Chapter - I

INTRODUCTION

Sport is a cultural phenomenon of modern age. It is an international language without barrier. To get fit for sports is to get fit for life. The scientific knowledge and technical know how has revolutionized the standard of human performance in games & sports. The sportsmen of today are trained by scientific equipments, using highly sophisticated technology. Due to global research in this direction coaches, physical-education teachers and sports scientists are in regular search for better techniques for their trainees. For further success, great effort is necessary in technical education, as well as, in education of coaches, group leaders and officials, for promotion and spotting of young talent and in the spotting of new talent.

Sports serve vital social and cultural functions, the importance of which can hardly be exaggerated. The contribution of sports towards the overall welfare of the human society may be capsuled in the following points:

1. Sports help in all round development of human personality.

2. It provides ample and healthy means for recreation and relaxation of human mind and body.
3. It is effective for rehabilitation and social adjustment of the injured, sick and handicapped.

4. It provides opportunities for social interaction, thereby, fostering peace and understanding among different people, nations, races and religions etc.

5. It performs preventive and curative functions for several diseases and ailments inflicting human body and mind.

6. It provides healthy and socially acceptable opportunities for the people and nations to compete against each other, thereby, touching heights of excellence of human endeavors and attainment.¹

Physical Education seems to have taken a new turn in the form of sports science. The sports science, in turn, has taken birth from various basic sciences. For many years, the research in sports was being undertaken within the framework of these basic sciences. But with advancement of time, new specializations and microspecialization have taken a respectable position. As a matter of fact, the research in sports now-a-days embraces knowledge from various disciplines of human sciences.²

Track and field is the medium through which we develop the organic, neuromuscular, intellectual, social, cultural, emotion and aesthetic personality of the people of the world, since time immemorial. In the first place these exercises are directly connected with the productive and war like activities of man. They hold a major place in defence and in the provision of the essentials of life.  

In the last few decades sports have gained tremendous popularity all over the globe. The popularity of sport is still increasing at a faster pace and this happy trend is likely to continue in the future also. When one looks, at a history of modern Olympic games, one sees that the number of sports for which competitions are held at Olympic Games has increased steadily. In addition to Olympic games indigenous sports have also become popular in each country. Several new sports like sky – diving, skating, motor racing have also come into existence and are quite popular with the masses. The television and press are giving much more coverage to sports. Sports have become an important social and cultural activity of modern world which is being given the rightful place it deserves by the nations and societies of the world.  

The actual movement in the various events of track and field goes back to the effort of primitive man to survive with no truly effective weapons available. Primitive man had to develop speed of foot, muscular power and ability to jump and leap in order to evade his natural enemies, when not doing these things to save his own life it can be assumed that he practiced with his fellow men in order to improve his skills from such practice the idea of athletic competition may have emerged.⁵

Throwing is one of them which contributes in the development of motor ability, kinesthetic sense and body awareness. Stone and spear throwing were few of the events. While the modern world uses similar implements for sports competition i.e. javelin. Javelin as an implement is said to have originated from ‘spear’.

The art of throwing a spear as a sport was first introduced in the ancient Olympic Games as one of the events of the pentathlon in 708 B.C. The modern javelin used in Olympic and National competition throughout the world is a spear of wood or metal with a sharp metal point. Javelin throwing was first included as an Olympic event in 1906 interim Olympic Games held at Athens. The first Olympic winner was Erik Lemming of Sweden. He was followed by Jonni Myrca of Finland in 1920 and 1924. It can be said that there has really not been any dramatic change in the

overall execution of javelin throwing techniques since 1906. The only really dramatic incident in the long history of the event was brought about by Spanish athlete named Migeul Salcedo who threw 300ft in 1956 with the phenomenal discus type turn and throw method. The throw was executed in an under arm slinging action with the implement held on the shaft behind the grip cord. The shaft was greased so that it slipped along the hand when it was released with a discus type turn and release. This style was not accurate and proved to be dangerous to the spectators, officials and fellow participants, as there was no certainty about the direction of its flight, the modern technique has been termed as the front facing style.⁶

This event is the only one of the throws that uses a runway (about 30 m long) rather than a ring for the approach. On his approach the thrower runs down the runway carrying the Javelin at about shoulder height just before reaching the foul line, he alters his step pattern and turns so that the non throwing side is in front of the one with the implement. He makes a half – turn back toward the throwing area and follows through as the throw is executed.

The Javelin is not required to stick in the ground as it comes back to earth, but the point must come down first. It must land within a 30 degree sector. Throwers from Scandinavian countries have played a major role in this event. In the women's event, the all-around athlete Mildred Didrikson won the first Olympic championship in 1932. Among women Javelin throwers, 200 feet is on a par with 300 feet for men.\(^7\)

A Javelin is gripped with the thumb and middle finger just behind the cord. Top Javelin throwers keep the non throwing arm straight in front of the body to counter the natural rotation of the trunk during release and follow-through. A straight arm pulling towards the body is much more effective at limiting rotation than a bent arm. Because Javelin throwers are allowed a run up this is the one field event where size is not necessarily an advantage. Jan Zelezny, who set a world record in 1996, was rather long and lanky.\(^8\)

The Javelin throw is an overhand throw. Its technique is difficult to learn because of the length of the implement. The beginner should therefore be allowed to learn the sequence of movement under simplified condition. The release movement is almost identical with a long throw with a cricket ball or a club, the use of these or similar implements in the

preliminary exercise will accelerate the learning process, mastering the overhand throw with these implements should be the first aim of the beginner. By comparison with other throwing events, the javelin throw requires less maximum strength, but a lot of explosive force, agility and mobility. The two latter attributes are frequently underrated in learning the event. The importance of agility is particularly marked in the performance of boys and girls throwing a cricket ball. The best results are here not always achieved by the strongest and toughest, but by throwers possessing excellent agility and flexibility. In the Javelin the proportional change in favour of strength, but agility and flexibility remain valuable attributes of the Javelin thrower⁹.

The science of biomechanics is concerned with the forces that act on a human body and the effects these forces produce. Physical education teachers and coaches of athletic teams, whether they recognize it or not, are likewise concerned with forces and effect. Their abilities to teach the basic technique of a sport or physical activity depends very largely on their appreciation of both the effects they are trying to produce and the forces that cause them. It seems only logical therefore that

physical educators, coaches and athletes should turn to biomechanics to provide a sound, scientific basis for the analysis of the techniques.\textsuperscript{10}

Biomechanics is an applied form of mechanics, and consequently the methods used to investigate it must be derived from those of mechanics. However, Biomechanics have not developed in the wake of mechanics but as a bordering science in other scientific disciplines such as Anatomy, Psychology, and the technique of sport\textsuperscript{11}.

Kinematics is that branch of biomechanics that is concerned with describing the motion of bodies. Thus kinematics deals with such things as how far a body moves, how fast it moves and how consistently it moves. It is not concerned at all with what causes a body to move in the way it does. This latter aspect of motion is the preserve of kinetics – a complementary branch of biomechanics.

Linear kinematics deals with the kinematics of translation or linear motion, while angular kinematics deals with the kinematics of rotation or angular motion\textsuperscript{12}.


The application of modern science and technology to sports is an effort to analyse and improve performance and is not a new idea. These efforts command little attention until a number of small innovative countries begin to organize programmes dedicated to the scientific development of Olympic athletes. The world of sports then became intrigued with the sports science areas of bio-mechanics, physiology, sports medicine and sports psychology and the application of practical methods including carbohydrate loading, blood doping, slow analysis attitude training, relaxation techniques and numerous others. There was a sudden realization that sports sciences offered the key to athlete domination.\textsuperscript{13}

Usually, cinematography is the technique most frequently used in sport biomechanics research for obtaining a record of human movement. These film records are quantitatively analyzed to obtain linear and angular displacement time data for total body or segmental movements. Typically, the basic displacement time functions of a motion do not provide sufficient information to described the activity fully. Thus, these data are further treated mathematically to determine the respective velocity and acceleration functions\textsuperscript{14}.

\textsuperscript{13}Ralph Mann, "The Elite Athlete, Project Sprints and Hurdles", \textit{Track Technique} 51 (December, 1983), p.2672.

It is further to be mentioned that sports biomechanics is more widely understood in the sports community and the demand for service is increasing. Researchers in sports biomechanics will have to consider carefully how much time they can devote to the provision of scientific services without impairing their performance as scholar researchers. To avoid the problems inherent in this situation, it may be necessary to develop programmes of study for the training of technicians in sports biomechanics; technicians who can provide the kind of services sought by sporting bodies.\(^{15}\)

Through continuous biomechanical research, as well as, through the vast experience of many throwing event coaches, it is now evident that each throwing event has a typical structural rhythm in the course of executing the movements. The rhythm structure of a top level Javelin thrower can be determined by examining the relationship between the last strides in the run-up with the final result in terms of distance achieved in a throw. Crucial factors that heavily influence the movements of the upper body segments, as well as, the release phase, and thus, the final result of the throw are the length of the last stride, duration of the last strides, frequency of the last stride in spite of the higher rate of frequency

during the last strides. There is typically short time duration in the last stride before the implements release. This fact has unearthed the existence of three peculiarities in the technique used currently by top level Javelin throwers.

1. There is the need for developing an optimum bend of the right knee joint, which must be maintained until after the left leg touches down for the release stride.

2. The right leg must not be extended at the knee joint by thrusting it forward too early, as this will not allow the velocity of the lower segments to be transferred to the upper body segments in a coordinated chain-link action at the right moment in executing the release actions.

3. It is important that the throwing hand is in a vertical plane with the planted left foot at the instant of release of the Javelin. This will ensure that there has been no unnecessary early use of the throwing shoulder and arm before the pelvis has completed its contribution to the transmission of velocity from the lower body segments to the upper segment of the body and the implements.¹⁶

The Javelin is a speed event. Force can be applied to the Javelin only when the left foot is planted firmly during the "block". Speed into the

block is accomplished most rapidly by maintaining the trunk in an erect posture during the run up and cross-steps while the hips are thrust forward, the trunk is kept erect and the shoulders are tilted slightly down word - i.e., the right shoulder is held higher than the left, and the left arm is swung low across the chest for balance. Thus, the center of balance is kept over the hips, without the trunk layback seen in other styles. This way, speed is better maintained and the left foot is grounded more quickly into the block or plant. The shoulders are kept “closed” with the thrower looking over the left shoulder at a point about 50 meters away. 17

In general, the “NEW” javelin throw events calls renewed athleticism. The New javelin essentials today are:

1) A natural run
2) Diminished layback
3) A run rather than a leap against the block
4) A straight strike

This strike will require the flexibility of a back stroke swimmer to be successful and will be achieved with alignment discipline, an alignment that, for simplicity’s sake, should be straight. The Javelin

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throw, for men and women alike, has regained its place as a legitimate event.\textsuperscript{18}

Study compares javelin release characteristics performed by one Croatian athlete with those performed by the best male throwers in the 1992 Olympic games in Barcelona. The achieved results have shown significant differences in numerous parameters: javelin release angle, release velocities, knee and elbow angle, grip distance, as well as differences in timing of peak joint centers speed. Since those technical short comings, significantly influence the distance of the throw, they should be corrected during the training process in order to increase the distances.\textsuperscript{19}

On the surface the technique of elite javelin throwers appears similar. This is evidenced by the comparable run - up speed and carry position for the 12 throwers. In this study, a deeper analysis shows that differences do occur in throwing styles, particularly in the delivery, although, the limited duration of this phase makes it very difficult for the athlete to modify his delivery technique, subtle differences in style can have important implication for an athlete's posture prior to final foot plant, for strength training methods and predisposition to injury, for instance the


throwing style of Backley place great demands upon the strength and flexibility of the shoulder joint musculature. The style of Zelezny or Wennlund may, however, demand greater priority on the elbow area. To provide fuller explanations of such issues, analysis of a large number of throws of each athlete would contribute greatly to the understanding between the movements of the thrower and the distance he ultimately achieves.  

At the beginning of the final contact phase, height of the body’s center of gravity decreased only after a period of 56 - 63 ms from the beginning. It started to increase simultaneously, with this increase (78 – 79 ms), potentiation through stretch – shortening cycles may have occurred and peak joint center speed occurred in sequence from proximal to distal segments and finally to javelin at release, 135 -141 ms After the beginning of the final foot contact phase both men’s and women’s grip of javelin and body center of gravity moved along a curved pathway to the right from the left (bracing) foot during the final contact. This movement pattern may demand that the athlete should have a high strength level to control the centripetal force and thus produce a high resultant release speed.  

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The Olympic trials in 1988 at Indianapolis produced some interesting principles for throwers:

1. All body parts that can be involved, are involved in the throw.
2. The throwing action begins from the center out wards from big / slow / strong muscles to smaller / faster / weaker ones.
3. Apply forces in the direction of the intended motion.
4. Apply force over the longest range of motion.
5. The body weight is transferred from the rear to the front leg.
6. The center of gravity must remain over the base during the application of force.²²

Throwing a Javelin to obtain maximum possible distance is a complex activity and one that is physically very demanding on the body. Furthermore, contrary to popular opinion, it is a leg and a total body activity rather than just an arm throw. Slight deviation in correct mechanics can detrimentally affect the distance obtained and greatly increase specific stresses on the joints, ligaments and tendons. To maximize potential today’s Javelin thrower needs to combine and blend a combination of speed, strength, coordination, flexibility, good throwing arm, kinesthetic sense or feel for the javelin. In addition to throws, for the thrower must learn to relax and "let things happen" instead of trying to

force to throw by “ arming it.” Besides throwing the Javelin in practice and working hard in the weight room jump like activities like hopping/bouncing are absolutely essential for developing the tensile strength and resiliency required in the lower body. Throwing balls, medicine balls and other related objects with one and or both hands are also a high prerequisite for developing specific throwing power. In addition, some combinations of activities such as gymnastics or ballet are necessary for increasing coordination, body awareness, dynamic flexibility and balance.\textsuperscript{23}

Swedish Javelin throwers have over many years regularly used physical capacity test to monitor their development. The test battery is made-up from the following:

1. The forward over the head shot (5.5/3kg) throw with two arms from a stepping forward position.

2. The standing triple jump from a double – legged take–off.

3. The backward over the head shot (7.25/4kg) throw with two arms from a standing position. The athlete can land on high jump pads for security.

4. The sargent jump (vertical jump from a standing position).

5. The snatch performed according to the normal weightlifting rules.

6. The 30 m. sprints from block, using electric timing to 1/100 sec accuracy. The timer is started when the lead foot strikes the track.

7. The shoulder flexibility test with a Javelin. The Javelin is brought with straight arm over the head to touch the back. The distance between forefingers decides the results.

The tests are completed in one session. The number of attempt allowed in each test is unlimited. The tests are conducted two to five times a year to allow coaches and athletes to evaluate the effect of training.\textsuperscript{24}

Margaret Whitbread prescribe technique check list:

1. Firm contact with the grip of the Javelin with palm upward at moment of release.

2. The point is close to the head.

3. The legs are working powerfully forward.

4. In the cross – step, the left leg is brought forward quickly so that the left leg has passed the right noticeably before the right touches the ground. (This causes the left leg to touch the ground more quickly).

5. The leg and feet drive forward and from this lean - back is achieved quickly.

\textsuperscript{24}Anders Borgstrom, "Physical Capacity Test for Javelin Throwers's" \textit{Track Technique}, 119 (Spring (1992) : 3809.
6. The trunk and knee must turn quickly and early enough (while leaning).

7. By turning the hip early, the angle of the torso will be made smaller, and the torso, as well as, the hand and the arm will move forward and upward.

From a standing position, the beginning position is with the left foot off the ground, the left ribs and left side of the torso facing the direction of the throw. Both the hands are held shoulder high. The thrower begins by turning the trunk as the left foot touches the ground. While the trunk is turning, you must turn the right knee and right instep in the direction of the throw while turning the hip, the arm pull is coordinated in such a way that the elbow must rise above the shoulders.\textsuperscript{25}

Most of the technique has been developed by teachers, coaches and athletes by trial and error method to improve the performance. New techniques have also been developed as a result of scientific analysis. Sports scientists are concerned with to find out the ideal technique of Javelin throwing to be more specific and to find out various physical and biomechanical variables, which may be considered as contributory for top class performance. Several studies are being conducted on Javelin throw in foreign countries but in India no efforts have been made in this

\textsuperscript{25} Margarete Whitbread, “Biomechanics of Javelin Throwing”, \textit{Track Technique} (Summer 1983): 2712.
direction. Keeping this view researcher worked to study the structure of Javelin throwing technique from biomechanical point of view.

**Statement of the Problem**

The purpose of the study was to determine the relationship of selected physical and kinematic variables with the performance of Javelin throwers.

**Delimitations**

1. The study was delimited to 50 male and 50 female Javelin throwers of university level.
2. The study was further delimited to the male / female Javelin throwers who have attained the performance level of 45 meters and 30 meters respectively.
3. The study was also restricted to the following physical and kinematical variables.

**Physical Variables**

1. Age
2. Height
3. Weight
Kinematical Variables

1. Length of third stride
2. Length of impulse stride
3. Length of final stance
4. Length of Reverse stride
5. Height of Center of Gravity of the body at final stance
6. Height of Center of Gravity of the body at moment release
7. Height of Release

Angular kinematical variables

1. Angular kinematical variable at final stance
   i. Ankle joint
      a. Angle of Right ankle joint
      b. Angle of Left ankle joint
   ii. Knee joint
      a. Angle of Right knee joint
      b. Angle of Left knee joint
   iii. Angle of Right Hip Joint
   iv. Trunk Inclination
   v. Angle of Right Elbow Joint (Throwing arm)
2. Angular kinematical variable at moment release
i. Ankle joint
   a. Angle of Right ankle joint
   b. Angle of Left ankle joint

ii. Knee joint
   a. Angle of Right Knee joint
   b. Angle of Left Knee joint

iii. Angle of Right Hip Joint

iv. Trunk Inclination

v. Angle of Right Elbow Joint (Throwing arm)

**Limitations**

1. Non-availability of Sophisticated Instruments was considered as limitation of the study.

2. Weather, Climatic Conditions and life style which might have affected the performance of the subjects were other limitations.

3. Absence of motivational device, daily routine and dietary habits were also considered as limitations of the study.
Hypothesis

It was hypothesised that there may not be significant relationships of selected physical and kinematical variables with the performance of Javelin throwers.

Definitions and Explanation of the Terms

Kinematics

1. Kinematics is that branch of biomechanics that is concerned with describing the motion of the bodies, thus kinematics deals with such things as how far a body moves, how fast it moves and how consistently it moves.\textsuperscript{26}

2. Kinematics analyse motion in terms of time, displacement, velocity or acceleration\textsuperscript{27}

3. Angular kinematic deals with the kinematics of rotation or angular motion\textsuperscript{28}

Physical Variables

\textsuperscript{28} Hay, \textit{The Biomechanics of Sports Techniques}, p. 13.
Physical variables refer to measurement of body, its segments and strength variables

**Significance of the Study**

The study may be significant in the following ways:

1. The study may reveal the relationship of selected physical and kinematical variables as predictors for the performance of Javelin throwers.
2. The result of the study may be helpful for physical education teachers and coaches in order to frame the training schedule effectively.
3. The result of the study may be helpful for preparing a model of technique.
4. The finding of the study may be helpful for talent identification.