Chapter - II

REVIEW OF RELATED LITERATURE

The scholar made a sincere attempt to locate literature by going through the various sources. Some of the relevant reviews have been cited below.

Jhajharia et al.\(^1\) (2012) studied, kinematical analysis of female basketball players in 3 point shooting (A Scientific Sports Engineering Study). Ten female Basketball players of CSJM University, Kanpur, were selected as subjects for the study. The videos as obtained by the use of digital video graphy were analyzed (the best trial) by Siliconcoach pro 7 software. Only one selected frame was analyzed. Selected variables were Ankle joint, Knee joint, Hip joint, Shoulder joint, Elbow joint, Wrist joint, Angle of release, Height of release, Velocity of ball and Standing height of players. The scores of the subjects in 3 point shot were used as the criterion variable in the study. To determine the degree of relationship between selected Kinematic variables with the performance in 3 point shot, Pearson’s product Moment Correlation Method was used.

The results revealed that the value of coefficient of correlation in case of Knee joint, Hip joint, Elbow joint, Wrist joint, Angle of release, height of release, velocity of ball and standing height of players showed insignificant relationship and in case of Ankle joint and Shoulder joint (right) showed significant relationship with the performance of subjects of coefficient of correlation for 8 degree of freedom (0.632).

Rojas et al.\(^2\) (2012) investigated to evaluate the anticipation time and kinematic factors in the movement of goalkeepers' center of mass when making a long-distance throw in handball. The sample group was composed of 14 goalkeepers


and field players. A force platform was used to measure the force of the goalkeepers' reaction movements, while the throwers' movements were recorded with high-speed cameras. The expert goalkeepers began to move 193 ± 67 ms before the ball was released, with a 67% success rate of interception. The inexperienced goalkeepers began their movement 209 ± 127 ms with a 24% success rate. The time taken by expert goalkeepers to begin a vertical movement of their CM, relative to the moment of the ball's release, was less than the time taken by inexperienced goalkeepers (77 ± 70 vs. 141 ± 108 ms respectively). The analysis of the velocity and movement indicated that expert goalkeepers wait longer before moving than the inexperienced goalkeepers.

Tillaar et al.³ (2012) investigated the throwing velocity and kinematics of over-arm throwing in team handball of elite female and male handball players. Kinematics and ball velocity of a 7 meter-throw in eleven elite male (age 23.6 ± 5.2 yr, body mass 87.0 ± 6.8 kg, height 1.85 ± 0.05 m) and eleven elite female (age 20.3 ± 1.8 yr, body mass 69.9 ± 5.5 kg, height 1.75 ± 0.05 m) team handball players were recorded. The analysis consisted of maximal joint angles, angles at ball release, maximal angular velocities of the joint movements, and maximal linear velocities of the distal endpoints of segments and their timing during the throw. The ball release velocity of the male handball players was significantly higher than the females (21.1 vs. 19.2 m · s(-1); p < 0.05). No major differences in kinematics were found, except for the maximal endpoint velocities of the hand and wrist segment, indicating that male and female handball players throw with the same technique. It was concluded that differences in throwing velocity in elite male and female handball players are generally not the result of changes in kinematics in the joint movements.

Hussain et al.⁴ (2011) studied analysis of forehand and backhand service in Badminton. For elucidate the differences between forehand and backhand short services in badminton, the present study was designed to analyze the kinematic variables and segmental angles - shuttle velocity, wrist angle, elbow angle and

shoulder angle of six male badminton players. The data were recorded during “North-Zone Intervarsity Championship” held at Aligarh Muslim University, Aligarh, India. All subjects in the study were right handed badminton players. The mean age, body height and body weight were reported as 18.33 years (±1.71), 166.5cm (±3.30) and 57.17kg (±7.93) respectively. The movements were recorded by ‘Canon Legria HF S10 Comcorder’ operating at 60 Hz. The identified clips were analyzed with the help of ‘Silicon Coach Pro 7’ motion analysis software. The result revealed that there was significant difference found between forehand and backhand short service in respect to shoulder angle at 0.05 level of Significance.

Dominic et al.\textsuperscript{5} (2011) investigated the relationship between the Kinematics characteristics of successful and unsuccessful shots during arm motion in Nigerian female basketball players and also the changes that take place in shooting techniques of players at three shooting distances of 2.74m, 4.67m and 6.40m shots. The stratified sampling technique was used to select 14 Subjects, consisting of 5 guards, 5 forwards and 4 centre players who represented Nigeria at the May 2009 edition of the West Africa Club side Championships in Togo. Videography was used to collect the data and APAS software was used for processing the data. Descriptive statistics of mean and standard deviation were used to describe the data while inferential statistics of Pearson Product Moment Correlation Coefficient and one way ANOVA was used to test for significant correlation among the three shooting distances. It was found that there was no significant difference between shooting accuracy of the guards, forwards and centre players. Significant intra and inter variability were found in the linear displacement, joint angular displacements and segmental displacements and velocity parameters of the segments. The ball projection parameters revealed intra significant variability while group relationship was established between successful and unsuccessful shooting distances parameters. The group correlation showed that group analysis hide the true status and performance of the participants in shooting and this may lead to wrong information about any of the basketball player if the mean value for the group was to be used. From the findings, intra trial analysis gives true position of each female basketball player’s jump shot status; therefore, it was recommended

\hspace{1cm} \textsuperscript{5} Dominic and Olufunmilola Leah. (2011). Kinematic Analysis of Arm Motion During Jump Shot in Nigerian Female Basketballers, Retrieved on 13\textsuperscript{th} May 2013 from: http://hdl.handle.net/123456789/2073
amongst others that sports scientists should engage in intra trial studies than inter trial
to enable individualistic approach to teaching and learning correct skills and
techniques for optimal performance. The insignificant difference also found in the
shooting accuracy and the elites' performance proved that players training and
practice should extend beyond the player's perimeter of play.

Delextrat et al. (2010) investigated the effect of playing experience on the
kinematic characteristics of the goal shooting action in netball players. Six county-
level junior and six senior goal shooters took part in the study. They were asked to
perform eight shots at goal and were equipped with 33 retro-reflective markers fixed
to anatomical landmarks for three-dimensional motion tracking. The shot was divided
into three periods: start of throw, shooting action, and release. The following variables
were determined for each period: position of the ball, joint angles and timings
between actions, joint angular velocities, and ranges of motion. The main results
showed a significant effect of playing experience, with senior shooters showing a
shorter delay between the movements involved in the shooting action, a significant
difference between the right and left elbow angles at the start of forearm extension,
and greater extension of the left shoulder and greater flexion of the left elbow at
release compared with junior shooters. These results might help to justify some of the
empirical observations made by coaches and direct them in their advice to players. In
particular, recommendations to junior players should focus on the simultaneity of leg
and arm actions and dissociation between the right and left arms during the shooting
action.

Ismail et al. (2010) Studied, Biomechanics Analysis for Right Leg Instep
Kick High. Quality kicking technique is the most important aspect of the soccer
player. The good kicking technique will increase quality of the games. The study was
focused on the biomechanics analysis of the national soccer players as well as
identifying to their kicking action and technique using the instep kicking. Data
management and analysis were performed using Silicon Pro Coach and the statistical

Sciences, 10: 1286-1292.
analysis carried out by using Minitab software. Image of instep kicking was captured during the study to obtain a visual of the kicking activity so that it can be analyzed. From that, the data for velocity, acceleration, angle of ankle and distance involved in kicking activity can be identified. Furthermore, the equation that relates with the variables was obtained through the ANOVA and regression model for each variable. Based on the findings, the velocity and distance was identified as significant to the force model. This study has shown that the highest average forces produced in force model analysis which using three step run. The highest average force is 5879.60 N, the highest average velocity is 8.2 m sec\(^{-1}\) with distance kick as much as 47.85 m and the multi linear model equation is \(y = -18.1+711x_1+0.146 x_2+396x_3\).

Erculj, Frane and Matej\(^8\) (2009) impact of fatigue on the position of the release arm and shoulder girdle over a longer shooting distance for an elite basketball player. The purpose of this case study is to establish how a gradual increase in fatigue affects the position of the arms and shoulders during a long shot in a basketball game. For this purpose, Primož Brezec, an elite National Basketball Association player, performed a total of 7 series of 20 shots from a distance of 7.24 m. The subject performed a special basketball motor task between individual series\(^6\) of shots. The fatigue gradually increased with each motor task, and in the meantime, the subject's heart rate (HR) and blood lactate concentration (LA) were measured. The height of each jump during the shot at the basket was measured, and all shots were recorded using a system of 3 digital cameras operating at a frequency of 50 Hz. Thereafter, a kinematic analysis was applied to calculate the height of the shoulder and wrist of the release arm, as well as the elbow and upper arm angles, with regard to the vertical line. The study results reveal statistically significant differences \((p < 0.05)\) between the series of throws in all measured variables. The heights of the shoulder axis and of the wrist both decrease with growing fatigue. This is particularly apparent in the last series, i.e., in the conditions of maximum fatigue (HR = 96% HR\(_{\text{peak}}\); LA = 9.7 mmol·L\(^{-1}\)). Both measured angles decrease drastically in the last series of shots. The results of the study clearly demonstrate changes in the shooting technique as a consequence of moderate and, in particular, heavy fatigue. The findings also suggest

the need for basketball coaches and basketball conditioning coaches to include moderate- and high-intensity exercise in their shooting practice sessions.

Laurie A. Malone⁹ to determine what factors are associated with successful free throw (FT) shooting in wheelchair basketball and to examine the relationship between shooting mechanics and player classification, a biomechanical analysis of clean shots was undertaken. Significant differences were observed between the player classes in FT shooting mechanics employed for a clean shot. Players from Classes 1 and 2 tended to release the ball from a lower height, with greater velocity and release angle. They demonstrated a smaller shoulder flexion angle at release and a greater maximum velocity at the shoulder and elbow. The clean shots of Classes 1 and 2 demanded greater accuracy with respect to release velocity and angle, yet the resulting ball trajectory displayed a greater margin for error than the shots observed in the upper classes. However, based on overall shooting percentage, the upper classes did not appear to take advantage of the predicted benefits provided by a higher ball release height.


and the force platform, resisting the forward momentum of the body. Negative acceleration of the upper limb following the propulsion phase reached a peak of 68.6 rad/s-2 for the arm and 82.4 rad/s-2 for the forearm. Peak shoulder deceleration torque was calculated at 4.1 Nm which was greater than during acceleration (1.6 Nm). The combination of kinematic and kinetic tools yielded a comprehensive analysis of the investigated skill. Future biomechanical studies may determine differences in skill execution between novice and professional players or variability in movement within a population of skilled netball players.

Chan et al. 11 (2009) studied to compare the knee loading and the hip position in the stance leg during a side-step cutting maneuver with and without dribbling while protecting the ball from a simulated defensive opponent. Thirteen recruited elite female basketball players were assessed in a randomized order to investigate three-dimensional kinematic and kinetic data by high-speed cameras. Results showed elite female basketball players that performed side-step cutting with dribbling exhibited a greater initial knee flexion angle (40.18 ± 9.50 vs. 34.54 ± 8.51 degrees; p = 0.004) and peak flexor moment (-1.12 ± 0.35 vs. -0.86 ± 0.38 N*m/Kg; p = 0.01), peak knee abduction angle (-8.48 ± 6.21 vs. -7.39 ± 5.26) degrees; p = 0.018) and peak abductor moment (-0.36 ± 0.61 vs. -0.10 ± 0.53 N*m/Kg; p = 0.02). The authors also found greater hip flexion angle and internal rotation angle during dribbling compared to non-dribbling tasks while the knee was in peak abduction, and in internal rotation. While the knee was in peak abduction angle, the hip flexion angle was 52.14 ± 10.33 vs. 60.77 ± 11.98; p = 0.00, and the hip internal rotation angle was 4.55 ± 6.61 vs. 6.39 ± 7.12; p = 0.00. Also, while the knee was in peak internal rotation angle, the hip flexion angle was 50.70 ± 8.84 vs. 58.52 ± 11.54; p = 0.00, and hip internal rotation angle was 6.46 ± 8.36 vs. 8.94 ± 7.63; p = 0.00. These findings suggested that female basketball players performing a side-step cutting maneuver with dribbling may experience a greater risk of non-contact ACL injury. This may warrant more task and sports-specific training in preventative programs for female basketball players to lower the risk of non-contact ACL injury.

Huang et al.\textsuperscript{12} (2007) studied, “Analysis of Volleyball Jump Topspin and Float Serve”. The purpose of this study is to describe the kinematic characteristics of the volleyball jump topspin and float serve. Thirteen international players performed jump topspin serves and another three players executed jump float serves participated in this study. Two JVC 9800 cameras (120Hz) recorded the players performed jump serves. The results showed the jump topspin serve has greater values than the jump float serve on ball velocity, COM velocities at takeoff, jump height, spike height, takeoff to line distance, and horizontal COM displacement. In addition, the mean 1.0cm and 0.7cm of COM spike difference for jump topspin and float serve indicates that elite volleyball players have good timing control during serve action. It is suggested that results from this study can provide useful information for coaches to train volleyball jump topspin and float serve.

Ishida et al.\textsuperscript{13} (2006) compared the kinematic features of the throwing motion between young baseball players of different age groups. Forty-four Japanese baseball players aged 6.1 to 12.3 years who regularly played baseball, including pitchers and position players, had their throwing actions analyzed three-dimensionally using high speed videography. Of this sample, 26 players aged above 9 years of age were categorized as the senior group, while the remaining 18 were categorized as the junior group. Senior group: throwers had greater height and body mass, and produced a greater ball speed than junior group: throwers. The throwing arm movement of senior group throwers was similar to that of adult skilled players. However, in the junior group throwers, the shoulder horizontal adduction angle was larger during the arm acceleration phase, and the maximum angular velocities of elbow extension and shoulder internal rotation occurred later than in senior group throwers. These results indicated that players aged above 9 years can acquire a mature throwing arm movement, while players younger than that will use an immature motion. A possible reason why these differences were shown is that the official baseball is relatively heavy for junior group throwers; they would be better advised to use a lighter ball in throwing practice.

\textsuperscript{12} Chenfu Huang et al. (2007), \textit{Kinematic Analysis of Volleyball Jump Topspin and Float Serve}, XXV ISBS Symposium, Ouro Preto-Brazil.

Roca et al.\textsuperscript{14} (2006) examined the relationship between shoulder alignment and elbow angle during the delivery action of fast-medium bowlers. The elbow and upper trunk alignment were recorded for 13 high-performance bowlers (mean age 20 years) using a 12-camera Vicon motion analysis system operating at 250 Hz. The three highest velocity trials for "good" and "short" length deliveries were analysed. Results showed that bowlers with a more front-on shoulder alignment at back-foot impact and when the upper arm was horizontal to the ground experienced a significantly greater elbow flexion–extension range when compared with those who had a more side-on orientation at the same point in the delivery action. Bowlers with greater shoulder counter-rotation also recorded higher elbow flexion and subsequently extension during the period from upper arm horizontal to ball release. Shoulder alignment and elbow angles were similar for "short" and "good" length deliveries. It was concluded that bowlers with a more front-on shoulder orientation at back-foot impact demonstrated a higher elbow extension from upper arm horizontal to ball release and are therefore more likely to infringe International Cricket Council elbow tolerance levels, compared with those who adopt a more side-on shoulder orientation at back-foot impact.

Hubbard\textsuperscript{15} and associates (2006) conducted study on three-dimensional dynamic model was presented for the motion of basketball shots that may contact the rim, the backboard, the bridge between the rim and board, and possibly the board and the bridge simultaneously. Non-linear ordinary differential equations with six degrees of freedom describe the ball angular velocity and ball centre position. The model included radial ball compliance and damping and contains five sub-models: purely gravitational flight, and ball-rim, ball-bridge, ball-board, and ball-bridge-board contact. Each contact sub-model has both slipping and non-slipping motions. Switching between the sub-models depends on the reaction force at, and velocity of, the contact point. Although the model can be used to study shots from any point on the court, researcher have used to study the sets of free throw release angle, velocity,


angular velocity, and lateral deviation angle that result in success (capture), as well as underhand free throws and those using an under-inflated ball. Free throw shots with larger backspin, lower inflation pressures, and underhand release conditions were shown to result in larger capture percentages.

Hirano\textsuperscript{16} (2006) compared the kinematic features of the throwing motion between young baseball players of different age groups. Forty-four Japanese baseball players aged 6.1 to 12.3 years who regularly played baseball, including pitchers and position players, had their throwing actions analyzed three-dimensionally using high speed videography. Of this sample, 26 players aged above 9 years of age were categorized as the senior group, while the remaining 18 were categorized as the junior group. Senior group throwers had greater height and body mass, and produced a greater ball speed than junior group throwers. The throwing arm movement of senior group throwers was similar to that of adult skilled players. However, in the junior group throwers, the shoulder horizontal adduction angle was larger during the arm acceleration phase, and the maximum angular velocities of elbow extension and shoulder internal rotation occurred later than in senior group throwers. These results indicated that players aged above 9 years can acquire a mature throwing arm movement, while players younger than that will use an immature motion. A possible reason why these differences were shown is that the official baseball is relatively heavy for junior group throwers; they would be better advised to use a lighter ball in throwing practice.

Huong\textsuperscript{17} (2006) conducted Kinematic analysis of the Volleyball Back row Jump Spike. Eight elite male players participated in this study. The result indicated that the 1 foot spike had a greater approach, center of mass (CM), a greater horizontal CM velocity at take off and a shorter spiking time than that of two foot spike. The swing leg of the 1 foot jump spike also played an important role in contributing forward momentum to the jump during the support phase.


\textsuperscript{17} Chanfu Huong, Ging Chan Liu and Tai Yen Sheu. (2006). \textit{Kinematic Analysis of the Volleyball back row Jump Spike}, National Taiwan Normal University, Taiepei, Taiwan, retrieved on 15 June, 2011 from www.sportssscience.com,
Vasiliki Kouvelioti\textsuperscript{18} (2006) investigated shot's and jump shot's basic characteristics, in Basketball, as they appear in qualitative and quantitative (biomechanical) studies. The angle, height and velocity of ball release, the angle of ball insertion into the hoop, the balance and the center of mass of the body, are the main biomechanical characteristics of shooting. The optimal angle of ball release varies from $35^\circ$ up to $48^\circ$ and depends on the height, distance and velocity of ball release. The angle of insertion is a combination of various factors, mainly ball spin, ball trajectory, velocity, and the range of the hoop. A shot is successful when the ball falls into the basket at a range of angle relative to basket. As shot distance increases, the height of ball release decreases and the angle of ball release remains the same. Guards and forwards seem to have a greater extension and flexion range for the basic joints, than the centers. There are also differences in the shooting technique, between males and females. Further investigation on motor control and muscle activity patterns during Basketball shooting is required. The alteration of shooting technique in game and fatigued conditions is not investigated.

Primoz Pori\textsuperscript{19} (2005) examined the jump shot as it is one of the most important elements of specific handball motor behavior. He wanted to assess it with the method of expert modeling. The sample of subjects consisted of ten male elite handball players, members of the national Slovenian teams that played in the first national handball division (average height - 191.1 ± 4.48 cm; average body mass - 90.0 ± 4.40 kg, average age - 23.4 ± 4.2 years; average training experience in senior teams - 5.3 ± 2.1 years). He analyzed six backcourt players, two wing players and two pivots. Each of the subjects executed, after a 20-minute warm-up, three jump shots. Data processing was performed by APAS (Ariel Dynamics, California, and U.S.A). Expert modeling was performed with the SPEX expert system. He formed a success tree containing 17 variables, representing all five phases of the jump shot. In order to assess the validity of this kinematic model, three independent referees also assessed the quality of the jump shot. The ranks obtained from their marks were then compared


with the ranks obtained with the SPEX expert model. On the basis of the obtained results, he then constructed an expert mark for each analysed player. The level of concordance of the referees was high ($W = 0.875$), the coefficient of correlation between the actual ranks and the referee ranks was statistically significant (0.912). The final finding is that a kinematic model of the jump shot constructed in this way can also be a good criterion for assessing the quality of the basic technique of the jump shot for seniors.

Giatsis’s\textsuperscript{20} (2004) purpose of this investigation was to detect whether differences exist concerning the dynamic and kinematic parameters of vertical squat jump (SJ) on rigid (RS) and sand (SS) surface. Fifteen elite male beach volleyball players (age: 25.6 +/- 6.2 years; height: 188.0 +/- 3.5 cm; body mass: 83.2 +/- 6.0 kg; mean +/- SD, respectively) performed SJ. Force platform and kinematic analyses were used with paired sample T-tests to evaluate the differences. Vertical jump height was significantly smaller ($p < .001$) on SS than RS. Maximal force and maximal power were significantly higher on RS than SS ($p < .05$ and $p < .01$ respectively). Impulse time was larger in SS but with no significant difference ($p = .286$). Kinematic analysis revealed significant differences between the values of ankle joint during starting posture ($p < .01$) and of hip joint at the moment of take-off ($p < .05$). Ankle joint range of motion and angular velocity was larger in SS ($p < .05$). In conclusion, SJ height on SS was smaller than on RS because of the compliance and the instability of the sand. This resulted in a reduction in maximum force and take-off velocity. Furthermore, the compliance of SS made it hard for the ankle to push along the vertical axis of the movement of the body and as a result it slipped behind in an attempt to maximize propulsion. As a result, the body tries to balance and equalize this movement and move the hip to larger extension.

Previous studies of multipoint arm movements have shown that the CNS holds arm kinematics constant in different situations by predicatively compensating for the effects of interaction torques. It was determined whether this was also the case for wrist joint flexion in natural overarm throws performed by skilled subjects in 3D, a

situation where large passive torques can occur at the wrist. Specifically, Gribble\textsuperscript{21} (2004 investigated whether wrist flexion amplitudes are held constant in throws of different speeds. Joint rotations were recorded at 1,000 Hz with the search-coil technique. Contrary to a previous study on constrained 2D throwing, indirect evidence was found that in fast throws passive torques associated with forearm deceleration were exploited to increase wrist flexion velocity. This increase in wrist flexion velocity was associated with constant wrist flexion amplitudes at ball release (mean 27 degrees) for throws of different speeds. Furthermore, final wrist flexion positions after ball release were similar for a particular subject irrespective of the speed of the throw. This was associated in faster throws with increased magnitudes of wrist flexor and wrist extensor EMG activity which damped passive torques associated with forearm angular deceleration. It was concluded that wrist flexion in overarm throws of different speeds was produced by central signals which precisely controlled net joint torque by both exploiting and damping passive torques during different parts of the throw to keep wrist joint angular position parameters constant. As such the results showed that control strategies for natural 3D throwing are different from those for constrained 2D throwing.

Sanders\textsuperscript{22} (2003) the analysis of variability both within and between performers can reveal important information about how athletes satisfy situational constraints. Transitory changes in the basketball free-throw shot were examined across different stages in skill development. Six female basketball players were selected, representing a range of playing expertise (pretest: 0-90% baskets scored). Each participant was video recorded performing 30 shots. Contrary to predictions, there was not a clear pattern of a reduction in trajectory variability with increasing skill level. However, improvements in skill level were associated with an increasing amount of intertribal movement consistency from the elbow and wrist joints. It was suggested that the angular motions of the elbow and wrist joints were compensated for each other toward the end of each throw to adapt to subtle changes in release parameters of the ball.

Marko's (2002) aim of this study was to identify differences in some basic kinematic parameters between two different jump shot (JS) techniques used in handball. Ten male top-level handball players executed six JS (three shots using each technique). Among all attempts, he chose two JS for all players, the most characteristic for each technique, for further analysis. Two SVHS Video cameras operating at 25 frames per second were used for the acquisition of the data. Data processing was performed by APAS (Ariel Performance Analyses System). Basic statistics for variables were computed, and the t-test for paired samples was used to assess statistical significance differences between kinematic variables. Many similarities and differences between both shots were found. Most interesting are the following characteristics: almost all parameters of approach show that the efficiency of the approach in the last step was better in jump shots where the take-off leg is opposite the throwing hand (JS1); the body centre of gravity in JS2 (the take-off leg is on the same side as the hand with which the players are shooting) before the thrower moved forward significantly more than the body centre of gravity by JS1; in JS1 the height of the throw was significantly greater than in JS2; the angle between the shoulder axis and the horizontal axis in the sagittal plane at the end of the take-off was significantly greater in JS1. The angle in the hip axis was significantly greater in JS2; landing in JS1 was mostly made with the take-off leg (left leg) while in JS2 it was made with the opposite leg (left leg).

Oudejans (2002) research on visual search in aiming at far targets assumes pre-programmed motor control implying that relevant visual information is detected prior to the final shooting or throwing movements. Eye movement data indirectly support this claim for stationary tasks. Using the basketball jump shot as experimental task was investigated whether in dynamic tasks in which the target can be seen until ball release, continuous, instead of preprogrammed, motor control is possible. It was tested with the temporal occlusion paradigm: 10 expert shooters took shots under four viewing conditions, namely, no vision, full vision, early vision (vision occluded

---

23 Marko Sibila. (2002). Basic Kinematic differences between two types of Jump shot Techniques in Handball, Faculty of Sport, University of Ljubljana, Slovenia, p. 89.

during the final +/-350 ms before ball release), and late vision (vision occluded until these final +/-350 ms). Late-vision shooting appeared to be as good as shooting with full vision while early-vision performance was severely impaired. The results implied that the final shooting movements were controlled by continuous detection and use of visual information until the ball release. The data further suggested that visual and movement control of aiming at a far target developed in close correspondence with the style of execution.

Doyo\textsuperscript{25} (2002) conducted a study on Kinematics aspects of the reduced shooting ability of tetraplegic (TP) wheelchair basketball players were investigated and compared with those of able-bodied (AB) basketball players. TP showed significantly smaller values for the vertical component of ball release velocity (4.26 (degree/s) versus 5.45 (degree/s)) and maximum wrist flexion angular velocity (878.4 (degree/s) versus 1445.9 degrees) than AB. Moreover, for a specific shoulder horizontal adduction motion, a larger range of shoulder abduction motion and larger displacements of the right shoulder were observed in TP. The reduced ball velocity of TP subjects with lesions at the C7 to C8 levels depended on an insufficient wrist flexion angular velocity, where dysfunction of available musculature may be a causal determinant. Further, the specific motions observed in TP subjects most likely maximize the function of available musculature, thereby partially compensating for the dysfunction of the wrist flexor muscles and contributing to resultant ball release velocity.

Escamilla et al.\textsuperscript{26} (2001) compared and evaluated the kinematics of baseball pitchers who participated in the 1996 XXVI Centennial Olympic Games. Two synchronized video cameras operating at 120 Hz were used to video 48 pitchers from Australia, Japan, the Netherlands, Cuba, Italy, Korea, Nicaragua and the USA. All pitchers were analysed while throwing the fastball pitch. Twenty-one kinematic parameters were measured at lead foot contact, during the arm cocking and arm acceleration phases, and at the instant of ball release. These parameters included stride


length, foot angle and foot placement; shoulder abduction, shoulder horizontal adduction and shoulder external rotation; knee and elbow flexion; upper torso, shoulder internal rotation and elbow extension angular velocities; forward and lateral trunk tilt; and ball speed. A one-way analysis of variance (P < 0.01) was used to assess kinematic differences. Shoulder horizontal adduction and shoulder external rotation at lead foot contact and ball speed at the instant of ball release were significantly different among countries. The greater shoulder horizontal abduction observed in Cuban pitchers at lead foot contact is thought to be an important factor in the generation of force throughout the arm cocking and arm acceleration phases, and may in part explain why Cuban pitchers generated the greatest ball release speed. It was concluded that pitching kinematics were similar among baseball pitchers from different countries.

Bourret (2000) studied the matching equation that was applied to evaluate the allocation of two- and three-point shots by male and female college basketball players from a large Division 1 university. The matching law predicts that the proportion of shots taken from three-point range should match the proportional reinforcement rate produced by such shots. Thus, it was compared that, the proportion of three-point shots taken relative to all shots to the proportion of three-point shots scored relative to all shots scored. However, the matching equation was adjusted to account for the greater reinforced magnitude of the three-point basket (i.e., 1.5 times greater than the two-point basket reinforced magnitude). For players with substantial playing time, results showed that the overall distribution of two- and three-point shots was predicted by the matching equation. Game-by-game shot distribution was variable, but the cumulative proportion of shots taken from three-point range as the season progressed was predicted almost perfectly on a player-by-player basis for both male and female basketball players.

Cepero’s (2000) aim of this study was to analyze the adjustments in technique made by a basketball player when shooting against an opponent. The subjects used

---


consisted of 10 professional basketball players of the Spanish First Division League. Three-dimensional motion analysis based on video recordings (50 Hz) was used to obtain the kinematics characteristics of basketball jump shots with and without an opponent. It was found that when performing against an opponent the release angle of the ball increased, the flight time was reduced and postural adjustments as determined by the angles at the knee and shoulder increased, all significantly. There were several other non-significant differences that helped to interpret the changes in technique imposed by the presence of an opponent. It was suggested that when shooting with an opponent, players attempted to release the ball more quickly and from a greater height. This strategy will lessen the chance of the opponent intercepting the ball. It was concluded that the differences noted in the technical execution of the skill had implications for practice. It was suggested that training would benefit from practice with an opponent for at least some of the time to condition players to the demands which they were more likely to meet in the game situation.

Loye\textsuperscript{29} (1999) analysed the movement characteristics of 3 female Olympic Volleyball players performing the deep cross court spike was undertaken in this study. The investigation decided to film as many trials as was deemed necessary in order to obtain a minimum of 5 “good” hand driven spikes for each of the participants. Each spiker was allowed to warm up prior to the administration of the test. The ball was put in play by the spiker who passed it to a high skilled setter. Three 16 mm cameras photographed the spikers from the side, rear and overhead views. A playground Motion Analyzer was used to extract the data from the films. The conclusion indicated the distance of the start of the approach from 7.43 to 10.08 ft.; the angle of approach in relation to the side line and the net rangers from 39.46° to 65.22°; the max decrease in reacting height at the moment of contact, resulting from the utilization at the moment of contact, resulting from the utilization of hip and trunk flexion was 4.56 in; the maximum projection velocity of the ball was 44.05 mph.

Burton\textsuperscript{30} (1999) investigated the effect of distance on the accuracy and movement form in basketball shooting by using a dynamic systems approach. Five


males and five females young adults (M = 26 yr.) with no basketball experience beyond regular physical education shot a basketball 20 times at each of eight distances from 5 to 40 ft. (Natural condition). Also, they pretended to shoot the ball 5 times at each of the eight distances, for a total of 200 shot each (Pretend condition). In the Natural condition, shooting accuracy significantly decreased as shooting distance increased. Across both conditions and across four body components (feet position, hand position, trunk rotation, and jump height), the participants shifted from one movement pattern to another 86.3% of the time as shooting distance increased. The distances at which the transitions occurred were significantly shorter in the Natural than the pretend condition for the feet and hand components but not the trunk and jump-height components. These results indicated that shooting a basketball at increasing distances can be portrayed as a dynamic system characterized by abrupt changes in at least four body components at critical distances.

Barrentine (1998) conducted this study for kinematic analysis of the wrist and forearm during baseball pitching. Previous researchers studying baseball pitching have compared kinematic and kinetic parameters among different types of pitches, focusing on the trunk, shoulder, and elbow. The lack of data on the wrist and forearm limits the understanding of clinicians, coaches, and researchers regarding the mechanics of baseball pitching and the differences among types of pitches. The purpose of this study was to expand existing knowledge of baseball pitching by quantifying and comparing kinematic data of the wrist and forearm for the fastball (FA), curveball (CU) and change-up (CH) pitches. Kinematic and temporal parameters were determined from 8 collegiate pitchers recorded with a four-camera system (200 Hz). Although significant differences were observed for all pitch comparisons, the least number of differences occurred between the FA and CH. During arm cocking, peak wrist extension for the FA and CH pitches was greater than for the CU, while forearm supination was greater for the CU. In contrast to the current study, previous comparisons of kinematic data for trunk, shoulder, and elbow revealed similarities between the FA and CU pitches and differences between the FA and CH pitches. Kinematic differences among pitches depend on the segment of the body studied.

The purpose of the study by A. Ferreira and J. Abrantes (1997) was to analyse the effects of basket height and ball size on some mechanical parameters of shooting technique. Ten to thirteen years old right-handed basketball players were the subjects in this study. A total of 113 shoots were digitized and analysed in a bi-dimensional software program named BIOSIST. Two kinds of kinematics parameters were considered: instant kinematics parameters, determinate on the instant of ball release, and behavior kinematics parameters, which are relative to shooting time. Two heights of basket and two sizes of ball were used. Results point to significant differences in linear velocity of shooting hand and height of same segment on ball release, when regular and adapted conditions of basket height were compared. Ball size seemed to have more influence on displacement of centre of mass, particularly on its horizontal path during shooting time. Despite the small differences obtained on intersegmental angles, for both conditions of basket and ball, the adapted form of these variables promotes a better quality of execution for the players. More significant than ball size, the tendency of results reveals that the adaptation of basket height could create an execution in which its characteristics are similar to theoretical models used by coaches.

Reinschmidt (1997) using a theoretical approach studied the basketball free throw as a function of angle, speed and spin at release. The ball was constrained to the sagittal plane bisecting the hoop and normal to the backboard, and was permitted to bounce and change spin on both backboard and hoop. Combinations of angle speed and spin resulting in a successful shot were calculated analytically. Standard deviations for a shooter's angle and speed were used to predict the optimum trajectory for a specific position of release. Standard deviations for a shooter's angle and speed were used to predict the optimal trajectory for a specific position of release. An optimal trajectory was predicted which had an initial angle and speed of approximately 60 degrees and 7.3 m s⁻¹ respectively over the domain of spins [-2 to +2 m s⁻¹ surface speed; -16 to +16 radian s⁻¹].

---


The effect of air resistance and the sagittal plane constraint on the predicted optimal trajectory were discussed and quantified. The optimal trajectory depended on both the anthropometric characteristics and accuracy of the shooter, but generally a high backspin with an angle and speed combination which sent the ball closer to the far rim of the basket than the near rim was advantageous.

Bartlett\textsuperscript{34} (1996) conducted a study on three-dimensional cinematography (100 Hz) that was used to establish the relationship between distance and the kinematics of shooting with respect to playing position in basketball. Fifteen subjects, divided into guards, forwards and centers (N = 5), performed jump shots from each of three distances: 2.74, 4.57 and 6.40 m from the basket. Increases in mean release speed were found, as shooting distance increased for all groups. This was due to increased angular velocities of both shoulder flexion and elbow extension and an increased speed of the centre of mass in the direction of the basket. Release angles for the two shorter distances (52-55 degrees) tended to provide the advantage of a steep angle of entry into the basket, whereas those at the longest distance (48-50 degrees) were closer to those requiring the minimum possible release speed. All groups exhibited an earlier timing of release as shooting distance increased, which gave rise to an earlier rotation of the shoulder axis. The more consistent changes in kinematics patterns with changes in shooting distance exhibited by guards as compared to centers would suggest that such adjustments are easier to make for those players who regularly shoot from long range.

Milaovic and other\textsuperscript{35} (1996) studied the kinematics analysis of javelin release characteristics. The purpose of this study was to analyses characteristics performed by one creative athlete with those performed by the best male throwers in the 1992 Olympics game in Barcelona. The achieved results show significant difference in numerous parameters i.e. release angle, release velocities, knee and elbow angle, grip distance as well as difference in timing significantly influence. The distance of throw, they should be correlated during the training process is order to increase the distance.


\textsuperscript{35} Dragon milavic, Laden Mejovek and Zelijko Haraski. (1996). \textit{Kinetic Analysis of Javelin release characteristics, A case study}, International scientific journal on kinesiology and sport, p. 44.
Chenfu36 (1994) quantified and compared the biomechanical variables that characterized the advance and the intermediate Volleyball players when performing the quick and middle block jumps. Twenty four subjects were videotaped and the vertical ground reaction forces during the block jumps were recorded by a force platform. A two way repeated measure ANOVA was performed on the dependent variable between skill level and method of blocking. It was concluded that the vertical velocity of the body C.G. at take off was an important variable for increasing jumping height. The quick block showed a shorter propulsive phase time and a greater peak vertical ground reaction force. The middle block indicated the opposite. It was recommended that the plyometric exercises combined with actual blocking drills should be used during training to improve the blocking ability.

Bartlett37 (1993) conducted a study on Three-dimensional video techniques (50 Hz) were used to obtain images of basketball jump shots from one of three distances--short range (group 1, N = 5); medium range (group 2, N = 5); long range (group 3, N = 5) from the basket, as performed by members of the men's quarter-finalist teams at the games of the XVI Universiad in Sheffield. Fifteen sequences were digitized, beginning 20 frames prior to take-off to 10 frames after release. To facilitate analysis, the sequences were rotated about the ball position in the final frame so that the shot direction was parallel to one of the pre-defined orthogonal axes. Mean (+/- 1 S.D.) ball release speed was found to increase with distance from the basket (group 1 = 3.04 +/- 0.65 m s-1, group 2 = 4.71 +/- 0.74 m s-1, group 3 = 6.24 +/- 0.80 m s-1), while mean release angles were similar for all groups (group 1 = 48.8 +/- 10.1 degrees, group 2 = 47.8 +/- 5.8 degrees, group 3 = 51.9 +/- 5.5 degrees). The increased impulse necessary for the ball to reach the basket at increased shooting distances was derived from both an increase in angular velocity of the elbow joint of the shooting arm and an increased velocity of the centre of mass in the direction of the basket at release. Centre of mass speed at take-off was found to be influenced to a greater extent by the angular velocity of the ankle joint than that of the knee or hip joints.


Applegate (1992) Common sense suggests that decreasing visual acuity will have a negative effect on basketball shooting performance. To test the hypothesis that basketball shooting performance monotonically decreases with decreasing acuity, 19 subjects attempted 25 set shots from a fixed location at each of 5 different acuity levels: 6/6 or better and vision blurred (by optical defocus) to visual acuities of 6/12, 6/24, 6/48, and 6/75. The results revealed a small but statistically non significant decrease in shooting performance between the 6/6+ and 6/12 conditions. For visual acuities between 6/12 and 6/75, the number of baskets made remained constant. It was concluded that decreases in visual acuity over the range of 6/6+ to 6/75 resulting from defocus did not significantly reduce set shot shooting performance.

Park (1990) investigated selected kinematics and kinetic parameters of the three types of taekwondo front kicks. The performance of the 18 black belt level subjects were filmed using a 16mm. Camera set at 100 frame per second as they performed kicks with the supporting foot on a AMIS force platform. Statically treatment included an analysis of variance with a new man-karts follow-up test to compare the kicks and a Pearson’s product moment. Correlation was performed between knee angle and resultant foot velocity, and the kicking line. Result was (1) A shorter kick, accounted for by a shorter preparatory time (97.5m.sec.) (2) Tendency for greater foot velocity with greater knee flexion especially in the straight trunk position. (3) A lower foot position in KB than was found for KF and KS early in the Kicking pattern, (4) Similar patterns of liner and angular velocity and acceleration for the foot and segments (except foot angular acceleration), muscle moments of the hip, knee, ankle and vertical ground reaction forces of the supporting leg.

Jacques H. A. and Van Rossum (1989) studies on Fourty boys and girls of two age groups (mean ages 52 and 70 months, respectively) performed 35 trials on a throwing task demanding accuracy. As might be expected, the older children were

---

significantly more accurate than the younger ones but there were no sex differences. Film analysis of the throws showed that, although both age groups attempted to employ the adult strategy of varying velocity while keeping ball-release angle constant, the younger group was less successful in the latter aspect. The manner in which consistent release angles were arrived at by the older group was through the use of a movement pattern in which the elbow angle did not change during the forward swing. Such a movement pattern appeared less frequently in the younger age group. The results of this study provide support for a mode of research identifying functionally relevant kinematic variables that can subsequently be shown to follow from distinctive execution categories. In such a way, changes in outcome measures with increasing age and/or skill level can be functionally understood and identified.

Cielinski 41 (1989) conducted a study on effect of prohibiting the use of a pre shot routine on free-throw shooting in competitive situations was investigated. Twenty-five male high school basketball players were instructed to attempt 50 free throws alternating in blocks of 10 between the uses of their pre shot routine and shooting without it. To make the situation competitive, subjects were run in groups of five and their performance was recorded on a large easel placed to the side of the free-throw line. A significantly larger number of baskets were made in the pre shot routine condition than without the routine. A competitive situation led to a greater decrement in baskets than had been reported earlier during noncompetitive free-throw shooting.