CHAPTER – II

REVIEW OF RELATED LITERATURE

The investigator has attempted in this chapter to locate the literature related to this study. A summary of the writings of recognized authorities and of previous research provides evidence with what is already known and what is still unknown and interested. A careful review of research through journals, books, dissertations, internet and other sources of information in the problem to the investigation provide the important steps in the planning of any research study. The relevant studies gained from various sources which the research scholar has come across are cited below.

S. Amritpal and Deol N.S. (2010) studied kinematic analysis of spikers of Volleyball. The objective of the study was to analyze the volleyball spiking action used by the players. Correlation between players while performing same
Deol N.S. and S. Mandeep (2010) analysis the application of principles of forces in high drive kicks. The purpose of the study was to biomechanically analyze the principles of forces while attempting high drive in football. Principles of forces were studied and their application in high drive is examined. Two national football players selected for the study. In order to constant the height effect same height players (5’8”) were selected. Players were asked to perform active high drive and the performance was recorded. High speed video cameras were used to cover the high drive kick from different angles. After recording, analyses of the principle of application of forces were done with the help of motion analysis software (motion pro). Application of principles of forces was analyzed in respect to its effect on distance covered by the stroked ball. It was found that the correct application of principles of directions of force affect performance by 14.8%. With the proper application of principles of distance of force and body radius performance enhanced by 39.2% and 45.8% respectively. It was concluded that the proper applications of principles of force
(keeping other aspects constant like height and weight) affect the performance of
high drive in respect to distance and accuracy positively.

S. Mandeep (2010) presented collective views of experts in the evaluation
and improvement of sports techniques through biomechanical updated analyzing
technology. Author provided the examples of well known athletes like Michael
Johnson, P.T Usha, and Milkha Singh etc to display the importance of
biomechanical technology in improving performance. Author tried to show that
it actually become difficult to correct the technique of any elite athlete, because
the technique has been already well adopted and adjusted by the athlete. Any
change in the action of athlete, when he/she has reached at international level
may lead to disappointment and injury. So, that requires high coaching qualities.
Therefore, instead of changing the technique, biomechanists preferred suited
spikes that can assist in better performance of Johnson. On the other hand the
task becomes very easy and perfect, if the technique should be supervised and
evaluated at the initial level of learning and performance. Games and Sports in
college and university level is the best opportunity to catch young athletes and
evaluate their skills and techniques. The local level competitions in colleges and
universities can also not be neglected and the responsibility lies on the shoulders
of department of sports and physical education. The time has come to analyze
and coach players scientifically. Biomechanical approach is the best reliable
method to make players understanding the differences in good and poor skills
with scientific principles. Departments of Physical education in Universities and
especially coaching institutions must come forward to implement biomechanical
programs through teaching of biomechanical principles and technologies to physical educationists and coaches respectively.

Author also presented a report on availability of software by indicating that many motion capturing Hardware and software are available for the biomechanical analysis and understanding of the skills easily. The most common biomechanical instruments in the filed is Kinametic Measurement System (K.M.S.) and the main measurements they provide are speed of the subject (cutting speed, foot speed, sprint speed etc), gait timing, contact timing, balance and stability, Subject related angles and C.G of the body etc. The biomechanical instruments even helping in administering many standard tests like speed and explosive strength test, quickness and agility test, reaction time test and such other related tests. Force plate with gait analysis system is also one of the updating instrument designed for gait, balance, sports as well other static and dynamic analyses. Depending on the configuration of the biomechanical instrument, there cost ranges from 10’000 to 50 lacks or even more. The high sophisticated speed framed cameras cost more than 50’000 rupees, but a normal digital camera can also be used. In India specified biomechanical hardware and software are available in many of the Departments of Physical education and sport Sciences, but the utility is limited. This is the high time to understand the importance of these modern technologies in order to overcome many of the technical faults and moreover we should understand the fact that western and even Asian countries like China and Japan have well adopted the new technologies of sports sciences, which we are just thinking to start using. We
should not delay more and must become familiar with the biomechanical technologies of understanding and evaluating the techniques and strategies. It is really unfortunate that some of the departments of physical education and sport sciences have yet not introduced the subject of Sport Biomechanics and other scientific topics like Psycho-Physiology, Physio-Biomechanics, Kinanthropometry, nanotechnology in sports, Teaching Technology in Coaching and innovative learning through technologies in the field of Physical education and coaching. Sport does not simply involve physical activities but components of physics, mathematics, biology, psychology, sociology and many more. It is actually engineering, which needs regular updated scientific approaches in all the factors. In the elite level of competition 1/100th of second plays an important role in respect to speed, 1mm plays an important role in respect to distance and height. Author concluded by indicating that we have to keep our self very updated so that atleast this time, 1/100th of second could not beat our deserving athletes.

Nathial M.S. (2010) conducted a study with the purpose to compare the selected kinematical variables of the technique of male and female national sprinters in India. The videography and sequence photography technique was employed to register the sprinters techniques. In the study motion analyzer software motion pro and simi machix is used to asses biomechanical variable like the C.G of the body during the movement of take-off, Angle at Ankle joint (Supporting leg), Angle at Knee joint (supporting leg), angle at ankle joint (swinging leg), Angle at knee joint (swinging leg), Trunk inclination, stride
length etc. in the study it is hypothesized that there may be significant differences in the technique of male and female sprinters on selected kinematics variables. The criterion measure for this study was the performance of the subjects in 80meters run. The data were analyzed by ‘t’ test to ascertain the comparison of techniques of male and female sprinters. The results have shown the insignificant values of ‘t’ ratio for all the selected kinematics variables of the study at the significance level of 0.05.

S. Mandeep (2010) made an effort to describe the value of biomechanical applications in sports and performance. It mainly an effort of putting value of science in sports. The aim of the study was to get the importance of biomechanical analysis in the field of sports. One of the objectives of the study was to biomechanically analyze the selected skills of sports and evaluate the effect on performance. Biomechanical analyses were applied on players of football, sprint running and volleyball. Players were asked to perform active skill and the performance was recorded. Incase of any doubt or disappointment shown by the performing player, more attempts were given to the player, till he satisfied with his own performance and skill. Four high speed cameras were used cover the skill of different games from different placements. All cameras recorded the performance simultaneously. After recording analysis of biomechanical principles were done with the help of motion analyzing software (motion pro). It was found that the correct principles of biomechanical application affect performance positively. It was concluded that science plays important role in the field of physical education and sports.
Ruhal A.S. and Ruhal G.S. (2009) studied the relationship of kinematic variables with the performance of standing broad jump. The purpose of investigation was to study the relationship of kinematic variables i.e., angle at knee joints, angle at ankle joints, Height of the c.g, angle of take-off and total time taken with the performance of standing broad jump. Subjects were randomly selected from J.N.V University, Jodhpur and M.D.S University, Ajmer. The criterion measure used for the study was the performance in standing broad jump and selected kinematic variables were analyzed. To analyze the raw data coefficient of correlation (r) were calculated and results were compared with the help SPSS. Level of significance was set at 0.05. It was found that the selected kinematic variables were significantly related with the performance in broad jump. It was also found that the time take to perform the broad jump was not significantly related with performance in broad jump.

Kelly, McKean (2009) conducted a study with the purpose to detect differences in kinetics and kinematics during cutting maneuvers that contribute to gender predisposition. 21 elite male and 21 elite female soccer players between the ages of 14-18 years underwent a complete 3D kinematic, kinetic and electromyography (EMG) analysis of the lower limb during unanticipated running and cutting maneuvers. Hip, knee and ankle angles, forces and moments were collected during the stance phase of each maneuver. Subjects were instructed to run down the walkway of the lab at 3.5 ± 0.2 m/s. Just prior to their right foot landing on the force plate, a light system randomly directed the individuals to either 1) cut to the left (side-cut), 2) continue running straight or
3) cut to the right (cross-cut) until 5 successful trials were obtained for each direction. All cutting maneuvers were made at a 45-60° angle. The kinematic and kinetic waveforms for the entire stance phase of each task were analyzed using principal component analysis. Results showed that there was no significant difference between males and females in age, body mass index (BMI), years of soccer experience or speed of the cutting maneuvers. All players were injury free at the time of testing; however, many reported lower limb injuries previously in their soccer careers (M=62%, F=86%). From the research work it is concluded that the cross-cut was the most successful maneuver for identifying gender related differences in this elite soccer population. Females generated less hip flexion and a larger knee adduction moment than their male counterparts.

Motoyasu, Koshiyama and Katsumata (2009) made an afford to know the effects of joint movement on the accuracy of 3-point shooting in Basketball. The purpose of this study was to clarify characteristics of players who possess high accuracy of a 3-point shot with respect to joint movements and the ball trajectory. 12 experienced male basketball players (9 right-handed and 3 left-handed) participated in the experiment. The goal of task was to shoot the ball from a line 6.25m from the backboard into the basket. All participants were requested to shoot the ball through the ring. A high speed camera (sampling frequency: 250Hz, shutter speed: 1/2000; Nac, HSV-500) was positioned at the right or left side of the player’s shooting position, perpendicular to the plane of intended ball motion. The following 8 points were digitized: Right and left humeral line, elbow, wrist, 3rd metacarpophalangeal, hip, knee and ankle joints,
distal end of right and left feet. The coordinates of the external markers were used to calculate the following variables: release height, release speed, release angle of the ball, and the angle, angular velocity and angular acceleration of joints. From the investigation it was found that the distance between a ball and the center of the ring showed significant positive correlations with the ball release velocity, ball release angle, the ankle plantar flexion angle, hip angular acceleration, knee angular acceleration and ankle angular acceleration. That distance also showed significant negative correlations with the ball release height, vertical jump height, and the wrist flexion angle. Good shooters were able to achieve a low release speed by shooting a ball at the optimal release angle. Good shooters were also characterized by a lower jump height, a larger wrist flexion angle, and smaller joint movements of the lower limb compared with poor shooters.

Huang Chi (2009) made a biomechanical analysis of standing long jump with handheld weight. The purpose of this study was to investigate the biomechanical difference between unloaded and loaded groups, and to understand the joint moment and power of standing long jump. Fourteen male physical education students (height 174.64±6.21 cm, weight 73.07 ± 11.32 kg) participated the study, and performed no load, light load (L load, load 2-4kg), heavy load (H load, load 6-8kg), super heavy load (S load, load10-12kg) standing long jumps. A Redlake high speed camera (125Hz) was synchronized with a Kistler force platform (1250Hz) to collect the data, and Dempester’s study (1955) was used to calculate the human body parameter. We use one way
ANOVA to analyse the kinematic data, and the variables were calculated by SPSS for Windows (Version 12.0, Chicago, IL) with alpha level of 0.05. It was analyzed that the jumping distance was enhanced in the L loaded and H loaded groups, the result was familiar to other studies, and if the jumper jumped carrying too heavy weight, the performance was decreased. Besides, the horizontal CM takeoff velocity in L load and H load groups increased with load. In vertical CM takeoff velocity, it decreased with load, especially when they jumped with super heavy load (10kg-12kg). In our study, there was no significant difference between groups in joints moment. In the peak joints power, it decreased with load, and the S load group significantly less than the other three groups. The study indicated that the light load and heavy load groups had greater jump distance than no load group. The horizontal body CG takeoff velocity and horizontal impulse were enhanced with load. However, the vertical body CG takeoff velocity, peak hip and ankle joint angular velocity, and peak lower extremity joints power were decreased with load.

Smith R., Bake M. and Fiatarone (2009) investigated gait and posture in arthritic and healthy knees. The gait characteristics of patients with (osteoarthritis) OA of the knee were well studied and reported; however, less attention had been paid to the postural differences between OA affected and healthy knees. The aim of this study was to investigate the postural differences that may affect the gait in an OA group compared to the controls. Subjects (n=17) were community–dwelling women (age >40 yrs) with OA in at least one knee according to the American College of Rheumatology criteria confirmed by
magnetic resonance imaging and clinical examination. Seventeen body mass
index-matched asymptomatic women were recruited from the general population
in good general health with no history of knee pain or injury. A three-
dimensional motion analysis system was used to collect the biomechanical gait
data during self-selected habitual speed and internal moments were calculated
using inverse dynamics. Digital K400 Keiser pneumatic resistance machines
were used to perform one repetition maximum test unilaterally on knee
extension according to (de Vos & Singh et al. 2005). Comparisons between
groups were made by applying an analysis of covariance (ANCOVA) with age
added to the model as a confounding variable at p <0.05. From the investigation
it was found that the approximately 88% of the patients had OA in medial
compartment and 30% had severe OA. Maximum knee extension strength was
lower in the OA group compared to the matched controls. The OA group had
higher hip abduction angle and greater knee adduction moment (KAM) than
controls. In addition, at 30% of the stance phase shank adduction angle was
correlated with KAM and was greater in the OA group than controls.

Guimaraes R. and Cliquet (2009) made an effort to analyze and to
identify possible gait adaptations by individuals with objective patellofemoral
instability. Two groups of female subjects submitted to gait analysis at free speed
have been assessed. One group was composed by 9 individuals with objective
patellofemoral instability, with injuries duration between 1 and 6 years, selected
by the Orthopaedics Service of a University Hospital. The mean age of the
subjects was 24.00 (±6.02) years, mean height 1.62 (±0.06) m and mean weight
of 60.33 (±10.31) kg. The other group was constituted of 9 individuals with no joint change, with mean age of 25.00 (±1.87) years, mean height 1.62 (±0.05) m, and mean weight of 56.20 (±7.34) kg. The exclusion criteria were the following: presence or apparent evidence of locomotive disorder, such as spine displacements, differences on lower limbs length, or prosthesis use. This study was approved and authorized by the Committee of Ethics in Research of unicamp medical sciences school. For this, all subjects signed a “Free and Informed Consent Term”, stated their willingness to take part in the research. Seven reflexive markers were unilaterally fixated at anatomical sites such as: trochanter, 1 cm above the patella, knee interline, anterior tibial tuberosity, lateral malleolus, calcaneus and between the II and III metatarsal. After the markers were fixated, the individuals were asked to climb up and down, foot after foot, a staircase composed by three steps, 19 cm high each. Two positive attempts (those in which the subject stepped on the platform without increasing or reducing the length of the step) were selected and assessed. In the results Group B subjects showed lower knee flexion during the support period when compared to group A. However, a significant difference was found only when climbing up (group B peak = 53.52°±4.06 vs. group A peak=58.43°±5.80, p=0.0268). When climbing down, group B also presented a lower knee flexion degree as compared to group A, but the difference was not significant (group B peak = 25.33°±6.14 vs. group B peak= 28.36°±2.72, p=0.1011). In parallel, a significant reduction was identified for speed (climbing up: 0.56m/s±0.08 vs. 0.65m/s±0.05, p=0.0076; climbing down: 0.61m/s±0.12 vs. 0.71m/s±0.08,
p=0.0243) and for pace (up: 62.11 steps/min ± 9.80 vs. 74.44 steps / min±6.00, p=0.0027; down: 67.94 steps/min±12.78 vs. 80.22 steps/min±9.27, p=0.0165) in group B when compared to control group. From the results it was concluded that the Gait analysis of individuals with objective patellofemoral instability when climbing up and down stairs evidenced kinematic changes on the knee. Group B featured a lower knee flexion angle during the support phase when climbing up stairs. In parallel, this group showed a reduced speed and pace when climbing up and down stairs. These findings suggest the use of adjusting strategies by the group with patellofemoral instability when climbing up and down stairs. From a biomechanical point of view, the reduced knee flexion, pace and speed can enable a reduced stress on patellofemoral joint and of pain, as a result.

Zhou Fou (2009) conducted a kinematical research on elite chine’s male 3m spring board divers. The purpose of this research was to find some common features in kinematical parameters of elite diving athletes and thus to serve athlete training. The kinematical analysation of 407C dive was the objective of this research. Nine elite male athletes, each with three dives and the best one was digitized. One camera was applied for frontal and lateral photography of the dives, and a synchronous system was used to acquire both above water and under-water performances. All records were put into a computer and digitized using the TJH-02 motion analysis system. Following results were found in the study: 1. Average swing of board bouncing was 0.420m. 2. Average swing of board pushing before the lowest point of board was 0.734m; average angles of hip, knee and ankle in the best performance were 81.0°, 85.4° and 86.8°
separately at the lowest point of board. 3. After the lowest point of board, average swing of board elevating was 0.879m, average velocity of mass when taking off was 3.97m/s, average height of springing up was 0.845m and average angle of takeoff was 72.9°. 4. During the phase of springing up, the average time from somersaulting to tuck position was 0.14s; when somersaulting, the average hip and knee angles were 38.7° and 58.7°; when most tightly somersaulting, the average hip and knee angles were 28.7° and 33.6°; the average duration for the first, the second and the third circle were 0.40s, 0.33s and 0.34s separately; the average centre of mass height after somersault was 3.09m; the average hip, knee and ankle entry angles were 130.0°, 159.7° and 166.6° separately; the total time from taking off to finish was 1.53s. It was concluded in the study that all kinematical data in the research certified that entry with splash was a key technique in diving. Four key notes, including higher jump, tighter twist, earlier open and tighter arm, were concluded and suggested to be applied in athlete training.

Aydin, Bergun and Mensure (2009) conducted study on kinematic analyses of overarm movements for different sports. The aim of this study was to compare the kinematics of the overarm throw for different sports. Nine female volleyball players (age: 24±4yrs, height: 174.45±4.50 cm, weight: 68.03±5.32 kg) from the women’s volleyball super league and eleven female handball players (age: 20±2yrs, height: 174.63±7.28 cm, weight: 65.81±5.21 kg) from the national women handball team joined this study. All the players in this study were right-handed. They had no history of injury within the last year. Volleyball
passers and handball goalkeepers were not analyzed here. The measurements of both teams were conducted in an Olympic hall. The players were allowed to have as many trials as they wanted after they had warmed up. Reflective markers with 3cm in diameter were placed on the ulnar styloid, lateral humeral epicondyle, and lateral superior tip of the acromions. The arm segment was made up by putting together acromion and a humeral epicondyle, and the forearm segment was made up by putting together humeral epicondyle and ulnar styloid. In the backswing phase, statistically significant differences were found between the volleyball players and the handball players in terms of angle, angular velocity, and angular acceleration on all the planes (p<.05). In the acceleration phase, the statistically significant differences were found between the volleyball players and the handball players in the angle on the transverse plane, in angular velocity on the vertical plane, and in angle, angular velocity, and angular acceleration on the sagittal plane.

Greenwald, Rosca and Morra (2009) studied the influence of contemporary knee design on high flexion. It was a kinematic comparison with the normal knee. In the study animated models of artificial knee placement were constructed through the motion captured 3D animated software. Those models were further compared with the healthy knee systems. This study compared the motion of six contemporary total knee arthroplasty (TKA) designs with recent in kinematic data of the healthy un-operated knee through deep flexion by employing a computational kinematic simulator. A dynamic, validated musculoskeletal modeling system was utilized in this study. It provided a
musculoskeletal modeling environment of the left leg of a nominal sized patient in which activities such as walking gait, lunge, stair ascent and descent and deep knee bend were simulated. Activities were propelled by muscle forces and constrained by soft tissues. Solid models of scanned TKA component geometries were arranged in the joint space to reflect a successful virtual surgery. Unique flexion facet centers (FFC) were determined for each femoral component using computer aided design tools. The FFC is depicted as a sphere at the circles’ center. Medial and lateral flexion facet centers were joined to create a “barbell” structure, which was rigidly affixed to the femoral component to better visualize its motion. The resulting animations and plots characterize motion of the femoral component relative to the tibial insert in comparison to that of the normal knee was evaluated. Each design flexes until the posterior femoral bone cut surface impinges against the tibial insert. In the results the Legacy LPS-Flex Fixed achieved the highest flexion angle among the designs studied. At full extension, impingement of the anterior aspect of the femoral cam and tibial post was observed. During deep flexion, the femoral component rolls and slides anteriorly until the femoral cam and tibial post articulate at 105° of knee flexion. Of the designs studied, the Journey most closely replicates healthy un-operated knee kinematics. In general, the femoral component consistently rolls back after engaging the cam and post at 54° of flexion and offers a medial pivot, both hallmarks of normal knee motion. The Vanguard PS design rolls and slides anteriorly until engaging the post cam mechanism at 78° of flexion. It was concluded that the knee implant designs investigated did not replicate the
kinematics of the healthy un-operated knee. Post and cam designs achieved higher flexion than non post and cam designs. The post and cam mechanism drove tibio-femoral contact toward the posterior edge of the insert, allowing higher flexion prior to impingement. Non post and cam designs demonstrated contact in the central or anterior areas of the insert during high flexion, diminishing their ability to achieve high flexion prior to posterior bony impingement.

Sharma, S.K. and D. Retta (2009) analyzed segmental placement of center of gravity of Michael Fred Phelps in track start during Beijing Olympics. The main purpose of this study was to find out the placement of center of gravity of different body segments of Michael Fred Phelps on track start position. To find out the scientific principles assist in determining the mechanics of motion to physical activities in order to obtain the most effective and efficient result. This guide the researcher in judging performance and for directing performance towards perfection with minimum expenditure of energy in the set reference of time, avoiding fatigue, excess of respiration, perspiration besides maintains poise and style with perfect synchronization. Phelps won 14 career Olympic medals, the most by any Olympians. This fact inspired the investigator to scientifically investigate the styles and techniques adopted by the Fred Phelps. For collecting the requisite information an observatory type of data sheet formatted by Dempster (1955) was used in this study. It was finalized that the c.g. falls on 2.45 on x-axis and -0.95 on y-axis.
Satpal Y. (2009) conducted a study on relationship of selected physical and biomechanical variables with the performance of discus throw. The purpose of the study was to find out relationship of selected physical and biomechanical variables with the performance of discus throw. The subjects were five males from L.N.I.P.E, Gwalior, who were state level discus throwers. The sequential photography technique was employed to record the discus technique. A motor driven, Nikon model EM camera was used. The subjects were photographed at execution phase in sagittal plane and only the release action of discus was analyzed. From the photographs, the stick figures were prepared by using joint-point method, and various biomechanical variables were obtained at the moment of releasing the discus. The physical variables of each subject were taken by an anthropometric kit. Product moment correlation was calculated between the selected physical and biomechanical variables with the performance of discus throwers. The level of significance was 0.05. The results showed that a significant relationship exist between performance in discus throw and certain physical and biomechanical variables, whereas some variables showed insignificant relationship with the performance.

Deol N.S., S. Mandeep and Gill, M. (2009) made an effort to put the value of physical education for special people, through kinematical analysis. The project was mainly undertaken with the motive of implementing the subject of physical education and benefitting them. In order to provide benefit of the kinematic field to the special people, the project was started under the guidance of specialists dealing with schools, organizations and clinics for mentally
challenged people. Many Mentally challenged people, received many deformities or improper ways of performing some basic movements like extra movements of extremities, walking with extra bend knees, walking deviation, body inclinations, foot out ward walking etc. It was noted that there were some walking faults. That occurred not because of any permanent or temporary physical deformity lack of care leading to improper movement but a successful attempt was made for the borderline case to omit un-demanded movements with proper guidance and training in a very planned and systematic way. Five mentally retarded subjects were taken, with their age ranging between 17-20 years. Special Motion pro software was used to analyze the movements of the subject after video-graphing them. They were provided five months training and after five months training subjects were again analyzed similarly. It was concluded that some body movements were corrected through the proper implementation of physical education training program.

S. Ratnesh (2008) studied the relationship of selected kinematic and anthropometric variables to the technique of front foot off drive in cricket. The subjects of this were five intervarsity cricket players of 18-25 years of age from Lakshmibai National Institute of Physical Education, Gwalior, India. The sequential photography technique was employed to register the technique of front foot off drive at the selected movements. The subjects were photographed at two movements i.e. moment stance and moment contact in the sagital plane. All the selected subjects were right handed batsman. To find the angular kinematic variables from the photographic sequence of moment stance and
moment contact, the stick figure method were used. The angular kinematic variables were the angles at: knee joints, ankle joints, hip joints, shoulder joints, elbow joints. The linear kinematic variables were the height of the centre of gravity at the moment stance and at moment of contact. The anthropometric measurements of each player were taken by using anthropometric kit. The anthropometric variables were stature, sitting height, leg length and arm length. Pearson’s product moment correlation was employed for the testing. The level of significance was set at 0.05 level. The result showed angle at right hip joint had positive relation with the technique of subjects in the front foot off drive in cricket during the moment stance and moment of contact. Angle at left had shown positive relationship with the technique of subjects in the front foot off drive in cricket during the moment stance. Whereas the angles at rest of the joints were found insignificant. The relationships of the selected linear kinematic variables were also found insignificant. Selected anthropometric variables showed insignificant relationship with the technique of subjects in front foot off drive.

K. Sarkar and S. Bhowmick (2008) conducted a study that was planed to analyze the relation of some selected anthropometric and mechanical parameters on running performance with primary boys as subjects. Thirty primary school boys of 7-9 years of age were selected as subjects. Selected factors included height, weight, leg length, leg power, stride length, stride frequency, body inclination, angle of leg placement, push off angle, horizontal projection of CG in braking phase (touch down). Horizontal projection of CG in propulsion phase,
velocity of swing leg in braking phase, velocity of swing leg in propulsion phase, angular velocity of thigh in propulsive phase, contact phase, flight phase, flight phase, braking phase and propulsion phase. Running action of the subjects was filmed by a video camera operated at 25 frames per second for the distance between 40-50m of the 80m race. The selected parameters of running with top speed were analyzed by motion analysis software. The results indicated that weight, height, leg length, leg power. Stride length, stride frequency, horizontal velocity of CG in braking phase and velocity of swing leg in braking phase influence the running performance very positively while angular velocity of thigh in propulsion phase, contact phase and breaking phase influenced very negatively.

S. Kehkashan and P. Vikas (2008) analyzed the relationship of selected kinematic variables with the performance of Harai-Make-komi. 10 university level judokas were selected for the study. The variables selected to investigate were ankle joints, knee joints, hip joints, shoulder joints, elbow joints and height of CG of body position. For cinematographic analysis digital handicam was exclusively used to record performance of the subjects. Still photography of Harai-Make-Komi of stages (Kuzushi and Tsukuri & Kame) were used for the purpose of kinematics data assortment. Performances of the subjects were evaluated by a panel of 3 judges on the basis of a given criterion based on scoring system in Judo. To find the relationship the Pearson’s product moment correlation were calculated and the level of significance was 0.05. the obtained values of coefficient of correlation at selected moments i.e. moments kuzushi
(balance break) and kake (execution) with selected kinematic variables were: in angular kinematics at the moment of kuzushi left ankle joint (-0.46), right ankle (0.522), left hip joint (-0.103), right hip joint (-0.40), left shoulder joint (-0.139), right shoulder joint (0.056), left elbow joint (0.072), right elbow joint (0.154), and at the moment of tsukuri left ankle joint (0.37), left hip joint (-0.739), right hip joint (-0.515), left shoulder joint (0.34), right shoulder joint (0.248), left elbow joint (0.059), right elbow joint (-0.04). In linear kinematics at the moment of kuzushi the height of CG was 0.236 and at moment of tsukuri &kake height of CG was 0.051. There was insignificant value of coefficient of correlation in case of all joints. Based on the interpretation of findings it was concluded that the Kinematic variables namely analysis angles of joints i.e ankle, knee, hip, shoulder, elbow etc and linear kinematics height of CG have insignificant relationship with the performance of Harai-Make-Komi, when other mechanical parameters were not considered.

Abdoddaleh, Asal and Mohammad (2008) conducted a comparative study of equilibrium between old athletes (active) and no athletes (non-active). This research was done with the aim of equilibrium studying and comparison of old athletes (active) group and no athletes (non-active) group. 20 old men who were 65 years old and used to perform physical activity (morning sports) and expanding leisure time in Iranshahr Park (Iran) and 23 old men no athletes (non-active) were attended voluntarily as statistical sample. Motor and biomechanical specifications of the samples like flexibility, reaction time, height, and mean of the thigh and leg size (research variables) and isotonic equilibrium variables
(depending variables) were studied. Balance board was used for measuring isotonic equilibrium, balance platform for measuring isometric equilibrium, reaction time measurement machinery for reaction time and flexibility box was used for measuring flexibility. To describe statistical data relating to equilibrium status in two old groups mean and standard deviation were used, for inferential analysis and studying of data independent ‘t’, for finding relation between some moving motor specification and equilibrium in old men multiple regression used and pearson’s calculation were done by spss and for rejection and accepting hypothesis significance level 0.05 was taken into consideration. It was found that the old men athletes group was better than old men no athletes group in isometric and isotonic equilibrium. In the study height variable showed least correlation with the isometric and isotonic equilibrium in two groups. Results of the study confirmed the positive effect of physical activity in expending old men equilibrium. It was concluded that the old athletes had a better condition than no athletes (non active).

P. Valadimir (2008) compared tennis shots between two different players, with the objective of obtaining more new and precise knowledge and information. Two young tennis players in age of 15 were recorded by two synchronized video cameras in three different tennis shots (serve, forehand and backhand). Biomechanical analysis was done with help of simi motion software. The selected biomechanical variables were trajectory, angles, velocity and acceleration of each body segment. The main segments taken into consideration were head, left arm, right arm, left elbow, right elbow, left wrist, right wrist, left
hip, right hip, left knee, right knee, left ankle and right ankle. There were significant differences found in angles of left arm, right arm, left elbow, right elbow, left wrist, right wrist, left hip, right hip, left knee, right knee and left ankle in the two selected players.

S. James (2008) studied the relationship between changes in electromyography and kinematic measurements during exhaustive running. The purpose of the research was to examine the relationship between changes in electromyography (EMG) and Kinematic measurements during exhaustive treadmill running in a group of competitive distance runners. Fifteen healthy male distance runners (age: 23.0 ± 4.6y, height: 1.80 ± 0.05m, mass 67.4 ± 7.8kg) participated in this study. Subjects were equipped with telemetric EMG system and surface electrodes were placed on the vastus lateralis (VL), semimembranous (SM), gluteous femoris (RS). Retroreflective markers were placed at key anatomical positions to determine joint angles. Subjects ran to exhaustion at an intensity which corresponded to approximately 95% of previous determined maximum oxygen consumption. Integrated EMG and media power frequency were calculated for each stride. Maximum and minimum knee and hip joints angles and angular velocities were calculated for each stride. Net differences between the start and end of the run were computed for all variables. Pearson’s product moment correlations were computed to determine the relationship between changes in EMG variables to changes in kinematic variables. Results showed that the subjects ran for 16.1 ± 4.1 minutes before reaching volitional exhaustion. All muscles studied showed a net increase in
Maximum hip flexion angle significantly increased during the run. No significant changes in leg kinematics were observed. It was concluded that change in EMG was positively correlated to change in maximal hip extension angle ($r=0.871$, $p=0.005$) and angular velocity ($r=0.873$, $p=0.005$).

Bhardwaj R. (2008) conducted a comparative study of kinematic analysis of vertical jump of boys of different age group. The purpose of the study was to kinematically analyze and compare the vertical jump performance of boys belonging to two age groups of 10 to 20 years and 21 to 24 years. Kinematic analysis employed sequence photography and considered height of the centre of gravity during four phases of vertical jump performance namely standing reach, crouch, jump & reach and landing as well as its vertical displacement (distance between standing reach and jump & reach). Centre of gravity in each phase was located using segmentation method. Along with centre of gravity the angular modification during four phases of vertical jump performance was considered. For angular measurements elgon stick figures were developed. To compare the kinematic variables of the four given phases of vertical jump of the both age groups t-test was applied and was tested at 0.05 level of significance. Results revealed that the height of the CG during standing ranged from 1.14m to 1.39m. The height of the CG during crouch ranged from 1.02m to 1.15m. It was also found that the displacement of CG during vertical jump ranged from 0.41m to 0.91m. The height of the vertical jump ranged from 38cm to 58cm. Results also revealed that the difference in the means of two age groups with respect to
modifications of angles during all the four phases of vertical jump at ankle joint, knee joint, hip joint and shoulder were found insignificant. The difference in angles at elbow joint was found to be insignificant. It was concluded that the boys of 18-20 years and 22-24 years age group did not exhibit significant difference in the vertical jump performance.

Lee, Chong-Hoon (2008) analyzed biomechanical differences between general walking shoe and functional shoe. The purpose of the study was to examine the effect of the MBT shoe through the comparison of MBT shoe to general shoe. For this, 12 healthy females in the age from 20-30 years participated in the experiment for testing kinematic variables. The angle of take on was not different between the types of shoes, but in case of speed it was significantly different in both high and low speed for MBT shoe and general shoe. However, it did not show a significant different in angle of ankle and angle of knee between two groups. There was difference found in angle of hip between the types of shoe, but in the case of moving speed it was different in moderate and low speed of MBT shoe. It was found that a significant difference exist in angle of take off between two shoe groups. MBT shoe showed higher angle than general shoe in the take on such as high speed (14%), moderate speed (16.9%), and low speed (16.6%).

N. Pothiwala and C. Poonam (2008) undertook a study of kinematic analysis of technique of penalty corner in field hockey. The purpose of the study was to find the relationship of selected kinematic variables to the performance of hitting during the penalty corner in field hockey. The subjects selected for the
purpose of the study were six male hockey players who had participated in all India inter-University Hockey championships. Age of the subjects was between 18-25 years. The sequential photographic technique was employed to record the performance of hockey players during the penalty corner. A motor driven Nokon model EM camera was used to record the moment execution. The subjects were photographed in sagital plane only. From the photographs, the stick figures were prepared by using the joint point method and various kinematical variables were obtained at the moment execution. The selected kinematic variables were angles of right and left ankle joint, knee joint, hip joint, elbow joint, height of center of gravity and time taken to execute shot. The height of C.G was found out by segmentation method and temporal characteristics or time taken when the ball was pushed from the penalty corner spot until it stroked the backboard. Three time keeper were kept for registering the time. The performance of hitting during penalty corner was obtained by points, recommended by Harban’s in the dribble and goal shooting test. Pearson’s product moment correlation method was used to calculate the relationship of selected kinematic variables with the performance of hitting in penalty corner. The level of significance was set at 0.05. It is found in the result that none of the selected kinematical variables pertaining to the angles at right ankle joint, left ankle joint, right knee joint, left knee joint, right hip joint, left hip joint, right elbow joint, left elbow joint have executed the significant relationship with the performance of subjects in penalty corner however the left ankle joint (‘r’0.67) left hip joint (‘r’0.70) and right elbow joint (‘r’0.69) had shown higher value of coefficient of correlation. The other variable
such as height of center of gravity at moment execution and the time taken to execute the shot also yield the insignificant value of coefficient of correlation at the selected level of significance. Based on the analysis and within the limitations of the study the conclusion drawn was that none of the selected kinematical variables had the significant relationship with the performance of players in penalty corner in hockey.

A.S. Sajwan (2008) analyzed biomechanically the block start in 100meters sprint. The analysis was conducted on four sprinters two boys and two girls of L.N.I.P.E Gwalior. The analysis of block start was made on the basis of video-recording by sony handy cam DCR-HC96. The movement was executed in plane which was perpendicular to the video camera's field view. In the beginning of video recording to record an object of known dimension (scale), the scale usually one black rural was placed in the plane of the action- precisely 1 meter. Biokin 2D motion analysis system V4.5 was used to analyze the block start of the selected subjects. Results showed that the trajectory, displacement linear velocity, linear acceleration of knee and ankle joint of the sprinter, one boy and one girl was in better position in quantitative evaluation. The results were visualized using graphs, stick figure and videos simultaneously on screen to measure the distance or angle. It was further concluded that the length of acceleration was determined by the starting position of the knee and when the body is stretched. It was concluded that one boy and one girl’s set positions was correct that had helped them to achieve lower trajectory, better displacement and good velocity of the knee and ankle joint.
Hsiao-Wen (2008) tried to analyze tennis volley through kinematical approach. The purpose of this study was to examine selected kinematic variables of the tennis volley. Fifteen skilled male tennis players served as subjects (age $21.3 \pm 1.5$ yr, height $180.3 \pm 5.5$ cm, mass $73.1 \pm 6.61$ kg). Twelve subjects were right-handed and the three others were left-handed and had played competitive tennis for many years. All subjects were all-court players and have competed in both singles and doubles, in the meanwhile, subjects could execute volley extensively. Subjects all signed informed consent before the test. The test was conducted at an outdoor tennis court. A tennis ball machine (Prince TE38-11) was placed behind the baseline on the opposite side of the count from the subject. The ball machine was mounted on an iron board which has four wheels and was 59 cm from the ground. The researcher controlled the lateral location of the ball’s trajectory by rotating the iron board. Marks were placed on the ground near the rear right corner of the board showing the lateral of machine which allowed the repeatable of ball placement. The ball machine was adjusted to the fastest speed which projected the ball at 21.3 m/s. To prevent the subject from anticipating the ball placement, a black paper board ($170$ cm high $\times$ 60 cm wide) with an opening ($35$ high $\times$ 50 cm wide) was placed in front of ball machine. Five trials were collected for each subject with 15 volley strokes. The rest interval between trials was 1.5 minutes. The ball was projected into five lateral locations randomly with three balls on each trial. Five lateral locations were left ($2$ m from the centre line of court), left-middle ($1$ m), middle ($0$ m), right-middle ($1$ m), and right ($2$ m). For the left-handed subjects, however, the left location
was on the forehand side of subjects. Two high-speed cameras (Fastec Imaging) operated at 250 Hz were genlocked to capture the volley stroke.

Phases of a volley were defined as follow:

- **Split-step phase** — which was the time of the small jump step before volley action, and it defined as the time of the toes off ground until the toes contact the ground.

- **Lateral side step phase** — which was defined as a step of the foot on the same side of oncoming ball before the crossover step of other foot.

- **Pushing phase** — from initial racket movement to contra lateral foot off.

- **Backswing phase** — from the ball release to initial racket movement.

- **Forward swing phase** — from the end of backswing to ball impact.

- **Stroke phase** — from the initial racket movement to ball impact.

The result showed that there were significant differences on pushing and stroke phase among five of the volley locations. The middle locations have the shortest pushing (0.249s) and stroke (0.466s) time on tennis volley, however, there were longest tennis volley times on the left locations, pushing (0.418s) and stroke (0.624s). No significant difference was found on ball velocity and contact height on five locations. The left location (43%) had the lowest percentage of ball return than the right (59%), right middle (53%), middle (63%) and left-middle (67%) location. The researchers suggested that those results (lower successful rate on left location volley) may be due to the longer distance for player to return the ball with backhand. When the ball was projected to the middle location (to the player directly), subjects preferred to perform the FH
volley (55%) than BH volley(45%), hence, this result may suggested that players can master the FH under the similar situation. From the results found it was concluded that there were lower successful rate when player perform a deep volley return with backhand. In addition, players preferred to perform the FH volley than the BH volley when the ball was projected to them directly.

Roemer K. (2008) tried to investigate shoulder kinematics in volleyball spikes. This study investigated the shoulder kinematics of volleyball spikes, performed during European League Games. For the kinematic description of the shoulder movement quaternions and the axis-angle approach was used to avoid the gimbal lock. The orientation of the resulting axis of rotation in the shoulder joint and the rotational angle were calculated. 16 diagonally performed volleyball spikes were analyzed. The subjects were European top level outside hitters of the national teams of Croatia, Estonia, Germany, and Netherlands. The spikes were captured during European League games. Therefore, motion analysis was executed using four high speed Basler cameras (100Hz) and the software Simi Motion. The 3D coordinates were digitized manually and the movements were reproduced with high accuracy using the man model DYNAMICUS. For the inter-individual comparison of the shoulder kinematics for these movements, the data was time normalized with respect to take-off and ball-impact. Only the phase between strike out position and ball impact was taken into account for this study. These results confirmed the assumption, that the movements in the sagittal plane and in the transversal plane influenced the orientation of RA. High negative correlations found for the x-coordinate and the
z-coordinate of RA and high positive correlations for the y-coordinate of RA. Furthermore, the movements in the frontal plane (ellb z-coord.) showed an influence only for few trials. Eight trials out of 16 showed no significant correlation. The other trials indicated significant positive correlation as well as significant negative correlation for the same coordinate. For example trial 13 showed a negative correlation with the x-coordinate of RA while trial 14 shows a positive one. The trajectories show two different movement techniques for the spike. For trial 13 the range of motion (ROM) for the internal/external rotation was 142°, from 87° of internal rotation to 55° of external rotation. For trial one a correlation with the elbow was detected but only weak correlation with the rotational angle was found. For this trial the ROM was 90°. These results indicated a dependency of the orientation of RA from the combination of abduction/adduction and rotation in the shoulder joint. No dependency between the arm movements in the sagittal and transversal plane with internal and external rotation in the shoulder joint was found for volleyball spikes. Brown et al. 1988 found for baseball pitchers an increased ROM for external rotation only within 90° abduction and suggested this finding to be a specific adaptation to throwing mechanics. The interdependency between abduction and rotation for diagonally performed volleyball spikes found in the study indicated specific spiking techniques. From the findings of the study it was concluded that concerning shoulder kinematics in volleyball spikes the abduction and adduction angles and the internal and external rotation were interdependent and indicated as different spike techniques.
Kersting G. (2008) conducted a methodological study of biomechanical analysis of on water rowing technique. Typically, two-dimensional assessments were carried out with fixed cameras mounted on-land next to a rowing course or by handheld cameras from an accompanying boat. The purpose of this study was to develop and validate a system for kinematic analyses of on water rowing. A three-camera (Basler A602f, 30 Hz) video recording system (SimiMotion 7.0) was mounted on a large catamaran-type motor boat with cameras set at various heights and the most distant cameras about 14 m apart. This arrangement was calibrated prior to and when the boat was in the berth using a customized calibration procedure. Twenty-two reference points were used, covering a volume of approximately 4.5 x 3 x 2.5 m. A total of nine elite level athletes in various boat categories were analyzed during training and race pace at Karapiro, New Zealand. Four trunk points and four reference points on the boat were marked up, while the remaining points of interest were digitized manually. Joint angles were calculated using Simi software. A reference experiment was performed on a movable rowing ergometer in the laboratory. A geometrically similar camera setup and calibration was created for the Basler cameras. Trials with one subject marked up using a 51 point full body marker (Ferdinands & Kersting, 2004) set were recorded using an 8-camera motion capture system (Vicon MX). Joint centre coordinates and joint angles were calculated from both systems and compared. Results of the study showed that the joint centres showed differences in location of up to 3 cm while joint angles displayed very similar patterns with varying levels of agreement. Mean deviations were calculated over
one full rowing stroke and varied from mean difference of less than 1 deg to 4.5 deg for the elbows. From the results this can be concluded that this study demonstrated a suitable method for three-dimensional rowing technique assessment on water.

Bezodis E. (2008) aimed to investigate how leg kinematics contributes to the performance, in terms of external horizontal power production, of three elite sprinters during the block and first step phases of a sprint. Three male sprinters, who have subsequently reached the European Indoor 60 m final, provided consent for an outdoor training session to be videotaped for analysis. A high-speed video camera (Redlake, Motion Pro HS-1; 200 Hz) was located perpendicular to the running lane, 40 m from the lane centre, and 0.75 m in front of the start line. Prior to the training session, a 2D area of 3.50 m horizontally x 1.60 m vertically was calibrated. Images were collected at a resolution of 1280 x 1024 pixels. Following a coach-directed warm-up, each sprinter completed three or four maximum effort 30 m sprints, commencing from blocks. The instants of movement onset, block exit, touchdown and toe-off were identified directly from the video. Eighteen anatomical landmarks were manually digitized and digitally filtered using cut-off frequencies determined by residual analysis. These filtered data were combined with segmental inertia data in order to create a 14-segment (head, trunk, upper arms, forearms, hands, thighs and feet) model and obtain the whole-body trajectory. Ankle, knee and hip angles and angular velocities were calculated. Block exit velocity and first stance take-off velocity were calculated as the derivative of first order polynomials fitted through raw horizontal data.
during each subsequent flight phase. Subject C exhibited a much greater increase in vertical position during the first stance phase compared to subjects A and B, particularly during the latter part of stance. Subject B exhibited slightly higher mean peak angular velocities at both hips during the block phase, but also a greater mean range of extension at the rear hip (41°) compared to subjects A (31°) and C (26°), and at the front hip (116°) compared to subject A (109°). Combined with his shorter push phase duration (0.330 s), subject B therefore produced higher average hip extension velocities, particularly at the rear hip. The rear hip extensors were the first active leg muscles during the block phase, and remained active throughout rear block contact. Although this contact is shorter than that with the front foot, large peak horizontal forces have previously been found to be generated at the rear block. An increased contribution from the rear hip extensors could therefore be important for a larger velocity increase during the early block phase whilst the rear leg remained in block contact. This could assist the generation of block exit velocity in a shorter period of time (i.e. power), and reinforces previous suggestions that better starters typically exhibit a stronger rear leg action. In contrast, subject A exhibited a larger and faster extension of the more distal joints during the block phase, particularly at the front ankle where mean peak angular velocity (597°/s) was considerably higher than subjects B (482°/s) and C (464°/s). Subject B was also able to limit the amount of dorsiflexion during early stance (8°) compared to subjects A and C (both 11°). It is likely that the higher total range of extension at the leg joints of subject B (160°) contributed to his greater performance by increasing the force
produced by the extensor muscles, whilst subjects A and C exhibited lower total leg joint extension (137 and 144°, respectively). However, despite a slightly lower total range of extension, subject A generated greater normalized power (1.40) than subject C (0.83) during the first stance, resulting in a greater increase in horizontal velocity (1.17 m/s) than subject C (0.94 m/s). It is concluded that an increased push with the rear leg in the blocks, particularly at the hip, may assist the generation of power in elite sprint starters. Although greater motion at the more distal joints could augment block velocity, this appeared to be largely due to a longer push duration rather than greater average force production. During first stance, a large extension of the leg joints appeared to be beneficial. The position of the c.g further in front of the stance foot at touchdown also improved performance by directing the subsequent leg extension more horizontally.

Wang, Xu, Li and Zhou (2008) conducted a kinematical research on hurdle clearance techniques of elite Chinese athlete in 100m hurdles. This investigation was conducted to find the technique defects and thus to serve athletic training through kinematical analysis to hurdle clearance techniques of Jing Liu. Although Jing Liu was the champion of women’s 100m Hurdle in 2007 Asian Games, the performance did not get the level of the world elite athletes. The motion was taped via two high-speed cameras with 3D fixed-points in this research. One was applied for frontal and lateral photography of the first hurdle, the other was applied for frontal and oblique photography of the first hurdle. The included angle of these two cameras was 100° with frequency of 100 frames per
second. The motion was digitised by 3-D-ignalTECv1.0c analysis system to analyze the hurdle clearance techniques with filtering frequency 8 Hz. Through kinematical analysis some differences were found from the desired technique and it was concluded that (1) the characteristics of Jing Liu’s hurdle clearance technique were small takeoff angle (19.3°), low mass height (2.13m) and short step length (0.42m) while passing hurdles and without active press of swing leg after hurdle clearance. (2) the thigh and the crus folded insufficiently (the smallest knee angle was 64.9°) while performing hurdles. (3) the height of centre of mass when passing hurdles was effective (0.35m).

Chi-Yang, Tsai (2006) conducted a study on the Kinematic analysis of Basketball three point shoot after high intensity program. The purpose of this study was to analyze Kinetic and kinematic characteristics of three points shooting by high speed camera. Basketball players have to finish the high intensity program which was designed from simulative basketball games. The high intensity testing program includes dribbling, sprint, jump shooting and three points shooting. The results of the experiments indicated that elbow, wrist, hip and ankle joints angle velocities would decrease, except the knee joint, after the high intensity programme. The Knee angle of take off was also increased. It indicated that the upper limb joints angular velocity decreased and player as had to increase knee joint angular velocity to maintain original power. Time durations also played influential role in the performance. The times from take off to ball release also decreased that means that there was a change in the
coordinates in Knee joint and elbow joint. Improvement in the power for the shot exhibited to be dependent on knee and ankle joint to much extent. After high intensity program the elbow and Knee joint extension were effective enough and closed to produce more power for the shot.

Nesbit S.M. (2005) made a kinematic and kinetic study of the golf swing. The study highlighted the importance of the wrists in generating club head velocity and orienting the club face. A full-body computer model of a golf swing was developed under the direction of the United States Golf Association (USGA) to study the biomechanics of the golfer, the interactions between the golfer and his equipment, and the behavior of the clubs. The model was built, analyzed and post processed with the aid of the commercial software package ADAMS (Mechanical Dynamics, Inc.). A total of 84 male and one female amateur golfer of various skill levels, experience, age, height, weight, and competitive rounds played per year were analyzed using the computer model. All subjects were right-handed. The overall goal of this study was to create a computer model of a golfer, then use the model to analyze the 3D mechanics of a golf swing for several subjects. Novel components included completely characterizing the 3D kinetics and kinematics of the downswing, performing an energy analysis of the swing, analyzing a large group of subjects for statistical information, searching for significant correlations, and highlighting similarities and differences in swing mechanics among select subjects. The analysis revealed the true complexity and individuality of the golf swing motion. While some data were similar among subjects, most data illustrated vast differences both in terms
of magnitude and profile. For example, the kinetic quantities consisting of the work, power, linear interaction force and the three components of torque illustrated how differently each subject drives and control the golf club. These differences had important implications for golf instruction, equipment design, and injury assessment. Also revealed were the quantities that were related to skill level such as hand trajectory, work ratio, work, club head and grip velocity, alpha torque and angular velocity, and power. The other quantities seemed to reflect swing style and not skill level. The study discovered little correlation between body type and swing characteristics or skill level.

Andrzej W. and Elisaz J. (2004) conducted a study on kinematic analysis of Handball Throws. The purpose of this study was to quantify selected Kinematic variables of the handball throwing and in particular, to establish the relationship between athlete’s movement pattern and throwing technique. Ten high performance handball field players were taken for the experiment. The average values of basic parameters of physical characteristics of the subjects were: 86.5 ± 9.8 Kg body mass, 1.89 ± 0.09m body height and 22.4 ± 1.8 years of age. The subjects were video tapped by two cameras at 60Hz throwing on the spot from the distance of 7m to the goal. Each throw was digitized and analysed using the Ariel performance Analysis System (APAS). Statistical analysis of the results was carried out with the use of statistical v.5.0 software. The results showed that the huge differences of throwing technique parameter values exist even among the high performance and handball players. The linear velocity of the ball was 24.45 m/s ± 1.97 m/s (range: 21.11 m/s , 28.50 m/s), horizontal
linear displacement of the hand with a ball (xy plane)- 1.74 m ± 0.14 m (1.60 m, 2.10 m) and rotational energy of the shoulder- 286 J ± 109 J (95 J, 511 J) the difference between the value of trunk momentum and the momentum of distal parts of upper limb (arm, forearm, wrist) appear to the one of the most important factors in the evaluation of throwing technique.

Elliot Bruce (The Hindu-2004) in response to a request from director, the srilanka cricket board, through ICC, Mr. Muralitharan’s spin bowling action was analysed in the Biomechanical Laboratory of the school of Human Movement and Exercise sciences of Wester Australia. The analysation was mainly done on the bowling skill ‘Doosra’. Biomechanical analysis was done from a position where the upper arm is horizontal to the release point of the ball. Six best deliveries were analysed. It was resulted that, (i) the wrist flexion–extension was 78 degree and 50 degree respectively. (ii) wrist abduction-abduction was 26 degree. (iii) forearm abduction angle was 18 degree. (iv) elbow flexion-extension, static 35 degree (flex) and dynamic 24 degree (fixed). (v) delivery type-Doosra with range of extension 10.02 degree (+ or – 0.63 ) extension and speed measured 72KM/hr (+ or –0.3). It was also viewed that wrist abduction seemed to be the major reason for production of impressive ‘Dusra’.

Coh M. (2003) analyzed the basic kinematics characteristics of Cathy Freeman’s sprinting stride in the section from 100mts to 200mts and an average stride length of the stride. On the basis of Cathyn Freeman’s body height (1.64 mts.). It was established that the horizontal velocity at the line of place at the foot of take-off leg on the ground was 8.77m/s. At the end of the contact phase,
the push-off angle, amounts to 62.3 degree. The distance of the action of the pushup force in the propulsion phase was 0.49 mts. The height of the C.G. in the beginning of the braking phase was the same as that at the end of the propulsion (0.97m). The height of the C.G. in the light phase of maximal amortization of the trajectory of C.G. of the athlete was 0.08m. The height of C.G. in the phase of maximal amortization the angle in the knee of the take-off leg can be connected to a suitable and selective reactivation of the knee extensors (rectus femoris, Vestus Lateralis muscle), which must be programmed and stimulated from the higher centers of the central nervous system.

Barfield (2002) compared the instep kicking technique of elite male and female football players. The objectives of this study were to examine kinematic instep kicking differences between elite female and male soccer players in dominant and nondominant limbs. Eight elite soccer players, six females and two males, volunteered to be subjects. All females were right foot dominant and one of the two males was right foot dominant. Foot dominance was self selected based on the players response to which foot they preferred to kick with for maximal ball velocity. Their age range was 19-22 years. Females had an average body mass of 60.1 kg and an average height of 164.25 cm. Male body mass average was 87.32 kg and height average was 184.15 cm. All subjects declared freedom from physical or orthopaedic injury, which would prevent them from exerting maximal effort in instep kicking. Prior to data collection all subjects warmed-up with flexibility exercises, light running and instep kicking. The use of human subjects was approved by the Institutional Review Board at the School
of Medicine of the University of North Carolina at Chapel Hill. The kinematic variables chosen for analysis defined as: (1) Maximum Toe Velocity (Max T Vel) was the maximum velocity of the distal end of the kicking foot between SFC with the floor and ball contact (BC) (2) Toe Velocity at Ball Contact (BC Toe Vel) was velocity of the distal end of the kicking foot at the point of BC (3) Mean Toe Velocity Between SFC and BC (Mean T Vel) was the average velocity of the distal end of the kicking foot between SFC and BC (4) Mean Toe Acceleration (Mean T Accel) was the average acceleration of the distal end of the kicking foot between SFC and BC (5) Ankle Velocity at BC was the velocity of the centroid of the lateral malleolus of the kicking foot at BC (6) Angular Velocity of the Knee at BC was the angular velocity, calculated relative to the thigh segment at BC. The three trials with the greatest ball velocity for dominant and nondominant sides were selected for data analysis. It was found in the results that the Ball velocity, the dependent variable, was significantly different when comparing between sides and genders. There were also statistically significant differences in body mass index (BMI) (p=0.01). The mean female BMI was 22.25 and the male mean BMI was 25.75. BMI was calculated as body mass in kg divided by height in meters squared. Dominant (D) and nondominant (ND) comparisons demonstrated that males had statistically significant (p<0.05) greater kinematic values than the females in 3 of the 6 variables on the D side and in 4 of the 6 variables on the ND side. Angular velocity at the knee at BC was greater among the females than among the males on the D side (19.79 rad.s⁻¹ ±4.49 versus 19.42 rad.s⁻¹ ±1.87), but less on the ND side (16.37 rad.s⁻¹ ±1.87).
1\{±1.43\} versus (16.12 \text{rad.s}^{-1}\{±4.0\}), although the differences were not statistically significant.

Kitagawa, Onishi and Kato (2001) made an effort to describe the principal kinematic variables of underwater running and walking. The purpose of this study was to determine kinematical characteristics of underwater locomotion and to compare them with those of land locomotion. Six male subjects performed walking and running on both conventional and underwater treadmills. Both treadmill speeds increased incrementally starting from 0.56 m s\(^{-1}\) to 3.33 m s\(^{-1}\), the maximum speed of the underwater treadmill. The motion analysis showed that underwater locomotion is characterized by the following points: (a) A transition from walking (1.11 m s\(^{-1}\)) to running occurred at a lower speed in water; (b) stride frequency was significantly lower in water; (c) in order to reduce the hydrodynamic resistance of water, a greater knee joint flexion used to reduce the trajectory area enclosed by the legs as the treadmill speed increased and (d) many kinematical differences were observed above a walking speed of 1.11 m s\(^{-1}\), also above this speed oxygen uptake was significantly higher in water. In water, the strategy of locomotion was quite different from that on land.

Murtaugh and Karen (2001) conducted a study in back and reverse arm stand triple somersault tuck dives. The purpose of the study was to determine strategies for initiating rotation in arm stand back and reverse triple somersault tuck dives from the 10m platform. Videotaped records of 17 elite male divers performing in competitions between 1995 and 1999 were analyzed. Linear and angular moment at last contact were comparable, they occurred significantly
earlier (p < 0.05) in reverse triple take-offs, allowing divers to enter the tuck more quickly. As diver lean the moment arm of the vertical platform reaction force increased with respect to the C.G. The vertical platform reaction force moment promotes back and opposes reverse somersaulting angular momentum. Man while, the horizontal platform reaction force moment promotes reverse and opposes back somersaulting angular momentum. Consequently divers performing reverse triples maintained a more vertical trunk. Position during the early part of the take-off, while those executing back triple leaned further before initiating lower and upper extremity actions to exert force against the platform. Since the strategy for reverse rotation may result in the head passing close to the platform and there is a very little gain in degree of difficulty. It was recommended that competitors execute back rather than reverse somersaulting arm stand dives.

Rojas F.J., Cepero and Gutierrez (2000) conducted a study on kinematic adjustments in the basketball jump shot against an opponent. The aim of this study was to analyze the adjustments in technique made by a basketball player when shooting against an opponent. The subjects used were 10 male, active professional basketball players from the First Division of the Spanish Basketball League (ACB) who volunteered to take part. All were right-handed and specialists in mid- and long-distance shooting. The mean age was 23.36 years with a mean height of 1.95 m and a mean mass of 90.43 kg. Two video cameras were used at 50 Hz to record the performance of the shots. The first was placed at a distance of 10 m from where the shot was to be made with an orientation of
458 to the direction of the shot, and the second was situated 11 m from the shot with an orientation of 458 to the direction of the shot and 90 degree to the orientation of the first camera. The cameras were started approximately 3 seconds prior to the beginning of each shot and were not switched off until the ball passed through the hoop to ensure the recording of a sufficient portion of the performance to permit analysis of release variables. After positioning the cameras, and before filming the shots, a reference object was filmed. The reference object was so oriented that the $x$-axis was in line with the direction of the shot, the $z$-axis was perpendicular and horizontal to the direction of the shot and the $y$-axis was perpendicular to the plane of the floor. In the study it is found that the release angle of the ball increased significantly in the presence of an opponent and this helped the player to avoid the possible interception of the ball by the opponent’s hand. The mean release angle of the ball in this study was 45 degrees. The velocity of ball release was not significantly different between the opponent and non-opponent conditions. In conclusion, it was stated that players attempted to release the ball more quickly and from a greater height when confronted with an opponent. This strategy lessens the chance of the opponent intercepting the ball. The greater initial knee position restricted the ability of the player to jump and therefore player performed a quicker but less powerful jump, while the more rapid upward movement of the ball helps to increase the joint angles at shoulder and elbow at release and this, combined with a more upright trunk, helps the ball to attain a greater height and a more vertical angle of projection. This interpretation was supported by significant differences and
trends in the biomechanical data collected. The differences in technical execution of the skill had implications for practice.

Soo Chung (1998) conducted a study with the purpose to investigate the pattern of motion of the striking arm and muscular/joint activities responsible for it during the arm swing phase of the volleyball spike. Eight female intercollegiate volleyball players served as subjects were filmed using the Direct Linear transformation method of three-dimensional cinematography, and film analysis procedure were used to obtain 3D coordinates of the ball and of 21 body temporal phases of the spike, the ball speed, the speed of the hand and the other factors contributing to increase the performance and the angular positions and angular velocities of the shoulder and elbow joints. The resultants forces and torque at the shoulder and elbow joints of the striking arm were investigated to determine the net patterns of the activity of the muscles at each joint. The angular momentum of the body and the contributions by the body segments to it were also investigated. From the investigation it was concluded that (i) the elbow muscles and joint contains no significant value in strengthening respective arm rotation and performance directly (ii) the shoulder muscles that rotated the arm about an axis perpendicular to the upper arm and contained in the plane of the arm caused the external rotation of the upper arm indirectly and affect performance.

Kim L. (1993) conducted a kinematical analysis of the flight phase in the long jump. The purpose of the study was to investigate the characteristics of the flight phase as a function of the angular momentum developed by the jumper. A
medium distance collegiate jumper was used to obtain kinematic data from the flight phase of a hitch kick style long jump. Filming method was used to obtain three dimensional coordinates. A 15 segment physical model was developed for simulation, with kinetic variables approximated using a rigid body inverse dynamics approach in the simulation the angular momentum was changed by altering the body configuration immediately after take-off. The approach velocity and take-off angle were unchanged. The study revealed in its primary purpose that the changes in the initial conditions resulted in modifications in the angular momentum and the momentum pattern of the arms and leg during the flight phase. It was also revealed in the study that many kinematical variables like Knee and elbow joints contributes in gaining good flight phase in long jump.

S. Dhannanjoy (1990) the purpose of the study was to develop suitable and feasible criteria for the evaluating different variations of Seoi Nage and to find out the contributing biomechanical, anthropometric flexibility and motor fitness factors for effective execution of different variation of Seoi Nage and Ippon seoi. The subjects were 28 male judoka, who were well experienced and well skilled and their age ranged between 18 to 30 years. Selected Biomechanical variables were recorded in pre-determined variation of the shoulder throw, at N.S.N.I.S., Patiala by using two dimensional cinematography method. In the study sixteen mm movie camera was used. After processing the filming were analysed on film analyzer in the biomechanical laboratory of N.S.N.I.S., Patiala. Following conclusions were drawn, (i) the angle at the ankle joint found not to be significantly correlated with total time. (ii) left elbow joint,
right knee joint and center of gravity at the basic stances prefer no correlation with the seoi nage perfecton (iii) angular velocity at hip formed by right shoulder when knee is extended from flexed position and total right hip in Ippon Seoi Nage should greater to reduce the total time of performance. (iv) execution time and total time taken in Ippon Seoi Nage were found to be linearly related to each other and strong predictor as well. (iv) to reduce the total time, the time of knee flexion from start of throw should be reduced in Ippon Seoi Nage. (v) the time of leg extension to belt in vertical was having a critical effect i.e. little reduction of the same reduces total time greatly in Ippon Seoi Nage.

Richard D. (1986) made an effort to describe the principal kinematic variables of men’s front salto vault. Further more it was of particular interest to describe the total body angular momentum and mechanical energy of the vault. Five male gymnasts were filmed with a 16mm camera operating at 200 frames per second. Each gymnast performed five 5 vault. Mean post flight hip height was 1.45m above the horse, with better vaults ranging from 1.52m to 1.83 m. Average distance of post flight was 2.78meters on measured from the end of the horse to the ankle upon landing. The board take off variables were relatively of post flight was 2.78m as measured from the end of the horse to the invariant. However, a combination of small variations in the board contact variables profoundly affected the out come of the vault. At board take-off the horizontal velocity and vertical velocity of the gymnasts was found 4.95m/s and 3.60m/s respectively. The mechanical energy analysis indicated that the trunk and legs
segments accounted for over 80% of the total body mechanical energy components.

Tezuka K. (1984) analyzed judo technique on selected kinetic parameters. The purpose of the study was to investigate the use of combined cinematography and dynamography in the determination of: (1) consistency of performance of skilled judoka, and (2) differences among throwing techniques. Throws were analyzed with respect to three phases: preparatory, step in and flight of receiver. Results indicated that different styles of performance may be utilized by different skilled judoka while successfully performing the same throwing techniques. Flight patterns of the receiver obtained from the film provided evidence of the interpretation of force-time patterns. These flights also were correlated with the initial position of the thrower. When the receiver was unbalanced (weight mostly on the leg), the flight was shorter. Forces did not appear to be high as compared to collision type sports, it could not be ascertained which style was mechanically more efficient, more effective or safer. Differences in weight and size may prevent the identification of any one pattern.

Dawson and Lov (1984) conducted a study to investigate the relationship of selected kinematic variables to in high jump. Two Locan phase locked cameras were used to film the right subject performing six trails at different heights. Camera speed was set at 150 frames per second. The kinematical data collected from the film included Center of Gravity, displacement, velocity and different angles of body segments. A four feet by four feet platform was at the take off point. This force platform recorded forces on an oscillograph in the
vertical and horizontal right and left and horizontal front and backward direction. Fourteen selected variables thought to be representative of curved approach run to the F.B style high jump were co-related using spss sub program pearson correlation. A descriptive analysis utilizing the independent variable and repeated observations of the film was written. A 3 factor analysis of factors was run to complete reliability of subjects approach pathway over six trials. A reliability coefficient of 0.92 was found for consistency of the subject approach pathway as defined by degree of curve at foot plant over the final seven stride. Relationship within subjects revealed significant co-relation between horizontal velocity and actual velocity, and bar height and actual velocity at the tangent to the spiral. Significant relationship existed within subject attempting higher bar height as compared to subject attempting lower height bar.

Kawamura (1984) measured the center of gravity of back and front in standing posture of 26 judoka and 30 kendo which was measured by akita system, center of gravity measurement apparatus consisting of a homogeneous board, weight measure and a wedge-shaped supporting from which the following conclusions were drawn, (i) the centre of gravity line in a static standing posture of a judo player was slightly backward from the center of length (46.5%). And (ii) the center of gravity line in shinzentai of judo players was 40.5% from the heel, which showed that the body weight was backward than during the static posture.

Ikai M. and Matsumoto Y. (1984) in order to make scientific investigations on the principles underlying the various techniques used in Judo,
first analyzed the techniques, and made observations on their kinetics, and further wished to synthesize by adding psychological and physiological investigations. Among the throwing techniques a few were selected, and serial photographs of the performers in action were taken by means of a high speed camera. Each serial photograph was carefully analysed, and the kinetic principles of the techniques studied. Photography was made with 16mm camera with a speed of thirty two frames per second. The techniques studied were, Tsurikomi- goshi and Hiza- guruma. The performers were selected from the students of the Tokyo University of education, namely, Iida, Higushi, Kodama, Enomoto and Matsumoto. Photographs were taken from the side and above and from these serial photographs the centre of gravity were measured according to Knoll’s construction method. In the study following results and conclusions were obtained, the landing velocities were measured at 5/32 m/sec. Prior to actually hitting the floor, and as a result it was found that in the Hiza- guruma velocity was the lowest with 1.95 m p.s., and the highest in the Tsurikomi-goshi registering 7 m.p.s. The landing velocities measured were lower than expected.

Ray and Sen (1983) studied the whole body canter of gravity and it was determine as a point of intersection of transverse, frontal and sagital plane on 27 east India males. The C.G in the x-axis was 40.93% of the total foot length from the posterior end of the feet, the C.G. in the y-axis was 48.43% of the foot breath from the right side of the footmark. The respective values of C.G. in the x and y axis in case of standing with arm up and feet together were 40.96% and 48.18% a significant change in the C.G. in z axis was observed with change in posture.
The values were compared with western studies. It was observed that increased body height shifts the C.G. towards the head, whereas, the C.G. is shifted downward if the height is unaltered but body weight is increased. It also concluded that age has particular no influence over the change in the C.G.

Rashed S. (1980) conducted a biomechanical cinematographic analysis of selected full twisting movement in gymnastics. The problem of the investigation was to conduct a biomechanical analysis and make a comparison of techniques utilized in performance of the following gymnastic events; (i) the back salto with a full twist in the floor exercise event, (ii) the flyaway with a full twist in rings event and (iii) the flyaway with a full twist in the horizontal bar event. Two phase locan cameras were used to film eight male subjects executing twisting movements in three events. Two trails were filmed for each subject in each event camera speed was set at 100 frames per second. Only one trail per subjects in each event was selected for analysis. A computer programme was used for the biomechanical analysis of data. Five national judges were used to identify the better and poor performers. Reliability measurements were conducted on the investigator’s digitizing skill and on the judge’s scores. In the floor exercise event all subjects initiated the twisting motion before their feet lost contact with the floor. Mean horizontal displacement of the performer’s center of gravity was 1.67m. Mean vertical displacement of their center of gravity was 1.31m. Mean contact time was 0.146 seconds and mean during flight was 0.798 seconds. Mean body angle at take off was 84.3 degrees. In regard to the ring event, mean horizontal displacement of the performer’s center of gravity was 0.34 meters.
Where as the mean vertical displacement of their center of gravity was 1.99 meters. Mean flight time was 0.86 seconds. Body angle at position of hands release was found to be 145.6. Concerning the horizontal bar events mean horizontal displacement of the performer’s center of gravity was 1.79 meters. Mean of time taken during the flight was 0.946 meters. Mean of the performer’s body angle at hands release was 86 degrees. In comparing the performance of three events with each other, it was found that the nature of the individual event altered substantially the nature of the twisting motion. The following conclusions were drawn from the investigation (i) the movement of the arms after the body become airborn may be the most important motion in executing the twist and (ii) the angle of view influences the judge’s evaluation of a performer.

Asami, Takkaaki, and Toketo (1978) had undertaken a study to determine the positions of the center of gravity of the body during the fundamental posture of the judo, keydo and also during the standing erect posture. He also studied relationship between ‘shizentai, and the center of gravity of the body, the result indicated that (i) the center of gravity in the recumbent posture was the highest in the keydo. (ii) the center of gravity line in the erect posture of the kendoist passed the 51.4% point from the heel with the length of the foot as 100%. (iii) the center of gravity line of the judiest in the natural standing posture passed the 40.5% points from the heel indicating that body weight was put more to the rear. (iv) the center of gravity line of the kendoist shifts comparatively to the front. It was concluded that in the judoist kendoist and kyudoist the positions of the
tended lines passed more to the front than the center of gravity lines in all the five groups.

Nelson Kwok (1973) conducted a qualitative study on a cinematographically analysis of sprint running on nineteen varsity athletes from the universities of Maryland. In the study ten subjects were track sprinters and nine were baseball subjects. A 16mm Bolex camera with a 35mm lens was placed approximately 155ft. from and perpendicular to the centre of the 15 yard filming zone. The camera operated at 64 frames per second. The purpose of the study was to examine the relationship of velocity of running to three factors which may influence their velocity. These factors were (a) the angle to which the leg is raised (b) the length of the two strides and (c) the angle that the leg makes with the ground at point of touch down. The study suggest that a blueprint for efficient running would include, (a) a force push of the rear leg, (b) High knee lift, (c) long stride and (d) placement of the foot directly beneath the C.G. of the runner.

Higgins F. (1972) studied the mechanical factors that contribute to the vertical jumping height of four basketball players. The investigation included analysis of angular measurements of the elbow, shoulder, knee, hip and ankle. In addition to angular measurements the velocities of the arm movement, order of the position, velocity and acceleration of body parts during the selected jump were also investigated. Movie picture were taken of 4 professional basketball players performing vertical jump. Each subject’s best and poorest jump from a series of seven trials were selected and analyzed. It was found that during the
poorest jump, all the subjects showed lower hyper extension of the arm at the preparatory position, less shoulder flexion at the point of take-off. At the apex of jump: the knee, hip and ankles displayed equal or less extension of the point of take-off while the angle of body lean was equal to or greater at this same point. A slower rate of arm velocity was displayed prior to take-off while on the other hand the rate of arm velocity was faster at the point of take-off. From the study it was concluded that arm position, velocity and acceleration of hip and knee extension were important factor in the performance of vertical jump. It is also further concluded that the range of arm motion assisted in attaining maximum height during the jump.