CHAPTER II

REVIEW OF RELATED LITERATURE

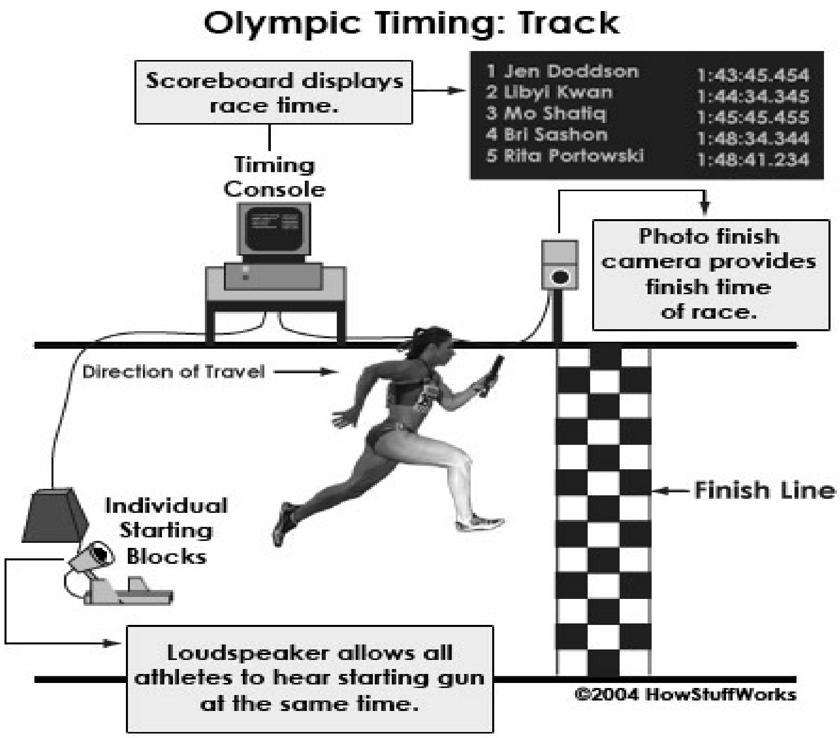
A study of relevant literature is essential to get a full picture of what has been done and said with regard to the problem under study. It is a key to the thinking of the investigator. The review of literature is instrumental in selection of the topic and it provides understanding of the problem in depth. Such a review brings about a deep insight and a clear perspective of the field. It helps the investigator to get a clear idea about the previous research which supports the findings of the present study. The research scholar has gone through numerous relevant literatures. Based on the purpose of the study, the reviews has been classified in to eight areas such as a) studies related to automatic timing assessments, b) studies on photo finishing technology, c) studies pertaining to standardizing the device, d) studies on assessing the long distance events using advanced technology, e) studies related to assessing the long distance events using laser technology, f) studies on radar technology in sports field, g) studies associated with advance technology devices in sports field, h) study related to infrared technology in sports field and which have been presented in this chapter.

2.1 STUDIES RELATED TO AUTOMATIC TIMING ASSESSMENTS

Automatic Timing Assessments were used in International sprinting events, especially 100 meter dash is the determination event of world's fastest men and women, such event may be completed within 10 seconds, so timing assessment must be very much accurate, because International level sprinters are taking part; Therefore every aspect of timekeeping in electronic method is essential, even the starting gun itself to judge precisely (**Albertville 1992)**.

FIGURE 5

AUTOMATIC TIMING ASSESSMENTS



To assess the accurate timings of sprinting events in Olympics, the electronic system were used since 1912 at Stockholm, Sweden. But high tech Electronic photo-finish technology fully integrated with time keeping methods was used in Olympic meets to assess the accurate timings of sprinters.

Gregor Kuntze et. al. (2010) conducted a study on automated feedback Coaching support system for sprint performance monitoring. This study was to investigate the feasibility of developing a cost-effective, automated performance feedback system to support sprint coaching. The proposed system is designed to deliver step length, step frequency, contact time and 10 m split time information of multiple athletes training on an indoor track. An integrated systems approach was chosen combining the novel Pisa Light-Gate (PLG) and Step Information Monitoring Systems (SIMS). Current results indicate data accuracy of RMS 1.662 cm for step length, RMS 0.977 ms for foot contact time and a split time detection accuracy of 8.45 ± 6.85 ms.

Maulder et. al. (2005) organized a study on jump kinetic determinants of sprint acceleration performance from the starting blocks in male sprinters. This research was to identify the jump kinetic determinants of sprint acceleration performance from a block start. Ten male track sprinters at a National and regional competitive level performed 10 m sprints from a block start. Anthropometric dimensions along with squat jump (SJ), countermovement jump (CMJ), continuous straight legged jump (SLJ), single leg hop for distance, and single leg triple hop for distance measures of power were also tested. Stepwise multiple regression analysis identified CMJ average power (W/kg) as a predictor of 10 m sprint performance from a block start. Pearson correlation analysis revealed CMJ force and power and SJ power generating capabilities to be strongly related to sprint performance. Further linear regression analysis predicted an increase in CMJ average and peak take-off power of 1 W/kg to both result in a decrease of 0.01 s (0.5%) in 10 m sprint performance. Further, an increase in SJ average and peak take-off power of 1 W/kg was predicted to result in a 0.01 s (0.5%) reduction in 10 m sprint time. The results of this study seem to suggest that the ability to generate power both elastically during a CMJ and concentrically during a SJ to be good indicators of predicting sprint performance over 10 m from a block start.

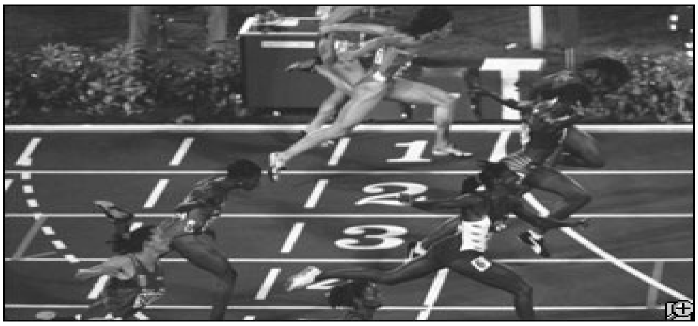
Miller, et. al. (2011) established a study on Limitations to maximum sprinting speed imposed by muscle mechanical properties. It has been suggested that the force-velocity relationship of skeletal muscle plays a critical limiting role in the maximum speed at which humans can sprint. However, this theory has not been tested directly and it is possible that other muscle mechanical properties play limiting roles as well. In this study, forward dynamics simulations of human sprinting were generated using a 2D musculoskeletal model actuated by Hill muscle models. The initial simulation results compared favorably to kinetic, and electromyography data recorded from sprinting humans. Muscle mechanical properties were then removed in isolation to quantify their effect on maximum sprinting speed. Removal of the force-velocity, excitation-activation, and force-length relationships increased the maximum speed by 15, 8, and 4%, respectively. Removal of the series elastic force-extension relationship decreased the maximum speed by 26%. Each relationship affected both stride length and stride frequency except for the force-length relationship, which mainly affected stride length. Removal of all muscular properties entirely (optimized joint torques) increased speed (+22%) to a greater extent than the removal of any single contractile property. The results indicate that the force-velocity relationship is indeed the most important contractile property of muscle regarding limits to maximum sprinting speed, but that other muscular properties also play important roles. Interactions between the various muscular properties should be considered when explaining limits to maximal human performance.

2.2 STUDIES ON PHOTO FINISHING TECHNOLOGY

Photo Finishing Method in track events is giving precision results in a sporting race, when two or more competitors crossing the finishing line at near the same time, through the naked eye the discrimination between the competitors may not be able to decide who crossed the line first. Through a strip photo, a series of rapidly triggered photographs, or a video taken at the finish line may be used for a more accurate ensure. Now a days, the photographs may be digital but usually involve special equipment. They may be triggered by a laser or photovoltaic way. In olden times, a hand cranked strip photograph was taken at the finishing line to determine the winner, but the enhanced technology currently finish-line photos are still used in nearly every modern racing sport. Although some sports using electronic equipment to track the racers during a race, at the finish line, photocells and digital cameras are used to establish the champions. Sometimes, as the 100 m sprint, all eight athletes can be separated by less than half a second. Photo stills are the most important evidence in selecting the champion. Still, they may be examined only when a race is very close or when a record has been broken. Such technology often used to give official times for events **(Andrew Davidhazy, 1961)**.

FIGURE 6

PHOTO FINISHING TECHNOLOGY

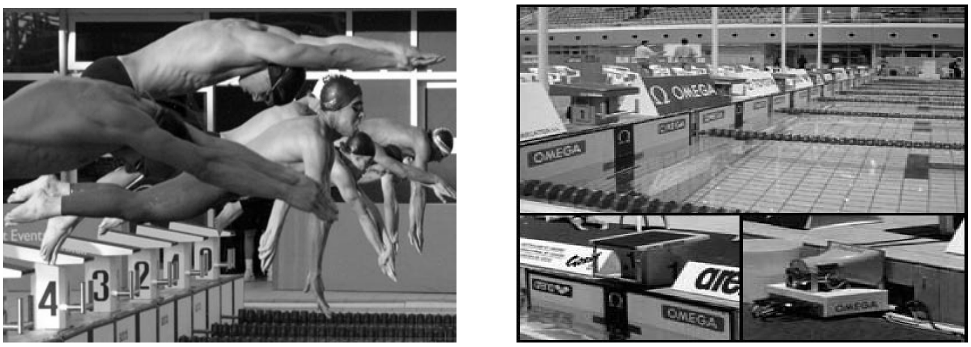


Havriluk (2010) conducted a study on Analysis of Swimming Performance Using Advanced Technology. This study explored that swimmers with advanced skills can derive information from the use of advanced technology. A comprehensive battery of analysis procedures provides quantitative data to augment a coach's qualitative analysis. Advanced technology does not eliminate the work that coaches and swimmers must do to improve technique. On the contrary, such thorough analysis adds to the coach's workload while making more effective use of their coaching skills. At the same time, the additional feedback adds to the swimmer's mental load by requiring constant focus to technique changes of the master. The extra effort is warranted, however, as advanced technology can be used to address the techniques and limitations otherwise that would be unnoticed.

Olympic timing gets automatically precise. In aquatics photo-finishing technology is used, as similar as track events, and recording an image of the finish at 100 frames per second. Timings are only published to the 100th of a second; Olympic timing standards require that timekeeping to be very accurate in millisecond**.** In international level competitions "Smart" systems are used. In case any mistake occurred, the time keeping system has up to four back-up systems**.** These systems kick in automatically when a piece of equipment fails so there are no losses in scores. In an Olympic some redundant systems back up the data by sprinting it out on a time-synchronized printer, while others ensure that times can still get to the audience and the media via scoreboards and the Internet. To measure the reaction time of swimmers the starting blocks were used in both track and swimming events, which have electronic pressure plates, where the athlete's feet rest. At the first sign of pressure (when the competitor pushes off), the starting block sends a signal to the timing console. If the reaction time is determined to be less than one tenth of a second, the clock is stopped and an alarm is sent to the timing official's headphones to restart the race. Often, the competitor who started prematurely is disqualified. In aquatic relay events, reaction time are analyzed not only at the start of the race but also as each swimmer "tags" his or her teammate. If the tagged swimmer leaves the starting block less than one tenth of a second after the first swimmer touches the contact plate in the water, the second swimmer is disqualified for a false start. In both cases, high-speed video cameras also record the action on a horizontal time scale in case of any disputes **(Tom Westenburg, 2002)**.

FIGURE 7

PHOTO FINISHING TECHNOLOGY IN AQUATICS



In horse racing, a factor known as a “dead heat” can occur, when two - or possibly more - horses cross the finish line at the same time, the photo finishes determine accurately where the horses were at the time of finish. Stewards at the racetrack usually put up photo status on the races during these photo finishes. The status of objection or inquiry can also trigger, if other horses or jockeys somehow interfered in the horse rankings and can disturb in Dead heats **(Saxby & Graham 2008)**.

FIGURE 8

PHOTO FINISHING TECHNOLOGY IN HORSE RACE

2.3 STUDIES PERTAINING TO STANDARDIZING THE DEVICE

DoAramaci et. al. (2010) conducted a study on reliability and validity of subjective notational analysis and global positioning system tracking to assess the athlete movement patterns. The course was designed, replicating ten minutes of futsal match-play movement patterns; it allowed a comparison of data derived from subjective notational analysis, GPS data and to the known distances of the course. The study analyzed six loco motor activity categories focusing on total distance covered, total duration of activities and total frequency of activities. The values between the known measurements and the Event Recorder were similar, whereas the majority of significant differences were found between the Event Recorder and GPS values. The reliability of subjective notational analysis was established with all ten participants being analyzed on two occasions, as well as analyzing five random futsal players twice during match-play. Subjective notational analysis is a valid and reliable method of tracking player movements, and may be a preferred and more effective method than GPS, particularly for indoor sports such as futsal, and field sports where short distances and changes in direction are observed.

Jose et. al. (2009) conducted a study to find out validity and reliability of a global positioning satellite system device to assess speed and repeated sprint ability (RSA) in athletes. The aim of this study was to assess the convergent validity and the test–retest reliability of a GPS device for measuring repeated sprint ability test variables. Two groups participated in this study, a group of 21 physical education students and a second group of 14 elite junior soccer players volunteered to participate in this study. Convergent validity was assessed as the correlation between sprint performance using both timing lights and a portable GPS device during a RSAT. The 7 × 30-m RSAT test–retest reliability using GPS device was assessed in elite junior soccer players repeating the test 1 week apart and expressing reliability as a coefficient of variation. Results showed a strong correlation between peak speed measures with the GPS device and RSAT performance measured with timing lights for the 15m respectively. There was a low coefficient of variation for summated maximal speed and peak speed. These results provide evidence to support the use of the GPS device as an alternative measure to assess repeated sprint performance.

Cesar Augusto & Otero Vaghetti et. al. (2006) organized a study on conducted on auditory and visual single reaction spans in surfers with different ability levels comparison of professional, amateur athletes and surf practitioners to identify the auditory and visual RTS in professional and amateur surfers as well as surf practitioners to verify whether there are statistical differences among the surfers groups as well as to correlate the reaction span with the athletes' performance. One hundred and three surfers participated in this study: 42 professional male athletes, 11 professional female athletes, 25 amateur college student athletes, and 25 surf practitioners. Data collection was conducted at the beaches where the following events took place. World Qualifying Series, world circuit phase, Super surf Professional Surfing Brazilian championship phase, catarinense college surf circuit phase. The following devices were used, a switch with a button of sensibility, a L.E.D. for visual stimulus, two loudspeakers of sound pressure for auditory stimulus, as well as an electronic device with the aim to generate the auditory, visual and synchronism signal. The data acquisition was performed with the use of the SAD software version 32. Statistically significant differences were found for the auditory and visual RTS between the professional (male) versus practitioners and professional (female) versus practitioners. Further statistically significant differences were found between the amateurs versus practitioners only for the visual RTS, with lower RTS for the more experienced ones. A positive correlation was found for the visual RTS between the professional (female) athletes versus the ranking.

2.4 STUDIES ON ASSESSING THE LONG DISTANCE EVENTS USING ADVANCED TECHNOLOGY

In long distance races, such as the marathon, the clock is still started with an electric gun like sprinting race. However, the large number of competitors can be participated and makes it impossible for all the runners to leave the starting line simultaneously, and dozens of runners can cross the finish line at a time. Because of these considerations, marathons require a more individual system of timing hence radio-frequency tags came to be used. A small radio-frequency (RFID) transponder was attached in each runner's shoe to send out a unique radio frequency, and a mat the loops of copper wire stretches over the starting line at a marathon as an antenna to picking up each runner's signal and sending the identification code and start time to the timing console. Mats are placed at 5-kilometer intervals to track each runner's progress, automatically displaying the best times on the scoreboard. Another mat is placed at the finish line to record each runner's finish time. Each competitor's time was compared with the time clock, which was initiated by the starting gun and it stopped when the first runner crossed the finish line **(Mark Roberti, 2010)**.

Fully automatic time is a form of race timing in which the clock is automatically activated by the starting device, and the finish time is either automatically recorded, or timed by analysis of a photo finish. The system is commonly used in track and field racing, and Horse Racing in these fields, it is also used in competitive swimming, for which the swimmers themselves record a finish time by touching a touchpad at the end of a race. In races started by a starting gun, a sensor is typically attached to the gun which sends an electronic signal to the timing system when fired. Alternatively, a starting light or sound which is electronically triggered (such as a horn), the system is typically also wired to the timing system. In sports that involve a finish line that is crossed (rather than a touch finish, as in swimming), the current finishing system is a photo finish which is then analyzed by judges. The current photo-finish system used in Olympic competition, as well as other top-level events uses a Digital Line-Scan Camera aimed straight along the finish line. This camera has an image field only a few pixels wide, with a single frame forming a narrow image only of the finish line, and anything which is crossing it. During a race, the camera takes images at an extremely high frame rate. Computer software then arranges these frames horizontally to form a panoramic image which effectively displays a graph of the finish line as time passes, with time denoted on the horizontal axis **(Andrew & David hazy 1961)**.

2.5 STUDIES RELATED TO ASSESSING THE LONG DISTANCE EVENTS USING LASER TECHNOLOGY

Laser range finder is a device to measuring distance. It is capable of instantaneously measuring distances to any target. Measured distance is displayed within the magnified monocular providing the hunter and golfer with a true view of the field and course.In the laser rangefinder device, laser beams are used to determine the distance of an object. The most common form of laser rangefinder operates on the time of flight principle by sending a laser pulse in a narrow beam towards the object and measuring the time taken by the pulse to be reflected off the target and returned to the sender. Due to the high speed of light, this technique is not appropriate for high precision measurements like sub-millimeter measurements, where triangulation and other techniques are often used; a long range laser rangefinder is capable of measuring distance up to 20 km, mounted on a tripod with an angular mount. The laser pulse may be coded to reduce the chance that the rangefinder can be jammed. It is possible to use Doppler Effect Techniques to judge whether the object is moving towards or away from the rangefinder, and if so how fast. The accuracy of the instrument is determined by the rise or fall time of the laser pulse and the speed of the receiver. Very sharp laser pulses and very fast detector can give the range of an object within a few millimeters. Laser rangefinders may be effectively used in various sports that require precision distance measurement, such as golfing, hunting, and archery **(Paul 2011).**

FIGURE 9

LASER TECHNOLOGY IN ASSESSING DISTANCE

The marathon is the epitome of athletics sport event because it is the only sport that athletes of all abilities can participate on an equal footing. Elite athletes are interested in winning the race in a record-breaking time while the majority of runners are concerned in making a new ‘personal best’. With the pressure of modern international athletic competitions comes a demand for fast and precise road course measurements for distance definition. The IAAF (International Association of Athletics Federation) regulations emphasize the requirement of not only producing "accurate" courses but also ensuring that courses are not short in order to guarantee that every possible lane a runner can take through the course is at least the stated distance. Unlike track races where running courses are ovular and of a standardized construction, road races courses vary tremendously. For this very reason marathon times were referred to as “world best” times not world records. Even today, the nominal length of marathon races is defined by IAAF standard and world record times and ‘fastest’ times are recorded, there is no standardization of road racing records because of the wide variety of courses. It is up to the runners to pick the courses that they know will suit them or are known to produce fast times. It is, therefore, critical to provide reliable techniques that can measure road courses with results that are easily reproducible **(Maria Tsakiri, et. al. 2004).**

2.6 STUDIES ON RADAR TECHNOLOGY IN SPORTS FIELD

Radar technology came to be used in sports to measure precisely the speed and direction of tennis, cricket and golf balls during play. This innovative technology is used in tournaments around the world and it provides fascinating insights into the playing techniques of famous sports people and averts the needless doubts. The inventor was concerned with engineering, initially working on sonar and radar projects. He was one of the responsible people for developing the sports tracking technology used around the world today, through the drive to be a part of something more exciting saw him applying his mind more creatively. His initial focus was on sonar projects, so he undertook it on behalf of the South African Navy. He ventured into the world of radar and enjoyed great success when he developed the radar technology that could measure the velocity and ballistics of projectiles in flight. This technology would go on to be used in military units around the world, and his every day investigation, the commercial use of his military projectile application and similar technology could be used to measure the speed of balls played during sport. And he looked at the cricket pitch and designed the EDH Speedball, which measured the speed at which the ball left the bowler's hand. Then he applied similar technology to the tennis court and invented the Raquet Radar, which measured the speed of a player's service. Finally he turned his attention to the golf course and developed the Flight Scope. A comprehensive 3D tracker, the Flight Scope is able to follow the trajectory of golf balls, providing information as to the speed, direction and angle of the ball as well as critical feedback to the golfer **(Henri Johnson 1989)**.

2.7 STUDIES ASSOCIATED WITH ADVANCE TECHNOLOGY DEVICES IN SPORTS FIELD

An Electronic Device to monitor the athlete’s performance both in training and in competition is important to the development and implementation of new approaches aimed at improving the sporting performance. The ability to measure and record athlete’s physiological information and positional information associated with athlete's movement in real-time, is critical in the process of athletics training and coaching. Blood oxygen, respiration, heart rates, velocity, acceleration/force, changes in direction, and position and many other factors are required in elite athlete training and coaching. The position, movement and force information plays an important role in effective analysis of the athlete performance. This device will provide positional data from the training and competition environment and provide both athlete's physiological data and performance data related to the sport. The movement sensor is an accelerometer combined with a GPS unit to sense instantaneous position and velocity. A GPS receiver transmitter is included in the device to derive location and speed parameters. Preferably physiological sensors are also attached to the athlete and integrated with the sensor system. Heart rate is the prime parameter to be measured and this may be sensed using electrical sensors or microphones. Respiratory rate is also important and may be measured by sensing the stretching of a chest band or using a microphone and signal recognition software. Another parameter is arterial oxygen saturation which may be measured non-invasively by a sensor, placed on an earlobe or fingertip, using pulse oximetry employing an infra-red absorption technique. Infra-red spectroscopy may be used for noninvasive measurement of blood lactate concentrations. Preferably velocity is derived from the global position sensor and the accelerometer data is sampled to obtain movement characteristics of the sport being monitored. Preferably the accelerometer data is integrated to derive velocity related movement characteristics and drift is checked every second using the output from the global position sensor. This system provides a platform device which can be used for a wide range of sports simply by providing appropriate software to derive from the accelerometer and GPS data, the desired sport parameters such as stride frequency, velocity, stride length, vertical acceleration and take off for long jump. The system of this invention can be used in swimming to identify stroke type, turns, and with number of laps and the stroke rate per lap as well as lap times. Careful analysis of each stroke can show the efficiency and power by comparing the acceleration and deceleration cycles and the effect of breathing cycles. In open water swimming the GPS can also be used to provide an indication of location, direction, and speed relative to the course. The device of this invention may also include an accelerometer so that tri-athletes who run and swim can obtain accelerometer (pedometer) based speed and distance data for the land portion of their activities. Similarly GPS devices may also be included to derive similar distance and speed data. By adding a magnetometer to the unit on the cyclist pedal cadence can be sensed **(Colin Mackintosh, et. al. 2008)**.

Pascal (2006) invented a heart rate monitor which is a personal monitoring device that allows a subject to measure one’s heart rate in real time or record one’s heart rate for later study. Early models consisted of a monitoring box with a set of electrode leads that attached to the chest. While these still exist, modern versions usually consist of two elements, a chest strap transmitter and a wrist receiver or mobile phone. In early plastic straps water or liquid was required to get good performance. Later units have used conductive smart fabric with builtin microprocessors that analyze the EKG signal to determine Heart rate.

Advanced models additionally measure heart rate variability, activity, and breathing rate to assess parameters relating to a subject's fitness. Some newer monitors have replaced the plastic straps with fabric sensors for comfort or garment integration. The new smart fabric technology has some promise to eliminate the need for elastic straps that hold the transmitter with embedded electrodes in contact with the chest. In old versions, detected heart beat converted as a radio signal and it transmitted, which the receiver uses to determine the current heart rate. This signal can be a simple radio pulse or a unique coded signal from the chest strap, the latter prevents one user's receiver from using signals from other nearby transmitters. Newer versions include a microprocessor that is continuously monitoring the EKG and calculating the heart rate. These can include accelerometers that can detect speed and distance eliminating the need for foot worn devices. There are a wide number of receiver designs, with various features. These include average heart rate during exercise period, time in a specific heart rate zone, calories burned, and breathing rate, built in speed and distance can be obtained.

FIGURE 10

HEART RATE MONITOR

Arthbkins (2007) invented pedometer. A pedometer or step counter is a device, which counts each step of a person by detecting the motion of the person's hips. This was used originally by sports and physical fitness enthusiasts; pedometers are now becoming popular as an everyday exercise measurer and motivator. Often worn with the belt and kept on all day, it can record how many steps the wearer has walked on the day, and thus the kilometers or miles. Some pedometers will also erroneously record the movements other than walking, though the most advanced devices record fewer of these 'false steps'. Step counters can give encouragement to compete with oneself in getting fit and losing weight. Step counters are being integrated into an increasing number of portable consumer electronic devices such as music players and mobile phones. Recently, exercise enthusiasts have observed that an advanced Global Positioning System (GPS) receiver with an odometer mode serves as a very accurate pedometer for outdoor activities, an advanced GPS odometer can reveal the accurate distance traveled within 1/100 of a mile.

FIGURE 11

PEDOMETER

ROSS (2011) introduced a foot pod attached to the top of the running shoe to transmit a wireless signal towards the wristwatch, by measuring leg turnover and cadence can measure speed and distance about as accurately as GPS. The foot pod uses advanced algorithms to determine foot angles, gait and velocity based on data measured by internal inertial sensors that are sensitive enough to pick up the acceleration of the foot pod more than 1000 times per second. On average, the typical runner gets 97% accuracy from a foot pod sensor "out of the box". With further calibration an even more accurate measurement can be achieved. A foot pod device is typically lighter and less bulky than a GPS system as well as less power hungry. It can be used effectively indoors and around buildings and other large objects, but as it has no concept of position, cannot help you navigate, measure altitude, or record routes in 3Dimensional way.

2.8 STUDY RELATED TO INFRARED TECHNOLOGY IN SPORTS FIELD

Measuring Method of Vertical Jump Using I R Rays is a most efficient and correct method, in this method, infrared transmitters are placed at ground level, when an athlete jumps and breaks the plane of the infrared rays with their fingers at the possible height, that interruption occurs is measured. These devices are used at the highest levels of collegiate and professional performance testing. They are composed of several (roughly 70) 14-inch prongs placed as 0.5 inches apart vertically. An athlete will then leap vertically and make contact with the retractable prongs to mark their leaping ability **(United States Patent, 5031903 2008).**

2.9 SUMMARY OF RELATED LITERATURE

The investigator reviewed different studies which revealed the purpose of automatic timing assessments, photo finishing technology, laser technology, radar technology, advanced infrared technology, standardizing the devices etc. such studies are mostly conducted in developed countries and only a very few studies are conducted in India. From the review of related literature, it was found that there is further scope for research to invent different devices to assess the performance of athletes. In the absence of relevant critical literature, available allied literatures were incorporated in the present investigation. Keeping in view that similar studies have not been conducted in India so far. Hence, the present investigation has been undertaken.

Based on the knowledge gained through related literature, the investigator formulated suitable methodology and which have been presented in next chapter.