot contact, ball
contact, left foot contact and ball release. The resultant ball velocity at the point where the ball was released off the stick face was designated as a key parameter in the optimal execution of this skill. The necessity to maximize drag distance, in particular, is highlighted throughout. The correct body and stick position at each of the four points is illustrated by comparing the highly skilled with the less skilled performer. He suggested that once the basics of the skill are mastered, it will be necessary for the coach and player to concentrate on refining the movement so that it is completed in the shorter possible period of time. This will also improve the success of the skill in the game situation as the defense has less time to react to the stroke as they come off the goal line.

The review of literature shows that there are numerous studies on penalty corner drag-flick technique but till date none of the investigator tried to compare penalty corner drag-flick technique of the leading world’s teams. The present study design to compare the execution of drag-flick technique of top world level teams and try to pin-point the methods to quantify key components of the drag-flick, thus to improve understanding of the biomechanical features of this important technique. The biomechanical analysis of penalty corner drag-flick execution is the answer to full fill existential vacuum, refinement, and stabilization of this sport in growing competitive sporting world to the changing demand.

At international level of competition a minute variation may result in win or lose (Sofwan, Norasrudin, Redzuan & Mubin, 2012; Hussain, Mohammad, Khan, Bari, Ahmad & Ahmad, 2011). Every nation is backing their teams and sports persons with biomechanical researchers to accomplish the need. Other developing countries have made their changes according to demand and thus superseded India performance. Indian hockey players need support from our researches to identify variation and
variables to steer their performance to those golden days of dominating world hockey. Thus the need for such kind of investigation would be self-evident. India has not even set to its initial in the biomechanical researches in any filed. In Indian no such research have been undertaking till date in biomechanics. In the computer era, the motion analyses software and programming made biomechanical research especially in kinematics possible to read the athletes motion. The penalty corner execution in hockey received very less biomechanical research attention than any other. Penalty corner is a complex movement and therefore generally follows different predictable stages. The theoretical concepts have conclusively defines that elite sportsmen of skilled levels and within skill levels exhibits to have mechanical variability. Thus the present research has been undertaken.

**Statement of the Problem**

In view of the negligible conversion rate of Indian players through penalty corner, existed paucity of research in the biomechanics of the penalty corner and unavailability of scientific data concerning with penalty corner of international caliber the researcher has designed the present study and stated as “Analysis of Penalty Corner of Indian Team as Compared to Foreign Counterparts in the Field Hockey: A Biomechanical Study” in order to pin-point the shortcoming in the execution of penalty corner by our players and thus to evolve corrective measures for proper improvement in its execution.
Definitions of the Operational Terms

In order to clarify the respective meaning of the terms employed in the present study the operational definitions have been forwarded as under:

**Field Hockey:** Field hockey is a team sport in which a team of players attempt to score goals by hitting, pushing or flicking the ball with hockey sticks into the opposing team’s goal. Its official name is simply hockey, and this is the common name for it in many countries. However, the name field hockey is used in countries where the word hockey is usually reserved for another form of hockey, such as ice hockey or indoor hockey or street hockey.

**Goalkeeper:** One of the participants of each team on the field who wears full protective equipment comprising at least headgear, leg guards and kickers and who is also permitted to wear goalkeeping hand protectors and other protective equipment.

**Attacker:** The team player who is trying to score a goal.

**Defender:** The team player who is trying to prevent a goal being scored.

**Back-line:** The shorter (55 meters) perimeter line.

**Goal-line:** The back-line between the goal-posts.

**Side-line:** The longer (91.40 meters) perimeter line.

**Circle:** The area enclosed by and including the two quarter circles and the lines joining them at each end of the
field opposite the centre of the back-lines. It is also called ‘D’.

23 Meters Area (25 Yards Area): The area enclosed by and including the line across the field 22.90 meters from each back-line, the relevant part of the side-lines, and the back-line.

Penalty Corner: The penalty corner is a special and important phase in the development of a field hockey match. Also called ‘PC’ or short corner or ‘penalty’, it is awarded to the offending team when the defending team committed a foul in its circle or a particularly bad foul in its defending quarter (23 meters area).

Pusher: One of the participants of the attacking team who pushes the ball from backline to top of the circle at the time of penalty corner execution.

Stopper: One of the participants of the attacking team who stops the ball at the top of the circle on a penalty corner execution.

Drag-flicker: The player who propel the ball into the goal by flicking the ball.

Sports Biomechanics: Sports Biomechanics is a quantitative based study and analysis of professional athletes and sports.

Analysis: Analysis is the process of breaking a complex topic or substance into smaller parts to gain a better understanding of it.

Biomechanical Analysis: The biomechanics is concerned with the muscular and mechanical aspect. In the muscular
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aspect we are concerned with the muscles, bone, joint, and movement of various segments of the body. In the mechanical aspect we deal with the kinematics and kinetics variables i.e. distance, speed, velocity, mass, inertia, force etc. Mechanical analysis can be done in qualitative and quantitatively.

**Kinematics:**

The kinematics is that branch of biomechanics, which concerned with description of the movement of segments of the body without regard to the forces and cause due to which the movement occurred. Kinematics has two branches i.e. Linear kinematics and Angular kinematics.

**Linear Kinematics:** It deals with the kinematics of translation, or linear motion. When a body moves, all part of it travels exactly the same distance, in the same direction in the same time.

**Linear Distance:** The actual distance covered by a body or an object is the distance. In other words it is the total distance covered by a body or an object from starting position to final position.

**Linear Displacement:** The minimum distance between the initial position and the final position of a body in motion is called displacement.

**Linear Velocity:** It is the rate at which a body moves from one location to another in a given direction in respect to time. So it can be defined as rate of change of position.
(displacement) of a body with respect to time in a given direction.

**Linear Speed:** The speed of moving body is the rate at which the distance is covered by the body.

**Angular Kinematics:** It deals with the kinematics of rotation or angular motion. In angular kinematics every particle of the body moves in a circle and the centers of all these circles lay at the axis of rotation.

**Angular Distance:** The angle traversed by a rotating body is called angular distance. In other words, it is the angle between the initial and the final position measured following the path of rotation.

**Angular Displacement:** The maximum angle between the initial position and the final position of a body in rotation is called angular displacement. In other words, it is the smaller of the two angles between the initial and final position.

**Angular Speed:** The average angular speed of a rotating body is defined as the rate at which angular distance is covered.

**Angular Velocity:** The average angular velocity of a rotating body is defined as the rate at which angular displacement has occurred.

**Drag-flick:** The drag-flick is a variation of penalty corner and specialist scoring shot usually played as a set piece during penalty corners. The action involves a player crouching low down next to the ball and picking it up
on the shaft of the hockey stick. The ball is then pushed along the ground whilst the stick is moving with a ‘slinging’ action. This serves to accelerate the ball, which is eventually released in a goal-wards direction, often raised.

**Technique:**
Technique is defined as motor procedure for tackling a motor task. Motor procedure should be understood as a system of movement of body in a definite sequence. Many of these movements, however, may take place simultaneously.

**Tactics:**
Tactics consist of tactical actions as well as other measures which are adopted before or during the competition for successful participation. Tactics is theory of rules, possibilities, means and forms of successful formulation of competition activity in sports.

**Push-in Distance (meters):** The linear distance from pusher to stopper.

**Push-in Ball Travel Time (seconds):** The time which was consumed to reach the ball from pusher to stopper.

**Push-in Ball Velocity (km/h):** The speed at which ball moves towards stopper from the pusher.

**Drag Distance (meters):** The distance which was covered by the drag-flicker when he drags the ball prior to flick the ball into goal-words.

**Drag Speed (km/h):** The speed at which the drag-flickers drag the ball along with the ground prior to flick the ball goal-words.
**Drag Time (seconds):** The time spends by drag-flicker to drag the ball prior to flick the ball.

**Stance Width (meters):** The maximum distance between right toe to left toe at the time of drag-flick.

**Stick Angle at Initial Ball Contact (degree):** The angle of the stick in relation to the ground at the time when drag-flicker initiates the movement.

**Stick Angle While Dragging the Ball (degree):** The angle of the stick in relation to the ground at the time of dragging the ball along the ground.

**Stick Angle at Release (degree):** The angle of the stick in relation to the ground at the time of release of the ball from the stick.

**Time Taken to Release the Ball (seconds):** The time consumed between initial touch to the release of the ball from the stick.

**Drag-flick Velocity (km/h):** The speed of drag-flick.

**Total Time Taken (seconds):** It was the time which starts at the point when pusher push the ball towards stopper and end when ball crosses the goal line (in case of converted penalty corners) or when ball trapped or stopped by any defender (in case of non-converted penalty corners).

**Preparation or Approach Phase:** It is a phase when drag-flicker prepare himself for drag-flick or any step taken towards the ball to put a player in proper position to strike the ball.
**Ball Contact Phase:** The point at which the stick first sticks the ball until the ball has left the stick.

**Release Phase:** The point at which the ball released by the drag-flicker’s stick.

**Fallow Through Phase:** Movement of the stick after impact until the end of the swing.

**Delimitations**

Every research is limited in several ways. It has to be delimited in terms of population covered, sample selected and scope of available study area. Following were the delimitations of the present empirical analytical study:

i. The study was confined to the men’s international hockey matches played in the year 2010 only.

ii. Research was conducted on the male players of the Indian and other top five ranked foreign hockey teams.

iii. Only top five ranked foreign teams for the year 2010 were considered for the study based on the ranking of F.I.H. for 2010.

iv. The study was restricted to the analysis of 8 converted and 8 non-converted (a total of 16 penalty corners) of the Indian team.

v. The study was further restricted to the analysis of 8 converted and 8 non-converted (a total of 16 penalty corners) for each of the first five ranked foreign counterparts.

vi. This study was a two-dimensional biomechanical analysis.
Limitations

There are numerous limitations which are par from our control. There are following limitations of the present study.

i. The quality of the video footage of the men’s international hockey matches considered as limitation of the study.

ii. The features of the motion analysis software used were the limitation of the study as it cannot be upgraded.

iii. The direction of wind during the course of data acquisition was also considered as the limitation of the study, as it can affect the rate of velocity.

Hypotheses

On the basis of previous research findings, literature reviewed, expert opinion and scholar’s own understanding of the problem, it was hypothesized that, there would be no significant differences in the selected biomechanical variables of penalty corner execution of Indian team as compared to foreign counterparts. It was further hypothesized that, there would be no significant differences in the variables of converted and non-converted penalty corner executions of each team selected in this study.
Objectives of the Study

The prime goal of the study was the analysis of penalty corner execution of Indian team as compared to foreign teams. In order to realize the goals of the study following objectives were stated:

i. Efforts were made to compare world’s top five ranked field hockey team’s penalty corners executions with Indian team’s penalty corners executions and thereby formulate coaching recommendations specific to penalty corner execution.

ii. The other objective of the study was to compare the variables of converted penalty corners with the non-converted penalty corner’s variable of Indian team.

iii. To compare the variables of converted penalty corners with the non-converted penalty corner’s variable of Australian team.

iv. To compare the variables of converted penalty corners with the non-converted penalty corner’s variable of Dutch team.

v. To compare the variables of converted penalty corners with the non-converted penalty corner’s variable of German team.

vi. To compare the variables of converted penalty corners with the non-converted penalty corner’s variable of English team.

vii. To compare the variables of converted penalty corners with the non-converted penalty corner’s variable of Spanish team.
Significances of the Study

The inference drawn out of the biomechanical analysis of penalty corner of Indian team as compared to foreign counterparts in the field hockey would be beneficial in the following ways:

i. The findings of the study would evolve new measures for improving the goal scoring ability of Indian team via penalty corner.

ii. The findings of the study would provide necessary feedback to the players, coaches and experts of penalty corner regarding their existing methods of execution of penalty corner.

iii. The findings of the study would go a long way in capitalizing the chance of goal scoring of our team India at international competitions.

iv. The findings of the study would benefit the budding penalty corner experts who could be best groomed from very beginning of their learning process to develop a flawless motor habit by using the principles derived from the present analytical study.

v. The findings of the study would offer new choices, new set plays and offering more possibilities to convert a goal from penalty corner.

vi. The biomechanical analysis of various movements involved in the process of taking penalty corner would explore the short coming and strength in the movement variations of specific team which helps to understand and justify the appropriate movement execution and techniques.

vii. The outcomes of the present analytical study of penalty corner can be used as guideline to enable coaches and others to train and guide their teams and players to success.
viii. The analysis of the technical aspect of skill movement which is involve in the execution of penalty corner would help players to integrate the technical and tactical components of the sport and in so doing invigorate their needed sports skills.

ix. The analysis of technical aspect would offer hope to understand the need of technique level to be a penalty corner specialist, because the research would unfold the technical aspect of penalty corner experts in respect to the position.

x. The biomechanical analysis of penalty corner execution in field hockey would provide a strategic functional guide to the players as well coaches to achieve efficiency during penalty corner execution.

xi. The study would be provide a reliable functional biomechanical manual or guide for hockey players and coaches to assess the performance of any hockey team or player and draw a particular training programme for a hockey team or player regarding penalty corner execution.

xii. This study would equip the player as well as trainers and coaches to get the maximum advantage of mechanical aspects in the penalty corner drag-flick execution.