Chapter - I
INTRODUCTION

The world of sports has a special place in the human society. It is an exhilarating source for enjoyment and recreation for people from different crossections of the society. Starting from the days when muscle strength was a major source of motive power, the physical and mental prowess have been challenged in the sports arena. History tells us that in some cases, these challenges ultimately led to competitions among men and sometimes between men and animals. Winners in the sports field have always been bestowed with the best honours in the society. Hero worship in fact started in the field of games and sports.

Inventing new games and sport forms has been one of the most creative activities in the human history. Through various games and athletics, the strength and enduring power of each muscle, sub-system and physiological faculty in the human body has been put on test. The world of sports has given the human kind an even playing ground for comparing each physical parameters of the human body with the best.

In course of time, however, the personal challenges in the area of sports have slowly but inexorably grew into group challenges and further into national challenges. The drive to win received support of the highest order. Nations aspiring to do well in sports, embarked upon a scientific quest for identifying and analyzing the key reasons responsible for excellence in any form of games or sports. These became priority research areas of national importance. For the last few centuries, the
human physiology for fitness or athletic prowess has been very seriously looked into with a purpose to find out and understand factors that improve performance in sports.

In the world of sports, records and scores are not to be there to remain unsurpassed for long. They are usually broken in no time. It now appears to be axiomatic that records of performance and human endurance will go on registering new heights in the days to come. It is now established that ranking in international sports is an index to a nation’s development.

The amateur world of sports which retained its character as a source of recreation for a long time, has for the last few decades turned into a perform-or-perish war field of professionals. The enormous amount of money being pumped into different tournaments has lured thousands of sports persons to turn professionals. It has also changed sports in the competitive arena from a source of sheer pleasure for the participants to a grinding do-or-die activity that requires individual performance level maintained at its peak.

Improvement of records in the Olympic games during the last few generations has been spectacular. It would be satisfying to conclude that this was all the result of scientific studies of sport. However, we know this is not true. An increase in world population in itself increases the probability that more people will be born with outstanding athletic talent. Some of the improvement in performance may be ascribed to more widespread and efficient recruitment so that now a boy or girl with athletic talent is much more likely to be discovered, and at a younger age.
The rising standards of living, particularly in developing countries must also be responsible for some of the improvement in world records. With a higher standard of living has come more widespread sports participation and hence athletically talented people are likely to be identified.

Field hockey is a sport with a long history that has undergone quite rapid and radical changes within the past two decades. Today hokey is essentially a team game and has developed into a fast and highly skillful one. The game includes short bursts of speed with rest pauses or slow movements in between for a period of 70 minutes with a rest of 10 minutes in between two halves of 35 minutes duration. The players have to be very alert and active during the play. It is not only the speed of movement, but also the tactics of movement that counts. The player has to perform number of zigzag movements and straight runs with high speed, in accordance with the requirements of the game. Hockey like football involves positional play where the role of players is very specific. The speed of the ball requires the players to be alert, quick, agile and having well developed coordination, neuromuscular control and postural reflexes. The synthetic surface in hockey calls for speed, stamina and strength. A very high level of physical fitness is demanded of a player to exploit his individual skills to the full. The characteristics of modern hockey have been described as short duration attacks with fast crossing in the middle field, continuous free running of those players who are not in possession of the ball; constant changing of positions during attacks and very good physical fitness in speed, endurance, stamina and agility – the basis of modern hockey.\(^1\) Hockey is a team

sport in which positional play has a considerable importance. Team games are sports where size, shape, body composition and fitness all play an important part in providing distinct advantage for specific playing positions particularly at the highest levels of performance where there is a high degree of player specialization².

While hitting a ball with hockey stick or pushing forcefully, the body segments apply near - maximum force, and the amount of force that can be applied has strong influence on success. Strength is a basic element in several other components important to performance. Power is the basic element in maximum striking and sprinting. Increased strength causes increased ability to apply force. Therefore, if velocity remains constant, increased strength contributes to power. Strength contributes to agility, which is defined as the ability to change direction of the body and its parts rapidly. Agility is demonstrated in such activities as the dodging, shuttle run, zigzag run, and squat thrust. Agility is essential to good performance in field games (such as football, soccer, and hockey) and court games (such as basketball, tennis, volleyball and badminton). Changing direction requires adequate strength to overcome momentum, which tends to keep the body moving in the same direction. After the direction has been changed, strength (really power, of which strength is a part) is important in regaining momentum in the new direction. Agile movements are actions that are well co-ordinated, efficient, quick, accurate and reflect confidence. Being agile reduces the effort necessary to perform movements.

Most sports require some degree of hand strength. The obvious examples of sports that require strong grip strength include weightlifting, wrestling, and gymnastics. Many other sports such as baseball, tennis, football and golf require at least moderate grip strength. Weak grip may lead to failure in executing skills. While grip strength alone does not predict performance in athletics, periodic measurement of grip strength can be beneficial in terms of athletic performance and injury prevention. The muscles of the flexor mechanism in the hand and forearm create grip strength while the extensors of the forearm stabilize the wrist. The reasons for the testing of grip strength are to establish baseline data on athletes during prescreening physicals, screenings, and performance testing, to establish a baseline for periodization schedules in post season, to help personal trainers establish individual levels of physical fitness and before and after a periodized rehabilitation program for the upper extremity.

Running is an athletic event by itself and is also important in other athletic activities. Strength is important to running speed, which is basic to performance in many activities. Actually, running speed is closely related to power because running is a series of body projections made alternately from the right and left feet. In running, the body is thrust forward by the force of body levers pushing against a resistive surface. Increased strength will cause increased force, which will improve running speed. Running is accompanied by a successive loss of balance of the extremity.

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alternate feet. Each balance loss is followed by a newly established base of support and then regaining of balance. Swinging of arms during running although transfer a limited momentum but the main purpose of arm swings is to provide the balance. It is therefore very clear that the players should be able to run fast with a stick in their hands without losing their balance.

In many sports, body composition is important for optimal physical performance. Generally, a relatively low body fat is desirable to optimize physical performance in sports requiring jumping and running. A large muscle mass enhances performance in strength and power activities. Because of these performance-related implications, coaches, parents, exercise scientists, sports medicine specialists, and of course the athletes themselves have an interest in body composition. Typically, athletes and physically active individuals are leaner than sedentary individuals, regardless of gender. However, female athletes have relatively greater body fat than male athletes in a given sport, and the average body fatness depends on the type of sport and the athletes’ position.

In addition to establishing physiological profiles and identifying the body composition characteristics among elite athletes within a specific sport, body composition data for athletes are useful in a variety of ways. The data can be useful

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for tracking changes in an athletes’ body composition to monitor the effectiveness of a training or dietary regimen, estimating an optimal body weight or competitive weight class for certain sports, such as wrestling, boxing, and body building and screening and monitoring the health status of athletes to detect and prevent disorders associated with excessively low body fat levels.

Because fat mass does not contribute to force production and because excess body fat makes it more difficult to move one’s body mass, a low body fat is generally considered advantageous in most sports. However, very low body fat can result in serious health complications, and some athletes turn to unhealthy behaviours in an effort to achieve a more desirable body composition. Body composition assessment can be a beneficial tool to screen athletes at risk for disorders associated with low body fat, to safely and effectively monitor athletes as they progress through diet and training programs, and to help athletes set and reach realistic body weight and body composition goals.

Physical activity and exercise training result in moderate weight loss, moderate–to–large losses in body fat, and small-to-moderate gains in Fat free mass. The degree of alteration in body composition depends on the mode of exercise, as well as the frequency, intensity and duration of training. In general, athletes have greater bone mineral content (BMC), bone mineral density (BMD) and FFM and a

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lower percent body fat than non athletes\textsuperscript{10}. Numerous studies show that females participating in high – impact activities have bone mineral densities significantly higher than those of non athletic women\textsuperscript{11,12,13,14,15}. Generally, these are modest increases (2-6 percent), but research also showed that the average bone mineral density of the United States Olympic Women’s field hockey team and elite female heptathletes was 13 to 14 percent greater than age – and race – matched bone mineral density reference values\textsuperscript{16,17}. Additionally, lumbar bone mineral density significantly increased (0.017g/cm\textsuperscript{2}) following 27 weeks of gymnastics training. Likewise, weight – trained men exhibited greater bone mineral density and fat free.


mass than controls\textsuperscript{18}.

In terms of technical development there are two areas of change that have affected the physiological requirements of the game. These are the hockey sticks and the playing surface. Advances in stick construction, over the past two decades in particular, have allowed players to reach greater levels of ball control and have also increased their hitting power\textsuperscript{19}. The crook of the stick has become much tighter and smaller in the more recent years, giving rise to the improvements in ball control. The physical properties of the stick have also changed, from sticks constructed purely of wood to sticks that are amalgams of wood and man-made materials such as Kevlar and aluminium. These changes have increased the rigidity of sticks, thereby allowing greater pace to be imparted to the ball since less energy is lost at impact in the vibration of the stick. It is now possible to attain a greater velocity on shot and pass with the same level of muscular work.

The playing surface may also have an influence on the severity of the physical and physiological strain on players. Adoption of synthetic surfaces at the 1976 Olympic Games and at all major international tournaments helped to increase the playing times and decrease the number of interruptions which was not the case


before 1976\textsuperscript{20}. Synthetic surface characteristics are more consistent over the whole playing area and the ball travels with greater pace. Both of these factors have caused changes in the style of play at an individual and a team level that can be reasoned to have affected the physiological requirements of the game\textsuperscript{21}. The playing changes that have been induced by the introduction of synthetic pitches all require of the modern player a greater level of all-round fitness. According to Malhotra and associates\textsuperscript{22}, higher physiological responses were associated with the artificial pitch, mean \( V_E \) being 56.8 vs 46.6 L/min and mean \( VO_2 \) being 2.26 vs 1.91 L/min. The \( VO_2 \) values would correspond to energy expenditures of approximately 46.5 kJ/min (11.1 kcal/min) and 39.3 kJ/min (9.4 kcal/min) for the artificial and grass pitches respectively. The higher physiological stress of playing on the synthetic pitch was due to the faster pace of play and higher running speeds.

The evolution of playing formations within hockey initially followed the same pattern as in soccer. The classical 2 : 3 : 5 formation dominated tactical thinking for decades until the mid-1960s when a sweeper system was introduced into play in West Germany. Since the mid-1960s the game has become more varied and dynamic in the formations that are used, the most popular system being 1 : 3 : 3 : 3, 1 : 3 : 2 : 4 and 4 : 2 : 4. In the early investigations of female hockey players, physique and muscular function were shown to differ between playng


\textsuperscript{22} Ibid
positions. Forwards require a more muscular physique because of the greater speed, power and strength necessary in attacking play\textsuperscript{23}. Somatotype is important in differentiating between players in various positional roles, particularly at higher levels of competition for women\textsuperscript{24}. There was a tendency for all players towards mesomorphy, but backs and halves tended to be more so inclined than forwards. Backs as a group had higher endomorphy ratings than halves or forwards and lower ectomorphy ratings. This somatotype profile would render them the less mobile but the more robust of the outfield players. Indian male players were examined for differences between playing positions\textsuperscript{25}. Goalkeepers were highest in vertical velocity in a stair run test and had the highest anaerobic power output. The poorer scores were for forwards, on both measures, backs and halfbacks being intermediate. In examining the issue of positional requirements one must bear in mind that the increased introduction of synthetic surfaces, together with the natural evolution of the game, has significantly altered systems of play.


In the field invasive games such as hockey, the skill requirements and postural stress are superimposed on the work-rate demanded by the game and its pattern of play. This is accentuated in players as they dribble the ball or move in a semicrouched posture. This position of the spinal flexion has been described as an ergonomically unsound position for fast locomotion. It may be implicated in risk of back injury\textsuperscript{26}. A biological effect of the postural stress during hockey play and practices is at the level of the intervertebral disc. Compressive loading of the discs causes them to lose height, water being extruded from the disc when the compressive load on it exceeds the interstitial osmotic pressure. The result is a change in the total body length, known as shrinkage\textsuperscript{27}. The rate of shrinkage is about four times that observed in running and almost twice that found in circuit-weight training\textsuperscript{28}. There are indications also that attention to training of back strength\textsuperscript{29} and flexibility\textsuperscript{30} may have a protective role to play in attenuating the risk of back injury to hockey players. Players have been shown to run faster on synthetic surfaces than on grass, partly because of the evenness of the surface\textsuperscript{31}. However the grass surface

\textsuperscript{26} N. Fox, Risks in Field Hockey : Sports Fitness and Sports Injuries, (London : Faber and Faber,1981), pp.112-117.

\textsuperscript{27} J.D.G. Troup et. al., “Changes in Stature with Spinal Loading and Their Relation to Perception of Exertion or Discomfort”, Stress Medicine, 1, (1985) : 303-307.


absorbs 10 percent more energy, contributing a greater cushioning effect on each impact with the ground. Additionally, turning is more difficult on a synthetic pitch\textsuperscript{32}. Thus, the synthetic surface might have a greater risk of injury during hockey play. Soft tissue injuries were found to be more frequent on Astroturf and joint injuries more frequent on grass\textsuperscript{33}. With the introduction of synthetic surface in hockey, the game has become very demanding. The synthetic surface unlike grass does not contribute much cushioning effect on each impact with the ground and this may be the reason for overall more soft tissue injuries.

The task of the players at all positions viz, goalkeepers, fullbacks, halfbacks and forwards is well defined and they have to display proficiency of fundamental skills and physical fitness.

A goalkeeper can do a lot for the teams’ morale. He is the backbone of the team. Goal keeping is described as a highly specialized position and any one who chooses to play in the goal should possess qualities such as reaction time, strength, agility, flexibility, courage and confidence.

The fullbacks offer a security which is of paramount importance in safeguarding the prestige of the team. In defense, the over – riding aim is to stop the opponents from scoring. A fullback therefore, has to be tall so that it is easy for him to tackle, intercept or clear the ball.


The halfbacks form a link between the attackers and fullbacks. They support both in attack and in defense. In the attack, they almost close down to the opponents’ 25 yards area and in defense, they are almost closer to the baseline, which means that they have got to do almost 75 yards of running in attack as well as in defense.

When a team regains the possession of the ball, they may find their opponents over stretched and vulnerable. The urgent need is then to get the ball into the build up area. An attack aims at entering the goal mouth of the opponent and trying to make an attempt to score. One who plays a match aims always to win the match. For this, the forward hockey players have to constantly attempt to enter the opponents’ shooting circle and try to score as much number of goals as they can. The forwards need to have a good physique, agility and speed to penetrate into the opponents’ shooting circle.

Hockey is our national game. In the past India has ruled the world of hockey till 1964 Tokyo Olympic Games where India defeated Pakistan by 1-0 to clinch a first place. However, with the advent of synthetic surface and change of rules we have unfortunately not tasted a major victory in recent major international competitions barring 1980 Moscow Olympics (marred by widespread boycotting of the games) and 1998 Bangkok Asian Games.

India is a developing country with a population of more than 100 crore people. Fortunately, the economic, nutritional, social, per capita income and overall
standard of living are on the rise. Therefore, there should be no reason for us to perform less at international levels. Why success in hockey in our country be seen as an exception and not as a rule? Why should we have a national atmosphere of defeatism, pessimism, despair, fatalism, a lack of trust and terrible, terrible intrigues? Nothing should hamper our prospects in the international arena. The Indian Hockey Federation (IHF) is taking active interest towards building of good teams at junior and senior levels. Round the year, camps are held followed by adequate international competitions. It is the prime duty of researchers to share hands with the players, coaches and promoters of the game to go into the minute aspects of the game more scientifically. Over the years, different researchers in India and abroad have contributed in their own way. However, much more needs to be done at junior level along with their senior counterparts. Junior Indian players have been consistently doing well internationally. We have to find out why the same juniors are not able to display equally convincing hockey at senior level when they reach that stage. Technically speaking, at that time the promoted juniors are supposed to possess better qualities than the junior players because they have spent more number of years in training and their training age is more.

Taking into consideration all the above points, the research scholar has taken the comparative study on morphological characteristics and motor abilities of Indian elite male hockey players at different positions and levels.
Statement of the problem

The purpose of this study was to compare the morphological and motor abilities of Indian male junior and senior hockey players at different playing positions.

Delimitations

1. A total of 222 male national level hockey players were selected as subjects.

2. Out of 222 players, 106 were seniors and 116 were junior players. Senior players comprised of 21 goalkeepers, 23 fullbacks, 31 halfbacks and 31 forwards. The junior players comprised of 23 goalkeepers, 21 fullbacks, 36 halfbacks and 36 forwards.

3. The subjects were selected from the national level coaching camps conducted at different centres of Sports Authority of India for international competitions.

4. The study was delimited to the following morphological variables.
   a) Height
   b) Weight
   c) Percent body fat
   d) Lean body mass
   e) Somatotype
5. The study was further delimited to the following motor ability variables.
   
a) Back strength
b) Grip strength
c) Explosive strength
d) Speed
e) Agility

6. The study was delimited to four different positions viz, goalkeepers, fullbacks, halfbacks and forwards in both Junior and Senior levels.

**Limitations**

1. Non availability of sophisticated instruments for measuring the body composition and motor abilities was considered as one of the limitations for the study.

2. Factors such as socio-economic status, dietary habits and geographical variations etc. which might have affected the morphological variables were not taken into consideration, which was considered as another limitation.

3. No special motivational techniques were used while conducting the tests for motor abilities was considered another limitation.
**Hypotheses**

1. There would not be any significant difference in height among the players of different positions in senior and junior category.

2. There would not be any significant difference in height between senior and junior hockey players of different positions.

3. There would not be any significant difference in weight among the players of different positions in senior and junior category.

4. There would not be any significant difference in weight between senior and junior hockey players of different positions.

5. There would not be any significant difference in percentage of body fat among the players of different positions in senior and junior category.

6. There would not be any significant difference in percentage of body fat between senior and junior hockey players of different positions.

7. There would not be any significant difference in lean body mass among the players of different positions in senior and junior category.

8. There would not be any significant difference in lean body mass between senior and junior hockey players of different positions.
9. There would not be any significant difference in the endomorphic component of somatotype among the players of different positions in senior and junior category.

10. There would not be any significant difference in the endomorphic component of somatotype between senior and junior hockey players of different positions.

11. There would not be any significant difference in the mesomorphic component of somatotype among the players of different positions in senior and junior category.

12. There would not be any significant difference in the mesomorphic component of somatotype between senior and junior hockey players of different positions.

13. There would not be any significant difference in the ectomorphic component of somatotype among the players of different positions in senior and junior category.

14. There would not be any significant difference in the ectomorphic component of somatotype between senior and junior hockey players of different positions.

15. There would not be any significant difference in back strength among the players of different positions in senior and junior category.

16. There would not be any significant difference in back strength between senior and junior hockey players of different positions.
17. There would not be any significant difference in the right grip strength among
the players of different positions in senior and junior category.

18. There would not be any significant difference in the right grip strength between
senior and junior hockey players of different positions.

19. There would not be any significant difference in the left grip strength among the
players of different positions in senior and junior category.

20. There would not be any significant difference in the left grip strength between
senior and junior hockey players of different positions.

21. There would not be any significant difference in agility among the players of
different positions in senior and junior category.

22. There would not be any significant difference in agility between senior and
junior hockey players of different positions.

23. There would not be any significant difference in the explosive strength among
the players of different positions in senior and junior category.

24. There would not be any significant difference in the explosive strength between
senior and junior hockey players of different positions.

25. There would not be any significant difference in speed among the players of
different positions in senior and junior category.

26. There would not be any significant difference in speed between senior and junior
hockey players of different positions.
Significance of the study

1. This study may be helpful in understanding the morphological characteristics and motor abilities of hockey players playing at different positions.

2. This study may be helpful in understanding the differences in morphological characteristics and motor abilities of senior and junior hockey players.

3. This study may contribute to the coaches and administrators in selecting suitable players at a particular position.

4. The results of the study may help the coaches in formulating appropriate training programmes for the development of motor abilities and body composition.

Definition and explanation of terms

1. **Aerobic** -- Activities such as running, cycling and swimming are termed aerobic because they involve the use of large muscles and depend on the body’s ability to use oxidative energy systems. Aerobic activities are characterized by continuous, rhythmical movement lasting for at least 15 minutes.

2. **Anaerobic** -- Activities such as weight-lifting, football and sprinting are described as anaerobic because they are usually performed at maximal intensity for a short time and are not dependent on oxidative energy systems.

3. **Anthropometry** -- Anthropometry means the measurement of man, whether living or dead, and consists primarily in the measurement of the dimensions of the body. Assessing the external body dimensions as reflections of body size, composition and shape. Commonly included in a set of anthropometric
dimensions are skinfolds, circumferences, skeletal widths, segment lengths, height and weight\textsuperscript{34}.

4. **Morphology** – Refers to the physical characteristics of the body such as age, height, weight and fat percent etc.

5. **Body Composition** – The amount of fat and lean tissue of which the body is composed. Lean tissue is primarily composed of bone, muscle, vital organs and connective tissue.

6. **Body Density** – It is defined as mass per unit volume i.e., \( D = \frac{M}{V} \). Body density is determined by dividing body weight by body volume (\( BD = \frac{BW}{BV} \)).

7. **Percent Body Fat** – The percent of total body weight which is composed of adipose tissue.

8. **Lean Body Weight** – Total body weight minus the weight of the body’s fat (both essential and storage fat) equals the lean body weight.

9. **Overweight** – Having weight in excess of normal. Not necessarily harmful if weight is lean body tissue.

10. **Motor abilities** -- Motor abilities are the conditional abilities of an organism which help to attain high level sports performance. They are strength, speed and endurance\textsuperscript{35}.

11. **Neuromuscular Parameters** -- Having to do with the timing and coordination of muscular activity\(^{36}\).

12. **Somatotype** -- Somatotype is a rating of body form, and is a general description of what the body as a whole looks like\(^{37}\).

13. **Endomorphy** - It is a measure of body fitness and is the first component, evaluated by measurement of the triceps, subcapular, and suprailiac skinfold thicknesses\(^{38}\).

14. **Mesomorphy** - It is a measure of muscularity and is a second component evaluated by measurement of height, bony width (humerous and femur), and circumferences corrected for skinfold thicknesses (i.e., arm circumference adjusted for triceps skifold and Calf circumference adjusted for calf skinfold)\(^{39}\).

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\(^{39}\) Ibid
15. **Ectomorphy** - It is a measure of proportionality between body weight and height and is the third component evaluated. The individual’s body weight and the ratio of height to the cube root of body weight are used for this purpose\(^{40}\).

16. **Agility** - It is defined as the ability to change direction of the body and its parts rapidly.

17. **Strength** – It is the ability of the body or a segment of the body to apply force.

18. **Speed** – It is the ability to cover large distance in less time.

\(^{40}\) *Ibid*