CHAPTER -1
INTRODUCTION

Research in common parlance refers to a search for knowledge. Once can also define Research as a scientific and systematic search for pertinent information on a specific topic. In fact, Research is an art of scientific investigation. The Advanced Learner’s Dictionary of Current English lays down the meaning of Research as “a careful investigation or inquiry especially through search for new facts in any branch of knowledge.” Redman and Mory define Research as a “systematized effort to gain new knowledge.” Some people consider Research as a movement, a movement from the known to the unknown. It is actually a voyage of discovery. We all possess the vital instinct of inquisitiveness for, when the unknown confronts us, we wonder and our inquisitiveness makes us probe and attain full and fuller understanding of the unknown. This inquisitiveness is the mother of all knowledge and the method, which man employs for obtaining the knowledge of whatever the unknown, can be termed as Research. (Kothari, C.R. 2004).

Research is undertaken within most of professions including Physical education and Sports. More than a set of skills, Research is a way of thinking: examining critically the various aspects of your day-to-day professional work; understanding and formulating guiding principles that govern a particular procedure; and developing and testing new theories that contribute to the advancement of your practice and profession. It is a habit of questioning what you do, and a systematic examination of clinical observations to explain and find answers for what you perceive, with a view to instituting appropriate changes for a more effective professional service. (K. Ranjit; 2011). The History of sports biomechanics is partly the history of kinesiology. The word kinesiology was first used in the late 19th century and become popular during the 20th century, where the word biomechanics did not become popular until the 1960s. The roots of the word kinesiology give it definition as the study of movement, but in its present day usages, kinesiology is defined as the study of human movement. For many years, the term kinesiology was used to describe that body of knowledge concerned with the structure and function of muscular-skeletal system of the human body. Later the study of the mechanical principal
applicable to human movement because widely accepted as an integral part of kinesiology. Later still the term was used quite literally to encompass aspects of all the sciences that impinge in any way on human movement. (McGinnis, Peter M., 2005). At this point it became clear that kinesiology had quite lost its usefulness to describe specifically that part of the science of movement concerned with either the muscular-skeletal system or the mechanical principles applicable to human movement. Several new terms were suggested as substitutes and anthropomechanics, anthrokinetics, biodynamic, biokinetik, homokinetics, and kinathropology all had their proponents. Ultimately, there emerged one term that gained much wider acceptance than other. That term was biomechanics. (Uppal, A.K., 2009).

Biomechanics is the study of forces and their effects on living systems, whereas exercise and sports biomechanics is the study of forces and their effects on humans in exercise and sports. Biomechanics may be a useful tool for physical educators, coaches, exercise scientists, athletic trainers, physical therapists, and others involved in human movement. Application of Biomechanics may lead to performance improvement of the reduction and rehabilitation of injury through improved technics, equipment, or training. (McGinnis, Peter M., 2005). The internal and external forces acting on a human body determine how the parts of that body move during the performance of a motor skill. They determine, in short, what is commonly referred to as the performer’s technique. (Uppal, A.K., 2009).

If you are probably planning a career as a physical education teacher, coach, or other physical activity specialist, and you probably are or have been active as a participant in one or more sports or fitness activities. Suppose a student or athlete asks you, “Why do I have to do this skill this way?” or “why isn’t this technique better?” Perhaps you even asked such questions when you were a student or athlete. Was the coach or teacher able to answer your questions? Where you asked these questions? Could you answer them? Traditional teaching and coaching methods tell you why those techniques are best to teach or coach. Now focus on our specific topic of interest in biomechanics. Biomechanics includes the study of all living things, plants and animal biomechanics includes only animal as subjects of study; human biomechanics includes only human.’ and exercise and sports biomechanics includes only humans involved in
exercise and sports. We might be define exercise and sports biomechanics as the study of forces and their effects on humans in exercise and sports. (McGinnis, Peter M., 2005).

The laws governing motion indicate that motion is modified by a number of external environmental forces. Whether these forces are of help or these are hindrances, depends upon the prevailing conditions and the nature of motion. The problem in sports is to learn how to take maximum advantage of these external environmental forces under prevailing condition.

Ultimately, there emerged one term that gained much wider acceptance than any other. That term was biomechanics. The term biomechanics has been variously defined as:

“The mechanical bases of biological, especially muscular activity and the study of the principles and relations involved.” (Webster’s dictionary)

“The application of mechanical laws to living structures, specifically to the locomotor system of the human body.” (Donald Dic)

“The study of the structure and function of biological system by means of the methods of mechanics.” (Hervert hatze 1974)

“Biomechanics is the science concerned with the internal and external forces acting on a human body and the effects produced by this forces.” (James G. Hay)

A further and more restricted definition is offered here.

“Biomechanics may be defined as the science, which deals with the application of mechanical laws to living being especially to the locomotor system. The sports biomechanics may also be defined as the science, which examine the internal and external forces acting on the athlete and the athletic implements in use and the effects produced by these forces.”

A good knowledge of biomechanics will enable you to evaluate techniques used in unfamiliar sports skills as well as to better evaluate new techniques in sports that you are familiar with.
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Goles of sports biomechanics

Performance improvement: - The primary and ultimate goal of sports biomechanics is performance improvement in sports. Here performance improvement and injury prevention and rehabilitation are closely related together. Because an injured athlete will perform better than an injured athlete.

Technique improvement: - Coaches and teachers use biomechanics to determine what actions may improve performance. Coaches and teachers may use their knowledge of mechanics to correct actions of a student or athlete in order to improve the execution of a skill, or Researchers develop new and more effective techniques for performing a sports skill.

Equipment improvement: - How else can biomechanics contribute to performance improvement. The equipment worn may have an effect on the performance, either directly or through injury prevention. Beside shoes and apparel, many sports require the use of some sort of implement.

Training improvement: - An analysis of the technique deficiencies of an athlete can assist the coach and teacher in identifying the type of training of the athlete requires improving. Biomechanics has the potential of leading to modifications in training and thus improvements in performance.

Injury prevention and rehabilitation: - Some believe that injury prevention and rehabilitation should be the primary goal of exercise and sports biomechanics. Biomechanics can be used to provide the basis for alterations in technique, equipment, or training to prevent or rehabilitation injuries.

Analysis involves breaking something into smaller parts and then examining those parts. A qualitative analysis involves breaking into smaller parts than examining those parts without measuring or quantifying their characteristics. A qualitative biomechanical analysis of a movement or sports skill is thus breaking down the movement into its basic elements and then qualitatively examining those elements from a biomechanical perspective. Conducting a qualitative biomechanical analysis require you to use all the material, but not in a haphazard way. The approach may differ depending on the goal analysis. Is the goal to improve technique? To improve training? To prevent injury? To improve equipment. (McGinnis, Peter M., 2005).
Types of Biomechanical Analysis

The adjectives of qualitative and quantitative analysis describe how the characteristics of the performance are observed and analyzed by the coach, teacher, or clinician. If the performance or any of its aspects is qualified or measured (described with numbers), the resulting analysis based on these measurements will be a qualitative biomechanical analysis. If the performance or any of its aspects is evaluated using only the senses of the observer, the resulting analysis will be a qualitative biomechanical analysis. (McGinnis, Peter M., 2005).

Quantitative Biomechanical Analysis

Quantitative biomechanical analysts are mainly interested in improving performance and reducing injury risk. They use a mixture of experimental and theoretical approaches to seek answers to such questions as: What is the best running technique to minimize energy expenditure? How should the sequence of body movements be coordinated in a javelin throw to maximize the distance thrown? Why are lumbar spine injuries so common among fast bowlers in cricket? The quantitative experimental approach often takes one of two forms, usually referred to as the cross-sectional and longitudinal approaches. A cross-sectional study, for example, might evaluate a sports movement by comparing the techniques of different sports performers recorded at a particular competition. This can lead to a better overall understanding of the biomechanics of the skill studied and can help diagnose faults in technique. An alternative cross-sectional approach, which is less frequently used, is to compare several trials of the same individual, for example a series of high jumps by one athlete in a competition or in a training session. This is done to identify the performance variables that correlate with success for that athlete. In a longitudinal study, the same person, or group, is analyzed over a longer time to improve their performance; this probably involves providing feedback and modifying their movement patterns. Both the cross-sectional and the longitudinal approaches are relevant to the sports bio mechanist, although conclusions drawn from a cross-sectional study of several athletes cannot be generalized to a single athlete, or vice versa. Quantitative analysis will often involve the bio mechanist having to digitize a lot of data. This process of ‘coordinate digitization’ involves the identification of body landmarks used to aid the estimation of joint axes of
rotation. In videography, particularly in three-dimensional studies, this will normally be done by the investigator manually digitizing the required points using a computer mouse or similar device. Some video analysis systems can track markers in two dimensions, saving the investigator much time. Automatic marker-tracking systems, as their name implies, track markers automatically, and in three dimensions, although operator intervention may still be needed if too few cameras can see the marker during some part of the movement. Whichever way coordinate digitizing is performed, the linear coordinates of each digitized point are recorded and stored in computer memory. (Bartlett, R. 2007).

The cost of completing a Comprehensive Quantitative Biomechanical Analysis of a performance is high, so these types of analyses are usually done only for elite performance. The other reason Comprehensive Quantitative Biomechanical Analysis are usually limited to elite performers relates to the observer’s ability to direct errors. As the level of performance increases, the magnitude of errors in performance decreases. Errors made by novices are large and easy to detect visually using Quantitative Biomechanical Analysis techniques. With improved performance, the errors decrease in size and become more difficult to detect, and at the elite level, a Comprehensive Quantitative Biomechanical Analysis may be necessary to detect them. Quantitative Biomechanical Analysis are warranted in all of the above changes in the biomechanical variables being measured may be indistinguishable without special instruments. The movements occur too quickly to be readily perceived by the human eye, or the difference in position and displacement are too subtle to be noticed. In other cases, the biomechanical variables being measured may be too difficult for anyone other than the athlete (or patient or client) to perceive. (McGinnis, Peter M., 2005).

**Qualitative Biomechanical Analysis**

Qualitative research methods have been employed in anthropology, psychology, and sociology for many years. Thus general form of research has been called by various names, including ethnographic, naturalistic, interpretive, grounded, phenomenological, subjective, and participant observational research. Although the approaches are all slightly different, each “bears a strong family resemblance to others” (Erickson, 1986, p. 119). Teachers and coaches often perform qualitative biomechanical analysis, but they
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rarely perform any Quantitative Biomechanical Analysis. They observe their athletes and students performing and describe the mechanical characteristics of the performance subjectively. Comprehensive descriptors (faster, slower, higher, lower, shorter, longer, larger, smaller, and so on) may be used to describe these characteristics. The sense of sight, or visual observation, is basis for most qualitative analysis. (McGinnis, Peter M., 2005). The various approaches used by movement analysts have focused on biomechanics, motor development or pedagogy, and have sometimes been cross-disciplinary. Previous work has included development approaches, for example looking at whole-body developmental sequences, as in the four stages of acquiring throwing skills, or adopting a ‘movement-component approach’, focusing on the legs, the arms or the trunk. More recent developments have included logical decision trees. The focus has varied in the various pedagogical approaches. Sometimes the observer has been recommended to attend to the temporal phases and spatial aspects of the movement. Other approaches have integrated various disciplines, have considered the pre-observation, observation and post-observation stages of analysis, and introduced the concept of critical features – those that contribute most to successful performance of the skill. (Bartlett, R. 2007).

Qualitative Biomechanical Analysis to Improve Technique

A variety of procedure for conducting qualitative biomechanical analysis exist (Arend and Higgins 1976; Brown 1982; Hay 1984; Hay and Reid 1982; Knudson and Morrison 1997; McPherson 1988; Norman 1977). The method presented here is the one recommended by the author. It is not novel, but contains procedures common to existing methods and provides a systematic way of biomechanically analyzing human movements. A qualitative biomechanical analysis to improve technique involves four steps:-

1. **Description**: Develop a theoretical model of the most effective technique and describe what it would look like. Determine what you want to see when you observe your students or athletes.

2. **Observation**: Observation the performance of your student or athlete to determine what his or her technique actually looks like.
3. **Evaluation:** Compare the ideal technique to the observed performance. Identify and evaluate the errors.

4. **Instruction:** Educate the student or athlete by providing feedback and the instruction necessary to correct those errors.

This biomechanical analysis may be qualitative or quantitative. A Qualitative Biomechanical Analysis relies on subjective observation of the performance, whereas a Quantitative Biomechanical Analysis uses actual measurements to quantify certain mechanical parameters of the performance. Practitioners (coaches, teachers, and clinicians) use this or some similar procedure to evaluate the movement or performance of their students, athlete, or clients. *(McGinnis, Peter M., 2005).*

Performance in the 100 m sprint is influenced by a multitude of factors including starting strategy, stride length, stride frequency, physiological demands, biomechanics, neural influences, muscle composition, anthropometrics, and track and environmental conditions. The sprint start, the accelerative phase of the race, depends greatly on muscular power. Three considerations of the sprint start are reaction time (time to initiate response to the sound of the starting gun), movement time (onset of response until end of movement) and response time. Maximal velocity

Running is a result of stride length and stride frequency. While stride length can be greatly limited by an individual’s size and joint flexibility, stride frequency can be affected by muscle composition, neuromuscular development, and training. Although 100 m sprint world record times have progressed drastically, there is limited evidence for how technology has contributed to such improvement. As such, human physiology and physique combine to be the most influential determinants of improved sprint performance. *(Aditi S. Majumdar and Robert A. Robergs., 2011)*

The shortest existing competition in outdoor track and field running events is the 100 m sprint. As in any sprint race, the primary objective of the 100 m sprint is to cover the designated distance in the shortest time possible. Historically, the race has been recognized as a focal component of track and field, as the man and woman who owns the gender-specific world record in the 100 m sprint also traditionally carries the prominent title of “world’s fastest athlete”. As compared to other sprinting events, the relative simplicity of the 100 m sprint makes it ideal for studying the elements of sprint running.
Unlike other track-and-field sprints, such as the 200 m or 400 m event, the 100 m sprint does not involve a curve of the track. Thus, running technique involves purely linear movement, and no centrifugal or centripetal (outward and inward radial) forces. Given recent world record accomplishments in the male 100 m sprint event, we thought that a review of this event, and the multiple determinants to 100 m sprint performance would be a timely addition to the scientific and coaching literature within athletics. Consequently, the purpose of this review is to identify the features of the 100 m sprint that make it such an iconic event, and summarize the multi-faceted determinants to sprint running performance so that understanding and commentary on performance can be based on science rather than speculation or personal bias.

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The sport of Athletics is an exclusive collection of sporting events that involve competitive running, jumping, throwing, and walking. The most common types of athletics competitions are track and field, road running, cross country running, and race walking.

History of Athletics: The history of athletics its roots in human prehistory. The first recorded organized athletics events at a sports festival are the Ancient Olympic Games. At the first Games in 776 BC in Olympia, Greece, only one event was contested: the stadion footrace and the first Olympic winner was Koroibos. In later years further running competitions have been added. Also in the Ancient Olympic pentathlon, four of the events are part of the track and field we have even today. The long jump, the javelin throw, the discus throw and the stadion foot race. (https://en.m.wikipedia.org/wiki>sport)

Athletics events were also present at the Pan-Hellenic Games in Greece around this period, and they become known to Rome in 200 BC. In the middle Ages new track and field events began developing in parts of Northern Europe. The stone put and weight throw competitions popular among Celtic societies were precursors to the modern shot put and hammer throw events. Also the pole vault was popular in the Northern European Lowlands in the 18th century. Organized athletics are traced back to the Ancient Olympic Games from 776 BC. The rules and format of the modern events in
athletics were defined in Western Europe and North America in the 19th and early 20th century, and were then spread to other parts of the world. Most modern top level meetings are conducted by the International Association of Athletics Federations and its member federations. The athletics meeting forms the backbone of the Summer Olympics. The foremost international athletics meeting is the IAAF World Championships in Athletics, which incorporates track and field, marathon running and race walking. Other top level competitions in athletics include the IAAF World Cross Country Championships and the IAAF World Half Marathon Championships. Athletes with a physical disability compete at the Summer Paralympics and the IPC Athletics World Championships.

It is frequently said that sprinters are born and not made, and although research indicates that this is true, “an average sprinter can become top class with the right training and competition.”

Many factors led to the improvement of various factors of performance as well as the total performance of the athlete. Performance recorded before 1948 were run without block, on rather poor (by today’s standard), in resilient tracks. Clearly starting blocks, light weight shoes, composition track surfaces, new starting techniques and modern training programs have resulted in improved times from early track and field history.

Modern competitions in athletics, took place for the first time in the 19th century. Usually they were organized by educational institutions, military organizations and sports clubs as competitions between rival establishments. In these competitions the hurdling were introduced for the first time. Also, in the 19th century the first national associations have been established and organized the first national competitions. In 1880 the Amateur Athletic Association of England start organizing the annual AAA Championships while in United States in 1876 took place for the first time the USA Outdoor Track and Field Championships first by the New York Athletic Club.

In 1912 the International Amateur Athletic Federation (IAAF) was established, becoming the international governing body for athletics, having the amateurism as one of its founding principles for the sport. The first continental track and field competition was the 1919 South American Championships followed by the European Athletics Championships in 1934. In the 1928 Summer Olympics women competed for the first time
time. Furthermore, major athletics competitions for disabled athletes were first introduced at the 1960 Summer Paralympics. From the 1960s, the athletics gained more exposure through television coverage. After over half a century of amateurism, the amateur status of the sport began to be displaced by growing professionalism in the late 1970s. In 1982 The IAAF abandoned amateurism, and later changed its name as the International Association of Athletics Federations. The following year IAAF established the World Championships in Athletics – the first ever global competition for athletics which became one of track and field's most prestigious competitions along with the Olympics. (https://en.m.wikipedia.org/wiki/sport)

Athletics is an exclusive collection of sporting events that involve competitive running, jumping, throwing, and walking. The most common types of athletics competitions are track and field, road running, cross country running, and walking. The simplicity of the competitions, and the lack of a need for expensive equipment, makes athletics one of the most commonly competed sports in the world. Athletics is mostly an individual sport, with the exception of relay races and competitions which combine athletes' performances for a team score, such as cross country. (https://en.m.wikipedia.org/wiki/sport)

Running is a cyclic movement in which two consecutive strides make up a complete cycle of movement. It is an athletic event in itself and at the same time important in numerous other sports. Scientific investigations have been playing an increasingly important role in the training of athletics to attain excellence in performance in different spheres of sports. Athletics concentrates on the development of speed, flexibility, strength, ability, endurance etc. as a part of preparation of their respective sport game.

Whether one is a sprinter or a distance runner, you need speed and the stamina both, which is the ability to endure, to hang in there. Obviously a sprinter needs more speed than stamina and vice-versa. Speed depends not only on a considerable amount of anaerobic activity but also on the resiliency and responsiveness of the circulatory system, reaction time, flexibility and strength. (https://en.m.wikipedia.org/wiki/sport)

Sprinting is the fullest form of running performed over short distance in which maximum or near maximum effort can be sustained. Sprinting figures in the program of
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all major athletic championships including the Olympic game, in which the standard sprint event for men and women are the 100m, 200m, 400m, hurdle, as well as 4×100m and well as 4×400m relay.

Sprinting is the act of running over a short distance at (or near) top speed. It is used in many sports that incorporate running, typically as a way of quickly reaching a target or goal, or avoiding or catching an opponent. Human physiology dictates that a runner's near-top speed cannot be maintained for more than 30–35 seconds due to the depletion of Phosphocreatine stores in muscles, and perhaps secondarily to excessive Metabolic glycolysis as a result of Anaerobic glycolysis. (https://en.m.wikipedia.org/wiki/sport)

In athletics and track and field, sprints (or dashes) are races over short distances. They are among the oldest running competitions. The first 13 editions of the Ancient Olympic Games featured only one event—the stadion race, which was a race from one end of the stadium to the other. There are three sprinting events which are currently held at the Summer Olympics and outdoor World Championships: the 100 meters, 200 meters, and 400 meters. These events have their roots in races of imperial measurements which were later altered to metric: the 100 m evolved from the 100 yard dash, the 200 m distances came from the furlong (or 1/8 of a mile), and the 400 m was the successor to the 440 yard dash or quarter-mile race. (https://en.m.wikipedia.org/wiki/sport)

At the professional level, sprinters begin the race by assuming a crouching position in the starting blocks before leaning forward and gradually moving into an upright position as the race progresses and momentum is gained. The set position differs depending on the start. Body alignment is of key importance in producing the optimal amount of force. Ideally the athlete should begin in a 4-point stance and push off using both legs for maximum force production. Athletes remain in the same lane on the running track throughout all sprinting events, with the sole exception of the 400 m indoors. Races up to 100 m are largely focused upon acceleration to an athlete's maximum speed. All sprints beyond this distance increasingly incorporate an element of endurance. (https://en.m.wikipedia.org)

The 100 m sprint first officially appeared in the Modern Olympics in 1896, in Athens,Greece. In the inaugural race, Thomas Burke, of the United States, claimed
victory at 12.00 seconds, and was the lone sprinter who followed a squat starting stance. ([http://www.iaaf.org](http://www.iaaf.org) 2009).

The start of the race is prompted by an official who follows the standard IAAF mandated three-command start that involves two verbal cues and a final, loud gunshot from a starting pistol. The timing of the race begins at the firing of the starting pistol and concludes as the movement of the athletes across the plane of the finish line is electronically monitored. Some technological limitations of timing systems include sensitivity to light, wind, temperature and pressure. However, the most successful and commonly relied on optical systems oscillate at high frequencies, such that they operate optimally despite fluctuations in environmental conditions. ([Wagner, G., The 100-Meter Dash](http://www.iaaf.org) 1998).

The modern 100 m dash race is held on a straight stretch of the standard 400 m surfaced, oval Track. According to the International Association of Athletics Federations (IAAF), the governing organization of track and field, a crouch start is mandatory for the 100 m dash and all other sprint races up to and including the 400 m dash. The traditional starting position for sprint racing was a standing start. However, as early as 1884, athletes were increasingly adopting a crouched position, and the use of divots in the ground to better support the feet soon followed. The use of a starting block was accepted in 1937, and today we refer to the use of a starting block and related starting position as the crouch start. ([Salo, A. and Bezodis, 2004](http://www.iaaf.org)).

Starting blocks assist in overall acceleration during the sprint start, as the feet can exert large backwards forces and create a stretch of the calf muscles that consequentially load the muscles. When starting blocks first became mandatory in all sprint races, little scientific research supported the use of starting blocks. Recently, [Salo and Bezodis](http://www.iaaf.org) compared the two starting stances, standing and crouched, to determine if starting blocks should remain a mandatory implement of sprint races. Salo and Bezodis found that in using a staggered, standing start, the sprinter is able to increase acceleration in the initial phase of the race, compared to the crouch start. In a standing start, the distance between the front and rear foot is naturally long, causing the individual to exert a greater push on the front foot once the rear foot has cleared the ground. Although there is an initial delay in movement, a longer push produces a higher force, and thus, a greater velocity. ([Mero, A., Kuitunen, S., Harland, M., Kyrolainen, H. and Komi, P.V](http://www.iaaf.org) 2006).
Starting blocks are a device used in the sport of track and field by sprint athletes to hold their feet at the start of a race so they don’t slip as they push out at the sound of the gun. For most levels of competition, including all high level International competition, starting blocks are now mandatory equipment for the start of sprint races.

The invention of starting blocks is credited to Australian Charlie Booth and his father in 1929. Prior to their invention, runners would dig holes in the dirt track. Trowels were provided at the start of races. This was not the most consistent or stable system. It also was destructive to the track surface with the holes having to be filled for subsequent runners. When George became the first person to run 9.4 seconds for the 100 yard dash in 1930, his record was disallowed because he used starting blocks.

Wood was the first material used, with some tracks having permanently placed wooden starting blocks with golden structures at the start line. Portable blocks were held by long metal spikes that needed to be pounded into the ground. These devices evolved to metal blocks. The common blocks of the 1960s were heavy and adjusted by screws that were frequently broken or became rusted over the years. Lighter weight blocks were made of sheet metal. Nick Newton’s innovative design uses cast aluminum.

Modern blocks used for world records now must have sensors that detect the pressure from the athlete and can be used to time their reaction to the starting gun. Athletes who react faster than 100/1000ths of a second (one tenth of a second) can be charged with a false start and the race recalled. Many also carry electronic speakers so the sound of the gun arrives at the ears of the athletes at exactly the same time.

In the modern day sprint race, athletes have to use a crouched start from starting blocks (Rule 161, IAAF rules for competition, 2010 - 2011). One leg is placed in front of the other, pushing back against starting blocks whilst their hands are positioned directly behind the start line. The hips are held just above shoulder height with the head held in alignment with the back. On the sound of the gun, a vigorous arm action and powerful drive from the legs propel the athlete out of the blocks. (Williams, 1980).

According to Hunter et al. (2004) and Bezodias et al. (2008), research investigating the relative importance of developing a long stride length or a high stride rate has been inconsistent across published data. Mann and Herman (1985), et al. (1992) and Bezodias et al. (2008) suggested that SF was a more important contributor to the
velocity increase in sprint performance, where Mero and Komi (1985), Gajer et al. (1999), Shen (2000) and Mackala (2007) stated that SL was a more significant variable. However, it is not clear how those two kinematic parameters interact with each other across the entire distance of 100 m in order to accurately identify different phases of the sprint race. No data exist on how world class sprinters manipulate stride frequency and stride length in order to reach optimal efficiency of the sprint run.

In the last four years Usain Bolt improved the world record in the 100 m sprint three times, from 9.74 s to 9.58 s. Over the last 40 years this record has been revised up to thirteen times from 9.95 s to 9.58 s. The improvement equals 0.37 s (from 1968 to 2009) which is an increase in performance of 3.72%. By comparison, during the same time period, the 200 m world record was revised six times from 19.83 s to 19.19 s what amounts to 3.33 %.

The acceleration phase is the most important phase in a race. During this phase, after the sprinter has left the blocks, the athlete increases the length of their stride and decreases the amount of strides taken per second. Men usually have a rate of 4.6 strides per second and women a little more with 4.8 strides per second. Professional sprinters reach their highest speed at about the 60-70 meter mark, in a 100 meter race, for men. Professional women sprinters reach their top speeds at 50-60 meters. The acceleration phase differs at different levels of competition. Top runners usually cover 20-30 meters at top speed.

Acceleration performance is important for field sport athletes that require a high level of repeat sprint ability. Although acceleration is widely trained for, there is little evidence outlining which kinematic factors delineate between good and poor acceleration. Sprinting is the act of running over a short distance at (or near) top speed. It is used in many sports that incorporate running, typically as a way of quickly reaching a target or goal, or avoiding or catching an opponent. Human physiology dictates that a runner's near-top speed cannot be maintained for more than 30–35 seconds due to the depletion of Phosphocreatine stores in muscles, and perhaps secondarily to excessive Metabolic acidosis as a result of Anaerobic glycolysis.
Statement of the problem

The statement of the problem was stated as “Kinematical Analysis of Sprinting Performance at Varied Angles of Block in Athletics”.

Objectives of the study

1. To kinematically analyze sprinting performance at varied angles of block in Athletics.
2. To compare the set position at varied angles of block in Athletics.
3. To find out the relationship between dependent variable (sprinting performance) and independent variables (selected linear, angular kinematical & anthropometrical variables) at varied angles of block in Athletics.
4. To determine the key components of set position at varied angles of block in athletics.

Delimitations

1. The study was delimited to the Eight male (National / Inter University level) sprinters of Sub Centre Sports Authority of India, Lucknow and Banaras Hindu University Varanasi whose age ranged between 17 to 30 years.
2. The study was delimited on the set position at varied angles of block in athletics.
3. The study was further delimited to the selected anthropometrical, linear Kinematical and angular kinematical variables.
4. The study was conducted in controlled condition but not in natural competitive situation.

Anthropometrical Variables

1. Age
2. Height
3. Weight
4. Hand length
5. Fore arm length
6. Upper arm length
7. Lower leg length
8. Upper leg length
9. Foot length
**Linear Kinematical Variables**

1. Height of center of gravity of the body at set position.
2. First step length.
3. First stride length.
4. 30 m Speed of the subject.

**Angular Kinematical Variables**

Angular Kinematical Variables on set position (touching the ground by both hand, and both foot) at varied angles of block in athletics.

1. Angle of left ankle joint and Angle of right ankle joint
2. Angle of left knee joint and Angle of right knee joint
3. Angle of left hip joint and Angle of right hip joint
4. Angle of left shoulder joint and Angle of right shoulder joint
5. Angle of left elbow joint and Angle of right elbow joint
6. Angle of left wrist joint. Angle of right wrist joint
7. Angle of trunk inclination
8. Angle of Head Inclination

**Limitations**

1. Advance equipment like three-dimension motion analysis software was not used.
2. Other limitations were:-
   a. Weather condition.
   b. Diet of subject.
   c. Height of subject.
   d. Previous training of subjects, the time of testing.
**Hypotheses**

It was hypothesized that there may not be significance difference between varied angles of block with 30 m sprinting performance.

It was hypothesized that there may not be significance relationship between varied angles of block with 30 m sprinting performance.

**Definitions and Explanation of Terms**

**Biomechanical analysis**

Biomechanical analysis is the detailed study of human motion in relation to the conventional law of classic physics.

**Kinematics**

It is the branch of biomechanics that concerned with describing the motion of the bodies. It deals with such things that how far a body moves, how fast it moves and how consistently it moves.

**Kinetic**

The study of force causing or resulting from motion.

**The sprint**

A short fast race run over a distance of 400 meters or less. One of the sprint races that always create a lot of interest is the 100 meters.

**The crouch start**

The crouch start is used in all running events up to the 400 meters. It allows the runner through proper positioning of his center of gravity in the set position to respond most quickly to the gun and start the race.

**Starting block**

Starting block in track and field an apparatus that braces a runner’s feet at the start of race. Before the race the sprinters squatted down and positioned their feet in the starting blocks. Starting blocks may be adjusted in three ways: (a) the distance of each block from the start line, known as block distance or spacing, (b) the angle of each block
from the track /horizontal, known as block angles and, (c) the width of spacing between the feet, known as block width. Adjustments to any of these will cause changes in the athlete’s starting posture and in turn the mechanics of their start.

Starting blocks (a = block distance, b = block angle, c = block width, 1 = front foot side, 2 = rear foot side).

**Block Spacing**

The distance that an athlete positions each starting block back from the start line is referred to as block or foot spacing or distance. Since the crouched start will be first introduced the optimum distance to have between the toes and the start line has been the focus of much research. Starting positions are often referred to as bunched, medium and elongated, or variations thereof.

**Block angle**

It is the acute angle between the block and the horizontal surface of the track. The measurements were analyzed using software constructed for the research study by incorporating standard geometrical methods and techniques. The values were recorded in degrees. Research to find optimum angles of starting blocks has been less extensive with
just a few studies considering how the angle of the starting block to the floor may affect the athlete’s start.

**Block Clearance Time**
Defined as the time elapsed from the gun signal to clearing the instrumented front block.
The time was recorded in 1000th of a second.

**First stride time**
Defined as the time from the gun signal to the rear foot contact with the track. The time was recorded in 1000th of a second.

**First stride distance**
It is the distance between the start lines to the first stride. It was measured by using standard measuring tape and recorded in centimetres/meter.

**Block Width**
Spacing between the blocks i.e. how far the athlete spaces their feet apart laterally in the block, has also received little attention. Traditionally this has been something that will be determined by the design of the block and will be not adjustable.

**Block velocity**
Block velocity is defined as the sprinter's velocity at the moment contact with the front starting block is broken.

**Set’ position**
The position a sprinter adopts at the ‘set’ command, just prior to the start signal.

**Centre of gravity**
The center of gravity of any object is that point at which all of the weight of an object may be concentrated. The body’s C.G. may be described as the point about which a body balance, or the point at which the weight of the body is concentrated regardless of the irregular shape of a body, it is the C.G. or point about which it will balance.
**Significance of the study**

The modern age of the sport is the age of excellence. Accordingly the perfection of skill has got its immense importance. The research in this field may add lot in improvement in the performance of sprinters in athletics.

1. The study will examine the different mechanical factors which actually contribute to the sprinting performance.

2. The present study will explore and examine the factors and establish their optimum magnitude in relation to a good performance.

3. The results of the study will throw light on the important kinematical components/variables in athletics starting block angle at set position.

4. The coaches and physical educationist may use this reference while imparting coaching to athletes. It will add quantum of knowledge in area of bio-mechanics.

5. The findings of the study would provide a guide-line to the future research investigators in sports Biomechanics and Athletics.

6. The finding will add a new knowledge in the field of Research in physical education and Athletics.

7. This study will assist in an attempt to understand the effect of athletics starting block angle mechanics.

8. Develop a theoretical model of the most effective starting block angle in athletics.

9. Evaluate the performance by comparing it to the most effective starting block angle in athletics.