

**A BIOMECHANICAL ANALYSIS OF LAYUP SHOT
FROM DIFFERENT FIELD POSITIONS**

**A SYNOPSIS OF THESIS SUBMITTED TO
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INTRODUCTION

Sport encompasses all forms of physical activity that aim to express or improve physical fitness and mental well-being, form social bonds, or achieve competitive results at all levels through casual or organised participation. Sport has existed since the dawn of time because man is naturally athletic and playful. It often refers to a competitive use of physical and mental skills, as well as a playful self-development, self-actualization, and self-actualization. Sports have been around for as long as humans have existed. Since the beginning of human history, games and sports have existed as a socio-cultural phenomenon shaping human character and personality in their own characteristic style.

Science is a systematic human effort to understand the natural world's past and how it operates, using visible physical facts as the foundation of knowledge. It is done by observing natural phenomena and attempting to trigger natural processes under controlled conditions through experimentation. Science is a systematic human attempt to comprehend, or better comprehend, the history of the natural world and how the natural world functions, using measurable physical evidence as the foundation. It is achieved by observing natural phenomena and attempting to induce natural processes under regulated conditions through experimentation.

Biomechanics is also one of the most important elements of science in contemporary sport. We can analyse all human movements with the knowledge of this. "Biomechanics is the science that examines the internal and external forces acting on a human body and the effects produced by these forces" (James G. Hay). Biomechanics is a term formed by combining the words bio meaning "life" or "man" and mechanics refers to the physics branch that addresses movement and motion causes. In sport biomechanics, mechanical laws are applied to human movement in order for athletic performance to be better understood and sports injury to be reduced.

Basketball is a non-contact team sport played on a rectangular court by two teams of five players each. The objective is to shoot a ball through a hoop 18 inches (46 cm) in diameter and 10 feet (3.048 m) high that is mounted to a backboard at each end of the court. The game was invented in 1891 by Dr. James Naismith, who would be the first basketball coach of the Kansas Jayhawks, one of the most successful programs in the game's history. (wikipedia)

The basketball game began its journey in India in 1930, when it was first played. The first Indian National Championship for men was conducted in 1934 in New Delhi. The Basketball Federation of India (BFI), which controls the game in India was formed in 1950. Throughout history Indians have been able to appreciate the game from the beginning until the end because of its rapid and intense activity. It is now regarded as one of India's most frequently performed sports. India is one those first few countries in the history of basketball that adopted the game within a few years of its inception. (wikipedia)

Physical education professionals have long known that athlete's success is strongly influenced by age, height, weight and body structure. It recognises that the same age person varies considerably in size and shape and that the same height person is very different in the body weight, but the relative muscle fat and bone proportion are not equal. Training cannot change the constitutional qualities. Highness and physical are the main constitutional qualities. The players ought to be big. Even if the coach believes that a basketball player requires good height, it is difficult to specify a minimum height. In the same way the athletic body of the player should be. In addition to obvious physical characteristics and abilities such as good height, fairly high fitness and endurance, there are also many features necessary for not just basketball players but the majority of team sport players.

The layup shot in basketball is regarded as the most fundamental. The player lifts his foot out of the basket or his foot away when making a layup. It's a foul thing if one holds the other person's hand during your layup or push it away to prevent him or her. A layup is very handy and to defend it, you just have to stand with your arms stretched out in front of the adversary.

In the layup shot the player runs towards the basket while dribbling the ball in their right hand, they then place their right foot followed by their left and take off, releasing the ball towards the basket by completely extending their shooting arm (Sandeep & Bhardwaj, 2011). The layup is considered one of the more basic shots in basketball. The main obstacle when performing a layup is getting near the baskets rim and avoiding the taller defenders blocks (Sandeep & Bhardwaj, 2011). The layup is made with one hand and from a position under or beside the basket (Sandeep & Bhardwaj, 2011).

We have noticed that in India the popularity of basketball increasing rapidly with high speed. So, the players have to improve their skills and the coaches have to implement new training methods, strategies, etc. But there is merely any growth in the field of biomechanics research

about basketball, by which the players will raise their skills and the coaches will upgrade their training process. One of the main tasks of biomechanics in sports is to support the development of better motor dynamics for individual and team sports. By measuring motor characteristics and by comparing them with data from motor dynamics of athletes who have achieved good results. Raw data helps in the findings. The value of these data is increased and the findings are dependent if methods of mathematical statistics are used in the analysis. Such an approach, however, has its limitations. The fact that the motor characteristics measured the efficiency of the motor process, as well as the existing level of motor abilities, are included. Therefore, specific criteria are necessary for analyzing the efficiency of the motor process. Such criteria co exists more or less in all sports. They are derived from the large fund of experience of sports practice and they have (in most cases only afterward) been theoretically investigated. Thus, in different sports events, theories on the efficiency of motor processes have been established. These made essential contributions to the techniques in sports. There are several examples where a new technique was found in practice by trials, which was much better than a previously used technique and which soon replaced the old technique.

STATEMENT OF THE PROBLEM

The purpose of the study was to, biomechanically analysis the layup shot in basketball from different field positions. Thus the problem was accordingly stated as, **“A BIOMECHANICAL ANALYSIS OF LAYUP SHOT FROM DIFFERENT FIELD POSITIONS”**.

OBJECTIVES OF THE STUDY:

The objectives of the study were –

- To describe the biomechanical parameters contributing to layup shot in basketball.
- To determine the difference of biomechanical parameters for performing layup shot from the different parts of the two point field goal area.
- To explore the common biomechanical parameters in layup shot from the different parts of the two point field goal area.
- To distinguish the biomechanical parameters in layup shot from the different parts of the two point field goal area.

DELIMITATION OF THE STUDY:

The present study was conducted with following delimitations:

- The study was delimited to the national level basketball players from the state of West Bengal only.
- The study was further delimited to ten basketball players consisting five male and female players each.
- The study was further delimited to right handed players only.
- The data was collected during non-competition situations.
- The data for the present study was collected by using video technique.

LIMITATIONS OF THE STUDY:

The present study was conducted under following limiting conditions:

1. The previous fitness level of the players was taken into consideration.
2. The level of fatigue before layup shot was not considered.
3. The physiological and psychological factors which might influence the layup shot performance were considered as a limitation of the present study of the players.
4. The heredity and environmental factors which might influence the results of this study were not controlled.
5. Certain factors like personal habits, life style, diet and climatic conditions were not taken into account in this study.
6. Non availability of high speed cine cameras and updated motion analysis software was the major limitation for the study.
7. The data for the present study was not collected in competition situation.
8. The motivation, interest and arousal to perform best during test were limiting factors for this study.
9. The training age of the players was not considered in this study.
10. The non-availability of higher performer was a limiting factor for this study.

HYPOTHESIS

On the basis of knowledge reflected by the available literature, research findings, experts opinion and the scholar's won understanding of the problem it is hypothesized that there will be no significant differences in biomechanical parameters of layup shot in basketball from the different parts of the two point field goal area for both male and female basketball players.

REVIEW OF RELATED LITERATURE

Vencúrik, et al., (2021) conducted a study on the, “**Kinematic Analysis of 2-Point and 3-Point Jump Shot of Elite Young Male and Female Basketball Players.**” The study aims to compare the selected kinematic variables of 2-point (2-pt) and 3-point (3-pt) jump shots (after making a cut and receiving the ball) and ascertain the differences between elite male under 16 and 18 (U16M, U18M) and female under 16 and 18 (U16F, U18F) basketball players. Overall, forty-eight young male and female basketball players participated in the study. 3D motion analysis using an inertial suit with the addition of utilizing a smart ball was performed for assessing the 2-pt and 3-pt shooting techniques. Players in male categories shot for 2-pt with a higher center of mass difference in the vertical direction (U16M 5.7 cm, U18M 3.9 cm vs. U16F 1.4 cm, U18F 0.6 cm), with higher release shoulder angle (U16M 110.9, U18M 113.8 vs. U16F 103, U18F 105), and with a higher entry angle of the ball (U16M 34, U18M 32 vs. U16F 30, U18F 30) when compared to female categories ($p < 0.001$). In the 3-pt shooting, there were differences between male and female categories in the shoulder angle when releasing the ball ($p < 0.001$). In the players shooting speed, there were differences between U16M vs. U18F (0.95 ± 0.1 vs. 0.88 ± 0.1 ; $p = 0.03$) and U16F vs. U18F (0.96 ± 0.06 vs. 0.88 ± 0.1 ; $p = 0.02$) players. Male categories shot 3-pt shots with a smaller center of mass difference in the horizontal direction when compared to 2-pt shots ($p < 0.001$). The entry angle was higher in successful shooting attempts compared to unsuccessful shooting attempts when shooting for 3-pt ($p = 0.02$). Player shooting speed was higher in all categories (except U18F) when shooting for 3-pt ($p < 0.001$). It appears that performers show difference in kinematic variables based on distance from the basket.

Twinkle and Dr. Manju Mehta, (2020) examined the, “**Biomechanical Factors Contributing while Effective Shooting in Basketball.**” In this paper they mainly used the two dimensional technique to analyze the Three Point Shoot performance of Basketball and to acquire relevant bio-mechanic parameters of the execution of the motion at three different positions i.e: right side guard position, left side guard position and centre position. Mainly including the loss rate of body horizontal and vertical velocity of the ball, Wrist angle, Elbow angle, Shoulder angle, Hip angle, Knee angle, Ankle angle, Release height, Release angle and Release velocity, in order to analyze the recording in a more convenient way, they divide Three Point Shooting exertion movement in three phases as Preparation and Ball Elevation phase, Stability and Ball Release phase and Inertia and Follow through phase. Thirty skilled

active, right handed shooters male and female basketball players were participated in this study. A lot of combinations of shoulder, elbow and wrist angular velocities exist for each release condition. When the forearm and hand are vertical at release, the shoulder rotation contributes to the vertical component of ball release velocity, and the elbow and wrist rotations are vital considering the parabolic trajectory the ball may go into the basket ring when going for the trailing edge of the basketball ring, the scoring rate will be approx. 60.00% higher.

Natsuki Sado, Shinsuke Yoshioka and Senshi Fukashiro (2018) investigated, “**The Effects of Segmental Rotations on Vertical and Horizontal Energies During Take-off of a Long Jump.**” This study aimed to reveal the effect of segmental rotation on the generation of vertical velocity and loss of horizontal velocity during take-off of a long jump. 3D motion capture system and force plates were used to capture the long jumps by nine male athletes with an approach running distance of approximately 20 m. Forward rotations of the shank and thigh of the stance leg increased vertical energy (*Evert*) and decreased horizontal energy (*Ehori*); however, elevation of the free leg side of the pelvis increased *Evert* (0.53 ± 0.16 J/kg), although pelvic elevation did not decrease *Ehori* (0.01 ± 0.02 J/kg). It was revealed that although shank and thigh movements involved the loss of horizontal velocity, elevation of the free leg side of the pelvis generated vertical velocity without the loss of horizontal velocity. This study provides evidence for a new technical approach for a long jump.

Dr. Praveen Kumar (2016) analysed the, “**Relationship of Selected Kinematic Variables with the Performance of Basketball Players in Layup Shot.**” The purpose of this study was to measure the relationship of selected biomechanical variables to the performance in Lay-up shot. The subjects for this study were ten male basketball players of Dept. of Physical Education, Ch. Charan Singh University Meerut, who represented Ch. Charan Singh University Meerut in Intervarsity Championship. The age ranged from eighteen to twenty two years. All the subjects were right handed shooters. The data was analyzed by use of Pearson’s Product Moment Correlation. The level of significance chosen to test the hypothesis was. 05. None of the selected angular kinematic variables that is Ankle Joint (Right and Left), Knee Joint (Right and Left), Shoulder Joint (Right and Left), Elbow Joint (Right and Left) and Wrist (Right and Left), and Hip Joint (Left and Right) has significant relationship with the performance of basketball players in lay-up shot. Incase of linear kinematic variables that is

height of center of gravity at moment release does not have significant relationship with the performance of basketball players in lay-up shot.

Hui Liu, Dewei Mao, Bing Yu (2015) researched the, “**Effect of Approach Run Velocity on the Optimal Performance of the Triple Jump.**” The purpose of the study was to determine the effect of horizontal and vertical velocities at the landing of the last step of approach run on the performance and optimal phase ratio of the triple jump. For conducting the study Three-dimensional kinematic data of 13 elite male triple jumpers were obtained during a competition. Computer simulations were performed using a biomechanical model of the triple jump to determine the longest actual distance using the optimal phase ratio with altered horizontal and vertical velocities at the landing of the last step of approach run. The investigators found that the actual distance obtained using the optimal phase ratio significantly increased as the horizontal velocity at the landing of the last step of approach run increased ($p = 0.001$) and the corresponding downward vertical velocity decreased ($p = 0.001$). Increasing horizontal velocity at the landing of the last step of approach run decreased optimal hop percentage and increased optimal jump percentage ($p = 0.001$), while decreasing corresponding downward vertical velocity increased optimal hop percentage and decreased optimal jump percentage ($p = 0.001$). Lastly they conclude that the effects of the velocities at the landing of the last step of approach run on the optimal phase ratio were generally small and did not qualitatively alter optimal techniques.

Hussain & Bari, (2011) have conducted studied on, “**Biomechanical Analysis of Cricket Ball Throwing Techniques**”. This research article looks at the kinematic characteristics of different throwing techniques (under-arm, side-arm and over-head) with particular stress on the techniques of throwing in cricket. The technique is subdivided into: (1) Wind up phase, (2) late cocking Phase and (3) arm acceleration phases. The study was used to form the samples as, sixty (60) elite cricket players. The mean age of the cricket players were (21.82 ± 3.08) years, height – (62.38 ± 7.22 cm), weight (168.07 ± 6.68 kg). Each throwing techniques successful attempt for throwing distances 30m with 450 approach angle at 45^0 , 90^0 and 180^0 target angle from the stump were recorded using Canon Legaria SF-10, 8.1 Mp cameras in a field setting with (1/2000 shutter speed and at 60fps). The cameras were set-up on a rigid tripod and secured to the floor in the location. First camera was located to obtain maximum accuracy and second camera located to view the throwing performances, at given specified distance in the reconstruction of the two dimensional coordinate. The location of

camera were chosen so that the optical axes of camera intersected perpendicularly to the designated plane. The accuracy of throwing performances were considered in identify the footage for addition and were subjected to analysis. Result revealed that the significant mean difference were found among different throwing kinematics as well as ball velocity and accuracy and the ball speed had to be high to carry the full distance of the throw in the shortest time.

Sandeep Kr. and Barkha Bhardwaj (2011) carried on a study called the, “**Relationship Among Selected Biomechanical Variables with Lay-up Shot Performance of Basketball Player**”. In this study they were tried to measure the relationship of selected biomechanical variables to the performance in Lay-up shot. The subjects for this study were ten basketball players of Ch. Charan Singh University, Merrut, who represented Ch. Charan Singh University in Inter University Championship. The age ranged from eighteen to twenty two years. All the subjects were right handed shooters. The data was analyzed by use of Pearson’s Product Moment Correlation. The level of significance chosen to test the hypothesis 0.05. none of the selected angular biomechanical (kinematic) variables that is Ankle Joint (Right and Left), Knee Joint (Right and Left), Shoulder Joint (Right and Left), Elbow Joint (Right and Left), Wrist Joint (Right and Left) and Hip Joint (Right and Left) had significant relationship with the performance of basketball players in lay-up shot. Incase of linear biomechanical (kinematic) variables that is height of center of gravity at moment release did not had significant relationship with the performance of basketball players in lay-up shot.

Mandeep Singh (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, bio mechanists 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.

METHODOLOGY

This chapter described the selection of subjects, selection of variables, criterion measure, instruments and tools used, administration of lay-up shot, procedure for collecting data, recording of movements, method for analysis of recording film and statistical techniques for analyzing the data.

SELECTION OF SUBJECTS

For the purpose of the study ten healthy national level basketball players (5 male and 5 female) were selected from the state of West Bengal. They had no severe previous injury. They were active participants at the time of data collection. The players used to train themselves under the guidance of qualified coaches. All of them represented national level championship in basketball and they were active participants during the time of data collection. The subjects were undergone training for a considerable period of time. Therefore, it was ascertained that subjects possess reasonable level of technique. The age of the subjects ranged between 15 to 21 years. The subjects were explained about the objective of the study.



Photograph 1: Teachers, Subjects and Helpers

SELECTION OF VARIABLES

The researcher had gone through the available literature in detail pertaining to the game of basketball. Keeping the feasible criteria in mind, especially availability of instruments and software, the following anatomical and kinematical variables were chosen for the Lay-up shot.

Anthropometric Variables

- ✓ weight
- ✓ Height.
- ✓ Leg length.
- ✓ Arm length
- ✓ Two hand distance.

Kinematic Variables

- ✓ Two and half step length.
- ✓ Approach speed.
- ✓ Take off velocity (Vertical and Horizontal).
- ✓ Take off angle.
- ✓ Height of ball release.
- ✓ Angle of ball release.
- ✓ Speed of ball release.
- ✓ Segmental joint angle at release: - a) Ankle joint. b) Knee joint. c) Elbow joint. d) Wrist joint. e) Shoulder joint.
- ✓ Duration of total flight.
- ✓ Lowering of CG.

CRITERION MEASURE

The criterion measure for this study was the performance of the subjects in lay-up shot in basketball from different zones of the two-point field goal area. A total of three attempts were given to each of the subjects for each zone and the successful shots were recorded for analysis.

INSTRUMENTS AND TOOLS USED

For the purpose of data collection following instruments and tools were used in the present study.

- i) Three cameras with tripod stand- Two Nikon D3300-60fps,18-55mm (Camera 1 and 2), and Nikon D5100-25fps, 18-55mm (Camera 3) were used to record the basketball lay-up shot from different zones of the two point field goal area.
- ii) A motion analysis software Kinovea-0.8.24, was used to analyze the recorded movements.
- iii) A stadiometer was used to measure the height of the subjects in cm.
- iv) A steel tape was used to measure the leg length, arm length and two hand distance of the subjects.
- v) A weighing machine was used to measure the body weight in kg.
- vi) Other necessary equipments like standard inflated basketballs, well equipped basketball court, measuring tape, nails etc. were used.

	
Photograph 2: Equipments for Data Collection	Photograph 3: Ground Marking and Preparations

ADMINISTRATION OF LAY-UP SHOT

All the selected subjects were asked to perform the lay-up shot from different zones of the two-point field goal area. The subjects were well directed and informed about the purpose of the study and were well prepared for the study. After adequate warming up they were asked to perform the lay-up shot naturally as they perform during competition situations in the different zones. It was ascertained that subjects possess a reasonable level of technique. The selected subjects were national players and had performed in the various National Basketball Championships. The execution of lay-up shot by the players was video graphed in the outdoor basketball court of Jadavpur University, with a systematic filming method as required. The subjects were asked to perform three valid lay-up shots and after every attempt,

the ball was supplied to them for the next attempt. For the sole purpose of analysis, only the best lay-up shot was taken among the three. The performance of each subject was assessed as specified in the criterion measure. There were also a sufficient number of practice trials to ensure that they were completely comfortable with the test.

PROCEDURE FOR COLLECTING DATA

1. ANTHROPOMETRIC MEASUREMENT OF THE SUBJECTS

- **Body Weight:** For measuring the weight of the subject an electronic weighing machine was used.
- **Standing Height:** By using a stadiometer standing height of the subjects was measured in cm.
- **Two hand distance, arm length, leg length:** Still tape was used to measure the lengths of the said body segments in cm.

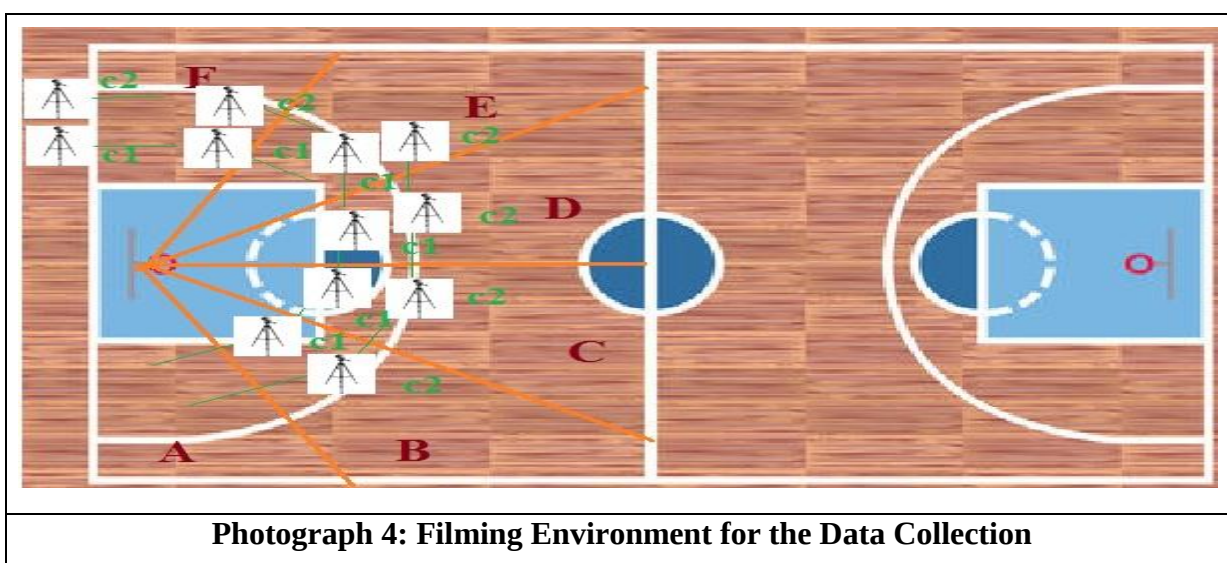
2. RECORDING OF MOVEMENTS

The recording of layup shots from different field positions of the selected subjects (National Level male and female basketball players) was done at the basketball ground of the Jadavpur University-Main Campus. Before starting the recording of movements, the purpose of the recording was briefly explained to all the subjects for better understanding and to increase their motivation level. The movement of the subject for executing the layup shot from different field positions was recorded by three cameras (respectively for each zone) following the basic principle of photography:

- a) Three fixed cameras were used for the recording of movements.
- b) To maintain the “Obliquity” error in minimal level, the cameras were placed far away from the subject as possible.
- c) For recording the action of the lay-up shot Camera-1, camera-2 and Camera-3 were placed in the sagittal right, sagittal left, and frontal plane respectively. The lateral distance of Camera-1 and Camera 2 from their respective sides of the basketball court (focusing lay-up) was 10.50 meters and the height of the camera was 1.30 meters from the ground. Camera-3 was placed at a distance of 10.50m from the line of lay-up shot for different zones and it was mounted at a height of 1.30m from the ground. For

calculating and converting the recorded distance into the real distance a reference scale was also recorded by all the cameras. The real length of this scale was 1mt.

Cameras were started a few seconds earlier than the starting of actual movement which was recorded. Then the movement for executing the lay-up shot was recorded for all the male and female subjects respectively from different zones. By maintaining the sequence all subjects performed three valid lay-up shots for each zone but the best one for each subject for that particular zone was selected for further analysis.



METHOD FOR ANALYSIS OF RECORDED FILM

To measure the selected kinematic variables the film was analyzed. The capture movement was transferred from the cameras to the computer and it was edited. Then the recorded

movement was displayed by computer and the movement of each subject for the selected technique was analyzed with the help of Kinovea-0.8.24 software.

PROCEDURE FOR ANALYSIS OF DATA

To test the kinematic data a two-way analysis of variance (ANOVA) was applied to obtain the significant mean difference. The level of significance was set at 0.05 in order to check the significance level. In cases where "F" ratios were significant, a Least Significant Difference (LSD) post hoc test was used to determine which variable differentiates across the different zones of the two point field goal area of the basketball court.

RESULTS AND DISCUSSIONS

This chapter includes the data, presentation & analysis of data, results, discussions and discussion of hypothesis.

THE DATA

In the present study for the anthropometric variables age, weight, height, two hand distance, arm's length, and leg length of the subjects were considered. Then for the kinematic variables related to the layup shot in basketball two and half step length, approach speed, take-off velocity, the height of ball release, angle of ball release, speed of ball release, segmental joint angles at release (i.e ankle joint, knee joint, elbow joint, wrist joint and shoulder joint), duration of the total flight and lowering of Cg were measured. All these were the data for the present study.

RESULTS

On the basis of analysis of data the followings results have obtained in the present study-

1. In the execution of basketball lay-up shots from different zones of the two-point field goal area, there was no significant difference in approach speed for Male basketball players but there was a significant difference that exists for the Female basketball players.

2. In two and half step length of the basketball lay-up shot from different zones of the two-point field goal area there was no significant difference for Male basketball players but for the Female basketball players there was significant difference exists.
3. In takeoff velocity of the basketball lay-up shot from different zones of the two-point field goal area there was no significant difference for Male basketball players but for the Female basketball players there was significant difference exists.
4. In vertical velocity of the basketball lay-up shot from different zones of the two-point field goal area there was no significant difference for both the Male and Female basketball players.
5. In horizontal velocity of the basketball lay-up shot from different zones of the two-point field goal area there was no significant difference for Male basketball players but for the Female basketball players there was significant difference exists.
6. In takeoff angle of the basketball lay-up shot from different zones of the two-point field goal area there was no significant difference for both the Male and Female basketball players.
7. In height of ball release of the basketball lay-up shot from different zones of the two-point field goal area there was no significant difference for both the Male and Female basketball players.
8. In angle of ball release of the basketball lay-up shot from different zones of the two-point field goal area there was no significant difference for both the Male and Female basketball players.
9. In speed of ball release of the basketball lay-up shot from different zones of the two-point field goal area there was significant difference exists for Male basketball players but for the Female basketball players there was no significant difference.
10. In angular velocity of ankle joint of the basketball lay-up shot from different zones of the two-point field goal area there was no significant difference for both the Male and Female basketball players.
11. In angular velocity of knee joint of the basketball lay-up shot from different zones of the two-point field goal area there was no significant difference for both the Male and Female basketball players.

12. In angular velocity of shoulder joint of the basketball lay-up shot from different zones of the two-point field goal area there was no significant difference for both the Male and Female basketball players.
13. In angular velocity of elbow joint of the basketball lay-up shot from different zones of the two-point field goal area there was no significant difference for both the Male and Female basketball players.
14. In angular velocity of wrist joint of the basketball lay-up shot from different zones of the two-point field goal area there was no significant difference for both the Male and Female basketball players.
15. In Duration of total flight of the basketball lay-up shot from different zones of the two-point field goal area there was no significant difference for both the Male and Female basketball players.
16. In Lowering of CG of the basketball lay-up shot from different zones of the two-point field goal area there was no significant difference for both the Male and Female basketball players.

DISCUSSIONS

Approach speed is a very important parameter for lay-up shots in basketball. Because it helps the basketball players to go faster for their lay-up and get the point quickly. The results of this study indicate that there was no significant difference in approach speed for a lay-up shot in basketball concerning different zones in the two-point field goal area for male basketball players. But for the female basketball players, there was a significant difference exists in approach Speed for lay-up shots in basketball concerning different zones in the two-point field goal area. That means the changing of the zones has no impact on the approach speed of the basketball lay-up shot for male basketball players rather than female basketball players. The male basketball players had comparatively greater height, are very comfortable with their skill, and were quite sure of getting the distance in comparison with the female basketball players. Whereas the female basketball players were keen to cover more distance and tried to get closer to the basket or backboard. **Keith Miniscalco & Greg Kot** in *Survival Guide for Coaching Youth Basketball*, mentioned that the faster a player was able to approach the basket, the better able the player was to launch off the floor and toward the rim with the ball. Another study of **Bridgett and Linthorne (2006)** on changes in long jump take-off technique

with increasing run-up speed, shows that as the athlete's run-up speed increased the jump distance and take-off speed increased. In our study, the female basketball players intended to cover more distance and to reach closer to the basket. That's why the female basketball players were trying to differentiate their approach speed for the different zones of the two-point field goal area.

In basketball, the players intend to get closer to the backboard. That's why two and half step length is an important factor for the layup shot in basketball. The result shows that there was no significant difference in two and half step lengths for male players in lay-up shot concerning different zones of the two-point field goal area. But for the female players, there was a significant difference exists in two and half step lengths in lay-up shot concerning different zones in the two-point field goal area. The male players had not changed their approach speed concerning the different zones of the two-point field goal area. That's why no difference was measured in their performance of two and half step lengths. **J. S. Hanna (2014)** conducted a study entitled, Comparison of Some Kinematic Variables of Layup Basketball of Older and Young Players. In this study he found that the length of first and second step for older players higher for the older player than the youth. But in the case of the female players, we had noticed the difference in approach speed concerning the different zones of the two-point field goal area. So, they had a significant difference in their performance of two and half step lengths concerning the different zones of the two-point field goal area. **Keith Miniscalco & Greg Kot** in Survival Guide for Coaching Youth Basketball mentioned that the faster a player can approach the basket, the better able the player was to launch off the floor and toward the rim with the ball. Another study by **Bridgett and Linthorne (2006)** on changes in long jump take-off technique with increasing run-up speed, shows that as the athlete's run-up speed increased the jump distance and take-off speed increased. In our study, the female basketball players intended to cover more distance and also tried to reach closer to the basket. That was the reason for the female basketball players to change their two and half step lengths in lay-up shots concerning different zones of the two-point field goal area.

The takeoff velocity in a basketball layup shot is very important for getting the desired height and distance to complete the shot. The result of the study indicates that there was no significant difference for male players and for the female players a significant difference exists in lay-up shot from different zones of the two-point field goal area. **J. S. Hanna (2014)**

conducted a study entitled, Comparison of Some Kinematic Variables of Layup Basketball of Older and Young Players. In this study he found that the speed of first and second step for older players higher for the older player than the youth. Takeoff velocity is very much related to the approach speed. If the approach speed increased the takeoff velocity also increased and vice versa. In this study, we noticed that for the female players there was a significant difference exists in approach Speed for layup shots in basketball concerning different zones of the two-point field goal area. The jump simulations by **Alexander (1990) and Seyfarth et al. (2000)** indicate that the optimum take-off changes as the run-up speed was increased in vertical jump and the study of **Bridgett and Linthorne (2006)** on Changes in long jump take-off technique with increasing run-up speed, shows that as the athlete's run-up speed increased the jump distance and take-off speed increased, which supports this fact. Further going for the detailed analysis we had noticed that the horizontal factor of the takeoff velocity had a significant difference for the female players rather than the vertical component in basketball lay-up shots concerning different zones of the two-point field goal area. **Weihsun Tai et al. (2019)** conducted a study on, Biomechanical Characteristics of Single Leg Jump in Collegiate Basketball Players Based on Approach Technique. In this study they found that approach speed can affect velocity of the horizontal-to-vertical transition. It describes that the main intention of the female basketball players was to cover more distance than gaining the vertical height to get closer to the basket.

In basketball layup shot takeoff angle is a vital variable. In this study, the result showed that there was no significant difference exists for both male and female players concerning different zones of the two-point field goal area. The study of **Linthorne, Bridgett, and Guzman (2005)**, on optimum take-off angle in the long jump, shows the direct proportional relation of the takeoff height with the takeoff angle. In this study, both male and female players have no change in their takeoff height i.e. the vertical component of the takeoff velocity concerning different zones of the two-point field goal area. That was the main reason for this result.

The height attained at the time the ball is released into the basket is crucial in basketball lay-ups. The players try to get a lot closer to the backboard and the basket. In this study, we have seen that in the case of height of ball release there was no significant difference exists for both male and female players concerning different zones in the two-point field goal area. The study of **Dr. Praveen Kumar (2016)**, on the Relationship of selected kinematic variables

with the performance of basketball players in layup shots, shows that the height achieved by the players at the moment of release does not have a significant relationship with the performance of the basketball players in layup shot. Another study conducted by, **Sandeep Kr. and Barkha Bhardwaj (2011)** carried on the, Relationship among selected biomechanical variables with lay-up shot performance of basketball player, explained that the height of centre of gravity at moment release did not had significant relationship with the performance of basketball players in lay-up shot. In our study, we also found a similar result with no significant difference exists for both male and female players concerning different zones of the two-point field goal area.

The angle of ball release is an essential part of the basketball layup shot. The result of the study shows that there was no significant difference exists in the angle of ball release for the male and female players, concerning different zones of the two-point field goal area. **Yuki Inaba et al.** in their study, Influence of Selection of Release Angle and Speed on Success Rates of Jump Shots in Basketball, did not found significant correlation with release angle and the success rate in jump shot. In another study which was conducted by **Rojas F.J., Cepero and Gutierrez (2000)** on kinematic adjustments in the basketball jump shot against an opponent. In the study it was found that the release angle of the ball changed in the presence of an opponent. As there were no opponent to resist their throw, they were very clam on their release. After achieving the desired height the sole intention of the players were to release the ball to hit on the some point backboard for the basket. That might be the reason why the players do not have to vary their ball release angle irrespective of male or female players concerning different zones of the two-point field goal area.

The main aim was to hit the board and put the ball into the basket. In this matter speed of the ball, release plays an important role in basketball layup shot. In this study, we have seen that there was significant difference exists in the speed of ball release for the male players but no significant difference was found for the female players irrespective in basketball lay-up shot concerning different zones of the two-point field goal area. **Linthorn& Everett, (2006)** have investigated “The release angle that maximizes the distance attained in a long soccer throw-in” and found that when using low release angles the player released the ball with a greater release speed. **Wagner et al. (2011)** have studied performance and kinematics of various throwing techniques in team handball and noticed that ball velocity was significant impacted by the run-up. **Miller (1993)** analyzed with Three-dimensional video techniques that were

used to obtain images of basketball jump shots from one of three distances from the basket. The result of the study shows that the increase in the mean ball release speed as the distance of the player from the basket increases. **P. Ranjith and Dr. P. Rajini Kumar, (2014)** examined the, “Biomechanical Analysis of Set shot in Basketball.” Among the selected variables they found that the speed of release having highest relationship. By these instances, we might assume that because of low ball release angle and steady approach speed there was a significant difference in speed of ball release for the male players in basketball lay-up shot concerning different zones of the two-point field goal area.

The angular velocity of the various segment has played an important role in the basketball layup shot. The result of the study shows that there was no significant difference exists for both male and female players in the angular velocity of the ankle, knee, shoulder, elbow, and wrist joint at the time of releasing the ball in a basketball layup shot concerning the different zones of the two-point field goal area. A study was conducted by **Dr. Praveen Kumar (2016)**, on the Relationship of selected kinematic variables with the performance of basketball players in layup shots. He found that none of the selected angular kinematic variables that was Ankle Joint (Right and Left), Knee Joint (Right and Left), Shoulder Joint (Right and Left), Elbow Joint (Right and Left) and Wrist (Right and Left), and Hip Joint (Left and Right) has a significant relationship with the performance of basketball players in lay-up shot. Like that, **Khan Nazia (2015)** on Relationship of Selected Kinematical Variables with the Performance of Female Basketball Players in Lay- Up Shot, **Birendra jhajharia, Upendra pandey and Mandeep Singh (2012)** on Kinematically analysed the female basketball players in 3 point shot, **Motoyasu, Koshiyama and Katsumata (2009)** on Effects of joint movement on the accuracy of 3-point shooting in Basketball, **Dr. Baljinder Singh Bal, Dr. Nishan Singh Deol, Prof. Perminder Jeet Kaur (2009)** on Relationship of Kinematic Variables with the Performance of Basketball Players in Lay-up Shot, also found that there were insignificant relationship between various angular velocities with the lay-up shot. Similarly, we also found that there was no significant difference exists for both male and female players in the angular velocity of the ankle, knee, shoulder, elbow, and wrist joint at the time of releasing the ball in basketball layup shot concerning the different zones in the two-point field goal area.

In this study, we want to investigate the difference that exists in the duration of the total flight concerning the different zones in the two-point field goal area. We found that there was no

significant difference exists for both male and female players concerning the different zones in the two-point field goal area. The duration does not differ much concerning the different zones irrespective of both male and female players. The height gained by the player (vertical velocity) does not have a significant difference concerning the different zones in the two-point field goal area. That might be the main cause for this result.

Lowering of C G is essential for stabilize the body and maintain the balance of the players in basketball layup shots. The result of the study shows that there was no significant difference exists in the lowering of C G for the male and female players, concerning different zones of the two-point field goal area. After achieving the desired height and completing the flight the players have enough time to land their body safely by lowering their body smoothly. In this study, the players are also instructed to go for lay-up shot only when they were ready and feels comfortable. And there was no opponent reside to obstruct their activities so, they were in no hurry to step up the velocity and stabilize themselves in their layup shot from different field positions irrespective of male or female players concerning different zones of the two-point field goal area.

DISCUSSION OF HYPOTHESIS

On the basis of the results obtained from the analysis of data the hypothesis may be discussed as follows:

The formulated hypothesis for this study is partially accepted and mostly rejected according to the results of the study. The formulated hypothesis that there would be no significant difference in biomechanical parameters of layup shot in basketball from the different zones of the two-point field goal area for both male and female basketball players was partially accepted because there were significant difference exists in approach speed, two and half step length and take-off velocity for female basketball players and in the speed of ball release for male basketball players. The hypothesis was mostly rejected because there were no significant differences subsists in two and half step length, approach speed, take-off velocity (vertical and horizontal), take-off angle, the height of ball release, angle of ball release, segmental joint angular velocity at release: - a) ankle joint. b) knee joint. c) elbow joint. d) wrist joint. e) shoulder joint, duration of the total flight and lowering of CG for male basketball players and in take-off angle, the height of ball release, angle of ball release, segmental joint angular velocity at release: - a) ankle joint. b) knee joint. c) elbow joint. d)

wrist joint. e) shoulder joint, duration of the total flight, and lowering of CG for female basketball players.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

Based on the analysis and within the limitations of the study following conclusions were drawn:

- I. Female basketball players vary their approach speed in layup shots from different zones (field positions) of the two-point field goal area of the basketball court.
- II. Male basketball players do not change their approach speed in the execution the layup shot from different zones (field positions) of the two-point field goal area.
- III. The distance covered in two and half step length by the female basketball players in layup shot changes notably in respect to different zones (field positions) of the two-point field goal area of the basketball court. Whereas the male players don't have any variety in that.
- IV. The takeoff velocity differs considerably for the female basketball players when performing the layup shot from different zones (field positions) of the two-point field goal area of the basketball court.
- V. There is a noticeable variation found in the horizontal velocity at take-off for the female basketball players performing the layup shot from different zones (field positions) of the two-point field goal area of the basketball court.
- VI. The vertical velocity at take-off is identical for both the male and female basketball players performing the layup shot from different zones (field positions) of the two-point field goal area of the basketball court.
- VII. Takeoff angle, angle of ball release, and height of ball release have no disparity in layup shot from different zones (field positions) of the two-point field goal area of the court for male and female basketball players.

- VIII. In layup shots from different zones (field positions) of the two-point field goal area of the basketball court, the speed of ball release differs for male basketball players.
- IX. The angular velocity of the ankle, knee, shoulder, elbow, and wrist (at the time of release) doesn't have alteration in performing the layup shot from different zones (field positions) of the two-point field goal area of the basketball court, for male and female basketball players.
- X. Duration of total flight and lowering of C.G don't have any considerable deviation in carrying out the layup shot from different zones (field positions) of the two-point field goal area of the basketball court, for both male and female basketball players.

RECOMMENDATIONS

With the help of results and conclusion derived from the present study, the following recommendations can be made:

1. It is recommended that the present study may be repeated by selecting subjects belonging to different population, sex, and age groups at a different skill level.
2. A similar study may be conducted in consideration of Indian International players.
3. A comparable study may be conducted taking a large sample and with a greater number of kinetic and kinematic variables.
4. A similar study may be conducted to compare considering Indian International to World-Class Level players (European, African, Asian, etc.).
5. A comparable study may be conducted with sophisticated equipments-instruments and subjects of higher performance levels.
6. A similar study may be conducted to analyse other techniques of basketball.
7. A similar study may be conducted by taking left handed basketball players instead of right handed basketball players.
8. A similar study may be conducted in 3D (three dimensional) analysis instead of 2D (two dimensional) with higher degree of freedom.
9. In a competition environment, a similar study with various types of subjects may be undertaken.
10. Similar analysis may be done in other games and sports also.

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